

Policy to Reduce Greenhouse Gas Emissions: is Agricultural Methane a Special Case?

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Summary

Climate change mitigation will require significant efforts from all emitting sectors, including agriculture. However, agricultural emission reduction measures raise specific concerns, both in respect of their distinct climate outcomes and how their implementation might support or frustrate wider objectives. We highlight some special characteristics regarding agricultural methane emissions. As methane is a relatively short-lived gas, we do not have the same strong physical requirement to completely eliminate net methane emissions as we do for carbon dioxide. An appreciation of the distinct nature and impacts of carbon dioxide and methane can bring nuance to discussions; especially around what different sectors must be expected to achieve, and thus help avoid negative trade-offs that might result from heavy-handed policy interventions. Nevertheless, significant and rapid methane emission reductions do remain important in realistically achieving our overall climate objectives. A number of technical measures to reduce ruminant methane are highlighted, but are not without their own challenges; and we are unlikely to meet climate or other environmental targets without systemic changes to the total food system, including overall consumption patterns. The appropriate policy tools to achieve these changes are emerging as a key, but contested, concern in Europe and beyond, making it vital we work through these arguments in a transparent manner.

The European Union has declared an objective of ‘achieving a climate-neutral EU by 2050’ in order to play its role in the global climate change mitigation targets enshrined in the Paris Agreement. This all-encompassing target thus necessitates consideration of all greenhouse gases (GHGs) and all sectors, including agriculture.

Limits to agricultural greenhouse gas emissions must be part of comprehensive climate policy, since rapid reductions will be required across all sectors if we are to achieve the Paris Agreement’s overarching goal of “[h]olding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C”.

Within this context, however, what we infer by ‘climate-neutrality’ and what this might mean for EU policy can have distinct implications for different actors. In this article, we outline some of these considerations for agricultural methane reductions, with a focus on ruminant methane (as the most significant source). These concerns arise due to both physical differences between methane and carbon dioxide (CO₂ – the primary contributor to global warming) and possible consequential impacts of agricultural emission reduction policies.

Global warming impacts of carbon dioxide and methane

Carbon dioxide and methane are, respectively, the first and second largest contributors to anthropogenic climate change. At present, concentrations of both gases are increasing, raising the global temperature. What will it take to divert from our current trajectory of ever-increasing warming? Due to its persistence, CO₂-induced warming reflects the total stock of all previous

anthropogenic emissions of CO₂, and so temperatures are only expected to stabilise once emissions are reduced to [net-]zero. For methane however, its warming contribution is primarily a function of recent emissions only, as natural removals occurring after its short atmospheric lifetime can balance ongoing emissions (Cain *et al.*, 2019). Furthermore, if methane emission rates are not sustained, atmospheric concentrations rapidly decline and much of its warming impact is undone as the gas automatically breaks down. In contrast, a reversal of CO₂-induced warming only occurs when the gas is actively removed from the atmosphere, because with CO₂ each extra emission results in cumulative addition to overall temperature increase. *Policy-makers should consider some of the implications resulting from these distinctly different dynamics.*

Most fundamentally, this difference in atmospheric lifetime sets distinct requirements for the two gases to achieve the same temperature impacts. To stabilise temperatures (the outcome of achieving 'net-zero' CO₂ emissions), methane emissions do not have to be completely removed; methane-induced warming can stabilise by reducing emissions by a small amount (circa 0.3%) each year (Lynch *et al.*, 2020).

Despite this, it would of course be even more beneficial to *not* have these ongoing emissions, which will contribute to elevated temperatures for as long as they are maintained (even if they may be argued as 'sustainable' or 'climate-neutral' with respect to net-zero CO₂). Methane also negatively impacts air quality, being a precursor to ground-level ozone formation. Merely stabilising the warming contribution from methane would likely be insufficient in the context of our global temperature targets. Even under the most ambitious pathways to net-zero CO₂ deemed feasible by climate-economic integrated assessment models, for global temperatures to stabilise below 1.5 degrees will also require rapid reductions in methane emissions, with agricultural methane emissions 24-47% below 2010 rates by 2050 (IPCC, 2018). The European Union could quite rightly be expected to achieve greater reductions than this global average, given its economic development and disproportionate per capita emissions and warming legacy. If global food system emissions continue along 'business-as-usual' increases, they alone will generate enough extra warming to take us past 1.5 degrees (Clark *et al.*, 2020).

There is, therefore, still an underlying imperative to reduce methane emissions. However, recognising the distinction in requirements and legacies of methane and CO₂ emitters could help highlight the responsibilities of different actors. This may become especially significant as we consider, for example, where some level of ruminant production may still be desired despite the ongoing methane emissions that will occur as a result, and/or we reach the technical and politically acceptable limits of methane emission reductions.

Within an overarching climate policy, these considerations may be particularly notable in determining which residual emissions need to be perpetually offset to achieve 'carbon neutrality' (and what this should mean in relation to 'climate neutrality'), whether and how this is defined in the Paris Agreement (Fuglestad *et al.*, 2018), and who should shoulder the burden of paying for these offsets.

The short atmospheric lifetime of methane also means that deferring any emission reductions has less impact on committing us to higher temperatures than for CO₂ or other longer-lived gases. If methane emission reductions are delayed we will still realise most of the temperature reduction benefits whenever the cut is finally made, whereas for CO₂ any postponement to reaching net-zero commits us to long-term, cumulative warming (or the costs of extra CO₂-removal) from all emissions during the period of delay (Pierrehumbert, 2014). In addition, because the largest determinant of global warming is the accumulating impact of CO₂ emissions,

reducing methane emissions only has a strong influence on peak warming if net-CO₂ emissions are already falling towards zero.

This is not an argument for avoiding methane emission reductions: where reductions can be implemented easily and cost-effectively there is no reason not to make them as soon as possible. Keeping global warming to 1.5-2°C will require us to eliminate net CO₂ emissions within the next few decades, and so if we are to achieve this, we are already at a point where methane reduction becomes significant to limit peak warming to this temperature range.

The key implication is instead that methane reduction policies should be additional or complementary, without risk of detracting from efforts on long-lived gases – particularly the core requirement of energy decarbonisation and net-zero CO₂.

While we do not expand on economic analyses in this article, we briefly note here that multi-gas mitigation strategies typically aim for global cost-effectiveness by allocating emission reduction efforts according to the cost of individual mitigations and the marginal impacts of the emissions they eliminate. Per-emission impacts of different gases are commonly defined by ‘emission metrics’ that give a single weighting for different gases (compared to CO₂), with by far the most common metric (for economic modelling and other policy and reporting purposes) being the ‘100-year Global Warming Potential’ (GWP₁₀₀). There is no intrinsic physical reason to favour this particular metric, but it has been shown to equate to an implicit discount rate of just over 3% (Sarofim and Giordano, 2018) and result in cost-optimal global mitigation for 21st Century temperature targets according to integrated climate-economic assessment models (IAMs) (Strefler *et al.*, 2014). However, IAMs also suggest that more complex gas exchange rates, such as weightings that scale independently over time for different gases, can achieve the same climate targets even more cost-effectively (Strefler *et al.*, 2014). It could also be questioned whether marginal impacts of individual emissions are an appropriate way to value different gases and design climate mitigation policy, given the distinct dynamics noted above, and wider context expanded upon below.

Concern over the appropriate treatment of methane with respect to CO₂ is particularly relevant to the agricultural sector, as although overall warming is dominated by energy generation and CO₂ emissions, agriculture accounts for approximately half of methane emissions globally (Mbow *et al.*, 2019). In the EU, the livestock sector is a specific focus, as although agriculture contributes only around 10% of total EU emissions (as of 2018, and aggregating different gases using the GWP₁₀₀), it is responsible for 54% of methane emissions, 98% of which come from livestock (figures derived from European Environment Agency greenhouse gas data viewer).

Reducing ruminant methane in Europe: means and risks

There are a number of potential routes to reducing ruminant methane. Some are relatively straightforward and have few obvious downsides. For example, continued improvements in animal health ensure more energy is directed to growth or consumable milk production and reduce excess mortality, thus boosting environmental performance by reducing “unproductive emissions” (Gerber *et al.*, 2013) of methane and other greenhouse gases.

A number of emerging strategies such as dietary supplements or vaccination to reduce methanogenesis may hold promise, but require further study to determine their overall potential, scalability and suitability for different types of production system, and ensure there are no adverse consequences (Beauchemin *et al.*, 2020). For example, there is currently much interest in seaweed as a methane-reducing dietary additive, but also concerns around the palatability to livestock and potential toxicity (Makkar *et al.*, 2016).

For methane-reducing managements and technologies that are shown to provide reliable benefits, the challenge is then to confirm their suitability across the large range of ruminant systems in Europe, and then achieve widespread adoption across them.

Other systemic interventions aimed at reducing ruminant methane emissions could play a role, but potential trade-offs must be anticipated and policy designed to avoid them. There is longstanding discussion over how far we should go in intensifying ruminant systems – increasing confinement housing and the amount of dedicated grain and high protein feeds in animal diets – to improve production efficiency (Capper, 2012). In some cases, intensification of ruminant systems may risk reducing methane at the expense of increased CO₂ emissions through additional energy use and/or nitrous oxide emissions through feed production. This is particularly notable in light of the points made above regarding methane and longer-lived gases.

A move away from more extensive ruminant production to greater stocking rates in intensive systems raises animal welfare concerns independent of any climate benefits or risks. Such a shift would also impact, for example, rural landscapes and food quality (or consumer perception thereof), that are currently linked to extensive production. Similar drawbacks can be argued if suggesting consumers replace ruminant meat with greater consumption of monogastric (pig and poultry) animal products.

Furthermore, increased demand for feed grains (for more intensive ruminant production or monogastrics) will exacerbate land use pressures overseas with consequences both for biodiversity loss and CO₂ release through the conversion of native vegetation to agriculture. The consequences may be a reduction in ruminant methane within the EU at the expense of increased CO₂ emissions and wider environmental impacts elsewhere.

A related concern is associated with reducing ruminant livestock numbers in Europe without commensurate declines in consumption, meaning that the equivalent amount of animal products will still be produced (with associated greenhouse gas emissions), but outside of the EU. This ‘carbon leakage’ can increase overall emissions if the activity is displaced to less emission-efficient regions. This issue is also present for the wider environmental effects noted above through ‘leakage’ of agricultural land use, particularly to the tropics. Even if the land footprints are similar and spared land in Europe is used for nature conservation, the net biodiversity impact is still likely to be negative, as tropical biodiversity is more greatly impacted by habitat fragmentation (Betts *et al.*, 2019).

Wider agri-food policy context

An even stronger lever for reducing methane emissions from ruminant livestock is reducing what causes them, i.e. ruminant livestock. Achieving this through intensification risks the outcomes noted above, and so an overall reduction in the consumption of ruminant products may be a more robust option. Further trade-offs highlighted above are avoided if this extends to reduced consumption of all livestock products. This suggests dietary change and agricultural readjustment and reconfiguration as a consideration for European climate policy. Agricultural methane reduction strategies could thus be part of and/or complementary to the EU Farm to Fork Strategy, given it already has an ambition of ‘[M]oving to a more plant-based diet with less red and processed meat and with more fruits and vegetables’ so as to ‘reduce not only risks of life-threatening diseases, but also the environmental impact of the food system’.

European agricultural policy has long had multiple objectives alongside food production (for example, rural development and supporting the family farm) and has attempted to limit multiple environmental negatives (for example, reducing nitrogen pollution and air quality impacts), while expanding agro-environmental public goods. So while part of the driving

ambition of the Farm to Fork Strategy is to reduce emissions, it notes a wider context, and methane – or indeed climate – is not the sole concern. Even supposing that technical measures to reduce ruminant methane are extremely successful (to the point where it is a non-issue, even), many policies that are currently advocated for reducing agricultural methane (e.g. lower numbers of ruminant livestock) will still be highlighted for their potential to provide wider net-benefits beyond emission reductions. Of these potential wider benefits, ‘land-sparing’ for alternative uses such as carbon sequestration and ecological restoration currently receives most attention; but this will also require appropriate analysis and policy tools to ensure that alternative land-uses do provide significant benefit and are achieved following agricultural transition.

How far policy can or should go in driving changes to diets, land-use and, ultimately, cultural values, is a much bigger (and much disputed) topic that will likely receive increasing attention in the coming years. The significant impacts of our current agri-food system, and the multifaceted benefits of improving it, make some level of state intervention on these points appear essential and inevitable.

We therefore have many potential routes to reducing ruminant methane, which may both provide co-benefits and introduce wider risks, as summarised by way of illustration in Table 1.

Table 1. Potential ruminant methane reduction strategies and their implications

Emission reduction strategy	Example policy interventions	Potential co-benefits	Potential risks and wider context
Targeted measures to reduce ruminant methane emissions	R&D for methane inhibitors and dietary additives	Methane eructation (belching) represents an energy loss, and so reducing enteric methane may also lead to greater feed conversion efficiency, hence lower input requirements and associated production impacts	Novel techniques may present animal health unknowns, and production impacts of the inhibitors/additives must themselves be assessed; Potentially significant allocation/diversion of mitigation resources, research effort and extension services into methane rather than prioritising efforts to reduce longer-lived GHGs
Increased efficiency of ruminant production	Agricultural subsidies promoting intensification of ruminant farming	Land-use requirements and other impacts may also be improved via general efficiency increases; Scope to greatly reduce overall impacts just by bringing worst performers up to wider standards given large spread in efficiency at present	Animal welfare concerns; Risk of pollution-swapping between methane and other greenhouse gases resulting in a negative trade-off over the long term; Similar or even reduced overall pollution loadings may pose greater health and environmental risks when concentrated to point-sources associated with higher-intensity systems (e.g., nitrogen pollution and ammonia air quality risk from livestock manures).

Lower numbers of ruminant livestock	Reduced demand and production through measures such as: meat taxes or greater subsidies for plant-based foods; educational programmes on impacts of ruminant livestock and foodstuffs; sourcing guidelines or production quotas	Wider environmental impacts of ruminants also reduced; New opportunities for agricultural land; Health benefits from reducing over-consumption of ruminant products. Lower overall animal numbers may allow focus on optimal production systems (e.g. locations and management types associated with high animal welfare, contributions to biodiversity conservation, and maintenance of soil carbon).	Systemic shifts in dietary preferences, food cultures, farming and landscapes are likely to be challenging to implement and may or may not be seen as positive by the public and different stakeholder groups; Depending on scale of transformation and strength of interventions, could prove politically costly when other climate policies may be more essential and pose fewer challenges in the face of public preferences and values; Unforeseen consequential impacts in consumer behaviour (e.g. rebound effects with greater consumer spending from reducing meat purchasing spent on goods or services with other environmental impacts).
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Conclusions

Reducing emissions of methane, as with any greenhouse gas, would help mitigate climate change, and large, rapid reductions in agricultural methane will almost certainly be necessary to keep global warming to 1.5-2°C. The European Union must play a part in achieving this outcome. Ruminant methane reductions can be achieved through multiple routes, but several require further investigation, and must be adopted cautiously so as to avoid negative consequences. Even assuming the adoption of new technologies and improved management, there are likely to be limits to the amount of agricultural emissions that can be eliminated, with ruminant methane a key source of residual emissions. There will be different views on how big a problem this is and what should be done about it.

There are compelling physical reasons why we could permit or justify some level of ongoing methane emissions in a way that we cannot for CO₂. So if ruminants can still play a positive role in, for example, integrated farming systems, there may be valid arguments to provide policy support for some population of ruminant livestock despite their methane. Similarly, some (lower) level of ruminant methane could potentially be tolerated if the presence of ruminants is an unavoidable consequence of other EU policy aims such as maintaining rural landscapes, livelihoods or traditional foods and types of production. Or we may wish to avoid wider negative consequences and exporting of impacts, or simply popular opposition, that could result from the strongest domestic methane mitigations.

Conversely, even if our technical measures are extremely successful in cutting ruminant methane emissions, we will still need overarching policy to drive systemic changes in agriculture and food systems to reduce wider negative impacts where there is damaging production and excess consumption of livestock products. Reducing ruminant (and other livestock) numbers holds potential to provide many benefits that align with multiple policy objectives. While these issues are, to an extent, recognised in the wider EU strategy, the challenge lies in developing sufficiently detailed and nuanced policy for a topic of increasingly heated public discourse.

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Figure 1. A cattle barn in Germany



Figure 2. Sheep grazing in the west of Ireland



Figure 3. A cow in Sweden