Reflections on metrics for monitoring and mitigating methane emissions

Caspar Donnison and Donal Murphy-Bokern

This submission is from Dr Caspar Donnison and Dr Donal Murphy-Bokern based on their published research on the application of GWP* (Donnison and Murphy-Bokern, 2024)[1] which is relevant to the Committee's interest in metrics.

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[1] Donnison, C. and Murphy-Bokern, D. (2024). Are climate neutrality claims in the livestock sector too good to be true? Environmental Research Letters, doi.org/10.1088/1748-9326/ad0f75).

Summary

This is a submission of evidence to the House of Lords enquiry into methane. It focuses on Question 11 in the call for evidence (What are the advantages and disadvantages of available metrics used to report and compare methane emissions including GWP_{100} and GWP*?). Some comments relevant to Questions 16-20 on agriculture are also provided.

Global warming metrics such as Global Warming Potential 100 (GWP_{100}) express the effectiveness of different greenhouse gases (GHGs) at causing global warming by converting each of them to a common currency expressed in carbon dioxide equivalents (CO_2e). GWP_{100} is the standard metric for public policy and commercial decision making. It was used by the policymakers who wrote the carefully calibrated text and goals of the Paris Agreement. It is science-based, simple, and it reflects the full warming effect of the emission of all GHGs versus them not emitted, i.e., the marginal effect. This makes GWP_{100} suitable for emissions accounting and for guiding mitigation. However, GWP_{100} leaves gaps in evidence with respect to the course of global warming caused by changes in the emission short-lived GHGs such as methane. It reports methane, which is short-lived, in the same way as long-lived GHGs such as CO_2.

GWP* is a complementary modelling approach for use at the global level, particularly for predicting the impact of changes in methane emissions on changes in warming in relation to set warming limits and goals. However, GWP* is not a warming metric because it does not address the full warming effect of an emission. It is also not an alternative to established warming metrics, particularly GWP_{100}. It transforms a relatively small change in the rate of emission of methane into a relatively large one-off pulse or withdrawal of CO_2, referred to as a warming equivalent (CO_{2we}). To use a motoring analogy, warming equivalents focus on acceleration and deceleration (increased or reduced emissions and warming) rather than speed (on-going emissions and warming) that maintains warming momentum. Therefore, when applied below the global level, GWP* has serious limitations and potentially distorting effects on mitigation policy and decision-making, especially for monitoring and for comparing businesses, products, and processes. Established large emitters (those travelling fast) benefit from the 'grandfathering' of their existing emissions (speed) because they can easily decelerate. False claims of 'climate neutrality' for activities and even countries with large but slightly declining emissions reflect the limitations and risks of applying GWP* at a sub-global level. Unfairness arising from grandfathering combined with a noisy almost random signal

modelled using GWP* presents very significant difficulties to mitigation policy. This can confront policy communities and public debate with mitigation mirages.

The assessment and selection of metrics must be made in relation to their purpose and their impact on decision-making. This requires an understanding of their effects on decision making. In communicating GWP*, some academics have engaged in strong advocacy for its use at the sub-global level, particularly by policymakers and farmers. There is much misunderstanding that started from the term 'GWP*' which misleadingly suggests an improved version of GWP or an alternative to GWP_{100}. Some of the communication of what GWP* does and does not do has been inconsistent and has misrepresented the climate science, leading to greenwashing. The terms 'warming' and 'further warming' have been used interchangeably. Reduced warming is often mistakenly referred to as 'cooling'. Business interests' handling of GWP* has distracted from the key challenge: to reduce all GHG emissions as quickly as possible.

Our observation is that British agri-business has so far not used GWP* for the type of greenwashing that has distorted public discourse in other countries. British farming is also taking a relatively realistic and measured approach to assessment of the potential of technical solutions. Emission reductions in line with the Paris Agreement would be facilitated by food system change with alignment of consumption of animal-sourced foods with public dietary guidelines. Focused on mitigation, the public debate about metrics will be well-served by a reminder that GWP* is not a warming metric: GWP* does not calculate the climate impact of methane emissions of business sectors, farms, or products. It is a tool to be used at the global level, and it should never be used instead of a warming metric such as GWP_{100}.

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This is a submission of evidence to the House of Lords enquiry into methane. We focus on Question 11 in the call for evidence (What are the advantages and disadvantages of available metrics used to report and compare methane emissions including GWP_{100} and GWP*?). We also provide some comments relevant to Questions 16-20 on agriculture. We draw on our recently published research,[2] and on experience in directing relevant agricultural research in Defra and in the economics of mitigation strategies.

Our points are:

1. We first need to be clear about what a global warming metric is.

All metrics and related tools use mathematics to model the effect of emissions on global temperature. The decisions they inform vary hugely from those of consumers assessing the carbon footprint of their consumption through to decisions on global climate protection policy and action. All metrics are based on a strong science-based logic, but with different purposes and approaches to modelling warming impacts in mind. Therefore, any judgement of metrics must relate to their purpose and this involves careful consideration of their effects on decision making.[3] Contrary to what the name implies, global warming metrics do not quantify warming impacts directly. The most widely used metric, Global Warming Potential (GWP), expresses the effectiveness of emissions of different gases at causing warming using a common emission currency which is carbon dioxide equivalents (CO_2e). Crucially, a global warming metric should reflect the whole warming effect of an emission regardless of whether it causes further warming or sustains already elevated temperatures caused by the emission source, e.g., a herd of cattle.[4]

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[2] Donnison, C. and Murphy-Bokern, D. (2024). Are climate neutrality claims in the livestock sector too good to be true? Environmental Research Letters, doi.org/10.1088/1748-9326/ad0f75).

[3] Persson, M.U., et al (2015) Environmental Research Letters. Climate metrics and the carbon footprint of livestock products: where's the beef? DOI 10.1088/1748-9326/10/3/034005

[4] Meinshausen, M and Nicholls, Z (2022). GWP * is a model, not a metric. Environmental Research Letters, https://doi.org/10.1088/1748-9326/ac5930 .

GWP_{100} is based on indisputable science and is an effective general-use metric of the warming potential of emissions. The 100-year variate, GWP_{100}, expresses the warming effect of gases as CO_2e over the 100 years following emission. One variation of this, GWP_{20}, expresses the warming in the 20 years following emission. Because most methane is oxidised in the first 12 years after emission, the CO_2e of one tonne of biogenic methane over the 100 years and over the 20 years following emission differ greatly, being 27 t and 81 t CO_2e respectively.

GWP_{100} is the standard metric used in international agreements such as the Paris Agreement and in monitoring countries' progress in meeting their commitments. It is also standard for most other relevant commercial purposes such as carbon foot-printing and product life-cycle assessment. It has several key advantages for these applications. These include simplicity of calculation, and the widespread understanding and acceptance of it. It is based on the science of the full warming effects of different gases over the given timeframe. GWP_{100} treats each tonne of a GHG equally, in line with the fact that the atmosphere is indifferent about the source or if the source is increasing, stable, or declining. This gives it very significant advantages as a currency for guiding and monitoring mitigation policy and for comparing the climate impact of products and processes.

The disadvantage of GWP_{100} is that it treats accumulating (long-living) and non-accumulating (short-lived) gases in the same way. This leaves significant gaps in evidence when predicting how global temperature will change over time, especially in the short-term, as affected by changes in the global mix of short- and long-lived GHG emissions, as noted by Professor Allen in oral evidence to the Committee on 13 March 2024. By averaging the effect of gases over 100 years, the standard 100-year variate (GWP_{100}) understates both the 'emergency handbrake' effect on warming of reducing methane emissions and the strong short-term warming effect of rising emissions.

2. GWP* is not a global warming metric. It is also not an alternative to GWP_{100}.

The mathematics behind GWP* is not complicated, but the implications of the mathematics are. A relatively simple calculation based on the change in methane emissions over a period (usually 20 years) provides a warming equivalent (CO_{2we}). Emission reductions greater than 0.3% per year register as negative warming equivalents while all changes in the other direction (above minus 0.3%) show increasing warming. Relatively small changes in the rate of methane emissions are transformed into relatively large one-off pulses or withdraws of CO_2 (warming equivalents, CO_{2we})

which are added to the emission of the long-living gases calculated using GWP_{100} for the relevant accounted period.

Considering that this calculation is very different from GWP_{100}, we agree with Professor Forster who stressed in oral evidence that GWP* is a 'different beast'. The communication of GWP* has led to the impression that it is comparable or interchangeable with GWP_{100}. This misunderstanding is not surprising: putting an asterisk on the end of the term 'GWP' suggests an improved version. In agreement with Meinshausen and Nicholls,[5] we conclude from our research that GWP* is not a warming metric. To use a motoring analogy, it focuses on acceleration and deceleration rather than speed. GWP* enables modelling of the change in the rate of warming (the acceleration being further warming and deceleration being reduced warming) while not accounting for the maintained ongoing warming (the speed). The key practical reason that GWP* does not serve as a warming metric is that it does not address the ongoing methane emissions that sustain already established warming. To return to the motoring analogy, it fails to recognise the on-going speed that sustains momentum.

3. GWP* is a complementary modelling approach for use at the global level.

GWP* is an effective modelling approach for understanding the short-term effects of changes in global methane emissions on global temperature, for example in the work of the UNFCCC. At this global level, it serves the prioritisation of the mitigation of long- and short-lived gases where it is important to use reductions in methane to prevent tipping points being reached. GWP* will also help in identifying different emission options, especially the handling of methane emissions, at the point where there is little or no further warming in line with the long-term temperature goal of Article 2 of the Paris Agreement, as communicated by Professor Allen to the Committee. But we are a long way from this situation.

4. GWP* has serious limitations as a guide to GHG mitigation at the sub-global level.

GWP* has serious limitations when used for decisions about mitigation made below the global level, especially in the assessment of the carbon footprint of businesses, processes, or products. Focused on emission change rather than emission level, GWP* 'grandfathers' existing emissions when used sub-globally. Established emitters, especially large emitters, benefit. The result has

[5] Meinshausen, M and Nicholls, Z (2022). GWP * is a model, not a metric. Environmental Research Letters, http://doi.org/10.1088/1748-9326/ac5930

profound implications for policy and commercial decision making because no two emissions of methane are treated in the same way. The impact calculated for an emission depends on the direction and rate of change of the emission source. An emission of a tonne of methane from a high but declining source is treated as having a positive effect on climate (mistakenly called a 'cooling' effect) while an emission of an identical tonne of methane from a low but increasing source is treated as having a negative (further warming) impact on climate. If we bring this down to the level of two neighbouring farms with the same level of methane emissions but with opposite increasing/decreasing trends, GWP* can be used to claim that the farm with declining emissions has a 'cooling effect' while the neighbour with increasing emissions is accelerating warming. The emissions from each of the two farms cause the same amount of warming because the emissions are the same. The resulting unfairness and serious misunderstanding present a very significant and difficult challenge to mitigation policy.

A further significant difficulty for policy use and decision-making below the global level is the almost stochastic or random character of the results from GWP* in many situations. The effect of GWP* transforming relatively small short-term changes in the rate of emissions into large changes in warming equivalents (CO_{2we}). is illustrated in Figure 1 from Meinshausen and Nicholls.[6] They show that with GWP*, interannual variability in emissions results in a signal from GWP* that is too noisy to build a control mechanism at country level. Even the use of the equivalent of a 20-year rolling average in the methane data does not iron out this variability. The result is that the entity under examination, for example a country or farm business sector, can move from not meeting mitigation commitments in a given period to over-achieving them in the next due to small changes in the rate of emissions between periods. This can confront policy communities and public debate with mitigation mirages.

The political ambition of the Paris Agreement is clear: to stop global warming (Article 2) by fairly achieving net-zero emissions of GHGs (Article 4) while fostering sustainable development (Article 6). The sector-level application of GWP* has been used in effect to trade-off Article 2 against

[6] Meinshausen, M and Nicholls, Z (2022). GWP * is a model, not a metric. Environmental Research Letters, http://doi.org/10.1088/1748-9326/ac5930.

Article 4. All this threatens to distract from the key challenge: to reduce all emissions as quickly as possible.

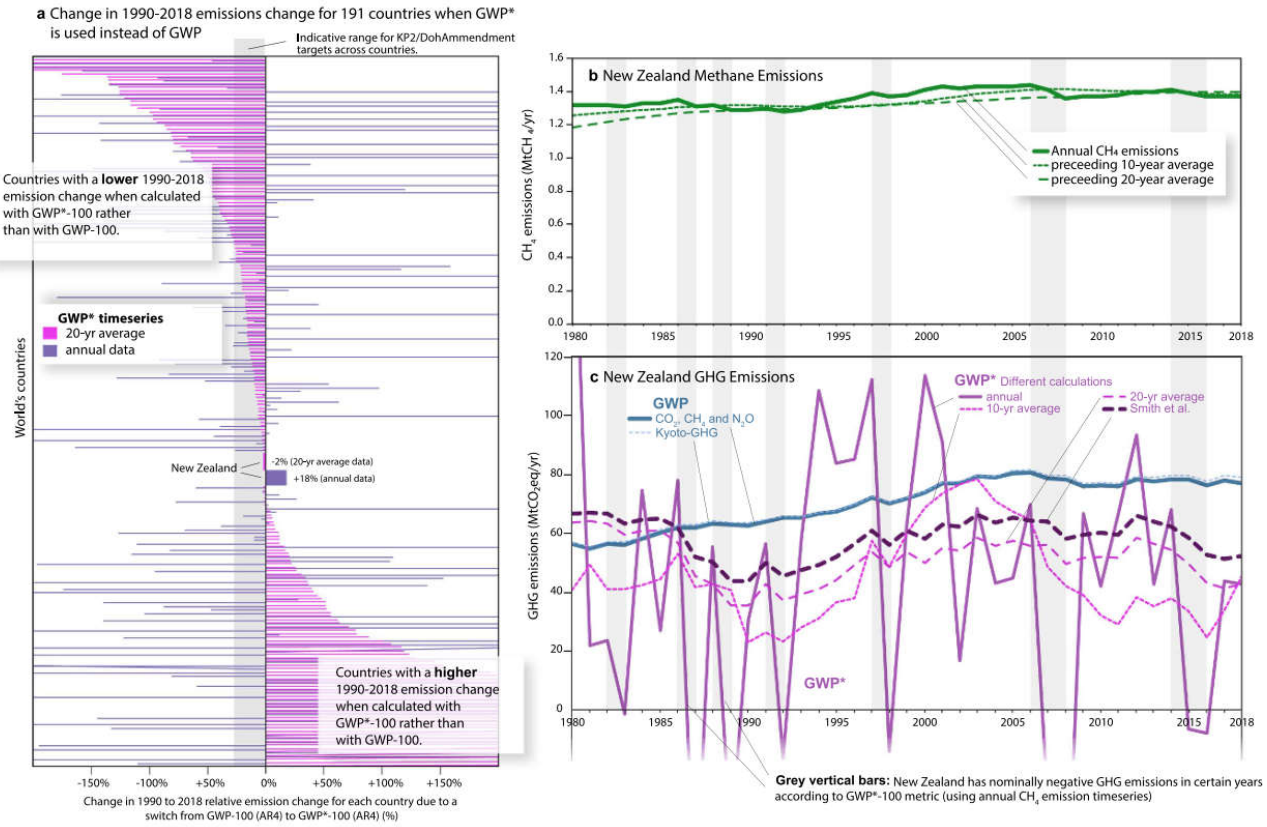

Figure 1. The effect of GWP* on aggregate greenhouse gas emission time series. (a) The change in 1990–2018 GHG (CO_2, CH_4 and N_2O) emissions when GWP is replaced by GWP*. Using GWP* instead of GWP would lead to emission changes that are more than 100% or 200% different over the 1990–2018 period. (b) Annual, 10- and 20-year smoothed CH_4 emissions for one country with relatively modest changes of 1990–2018 CH_4 emissions, i.e. New Zealand. (c) The variability of aggregate historical New Zealand emissions calculated by using the GWP metric (blue line) and different GWP* implementation (purple lines) on the basis of annual emissions (solid purple line), a 10-year smoothing period (bright small dashed line), a 20-year smoothing period according to the GWP* (purple thin dashed line) or the implementation with stock and flow pollutant shares using GWP*(dark purple dashed line). The GWP aggregated lines (using GWP_{100} AR4 values) are provided for CO_2, CH_4, N_2O emissions (bold line) as well as including HFCs, PFCs and SF6 (thin dashed line). From Meinshausen and Nicholls (2022).

5. GWP* has been poorly communicated.

What started off as an additional mathematical tool[7] for use for global climate change modelling now causes misunderstanding and confusion when applied to countries, businesses, and products.

[7] Allen, M.R. *et al.* (2018). A solution to the misrepresentations of CO_2-equivalent emissions of short-lived climate pollutants under ambitious mitigation. Climate and Atmospheric Science, https://doi:10.1038/s41612-018-0026-8

Scientists' presentations of GWP* as an alternative metric with the 'good news' that it shows that agriculture is or can easily be 'climate neutral' by turning warming impacts into cooling impacts have been welcomed by business communities, especially farmers.[8] Despite very significant drawbacks, GWP* has been actively promoted for use in a commercial context using academic precision in what is said and not said, but with the message subtly changing depending on the audience. On one side, academics have actively targeted public discourse in advocating for the use of GWP* for business-related questions. On the other, they brush aside the full policy and commercial consequences of this advocacy as not being their responsibility (as academics). In communications with farmers in particular, the terms 'warming' and 'further warming' have been used interchangeably and reduced warming is often mistakenly referred to as 'cooling'. It was therefore welcome to hear Professor Allen clarify to the Committee that the effect of declining methane emissions from a source, referred to by some as 'global cooling' should be understood as undoing the effect of past methane-induced warming. However, a misleading narrative based on the false information that "GWP_{100} gives the wrong answer" has spread through the agricultural policy community. Serious misunderstanding amongst farmers that near-stable emissions of methane do not cause warming has proliferated, including even in a viral video from a farmer in Northern Ireland (FarmTheoryNI) published on Tik-Tok.[9] The prospect of 'climate neutrality' for high emitting activities (which in any case is temporary), calculated using GWP*, has even been claimed for the GHG accounting of whole countries.[10, 11]

The IPCC stresses that the selection of metrics is a matter for their users, especially policy makers. The underlying issue here is both ethical and procedural: a lack of concern for the consequences of using metrics in circumstances for which they were not designed and the lack of separation between the academic presentation of metric options and the promotion of their use in policy and commercial decision making. Some of the resulting academic debate would be relevant to policy practice if we were now close to achieving temperature stabilisation. But we have only started the journey to climate stabilisation, and we are not progressing fast enough to avoid an overshoot of the

[8]Elgin, B. Beef industry tries to erase its emissions with fuzzy methane math. Bloomberg. https://www.bloomberg.com/news/features/2021-10-19/beef-industry-falsely-claims-low-cow-carbon-footprint

[9] FarmTheoryNI (2024) www.tiktok.com/@farmtheoryni/video/7335055594623208736

[10] Allen, M. (2019) A climate-neutral NZ? Yes, it's possible. *Newsroom*, 29 March. www.newsroom.co.nz/2019/03/29/510792/a-climate-neutral-nz-yes-its-possible

[11] Cain, M. (2019) New Zealand's farmers have a chance to be climate leaders. Climate Home News, 15 May. www.climatechangenews.com/2019/05/15/new-zealands-farmers-chance-climate-leaders

Paris target. Applied at the sub-global level, GWP* has served as a distraction from the mitigation challenge. It is now critical that policymakers advance swiftly to adopt national and sectoral mitigation strategies consistent with the Paris Agreement.

6. GWP* has been used for greenwashing.

Imagine a scenario in which a natural gas (methane) provider reduces leaks from old pipes. It then claims it is 'climate neutral' because a 'cooling' effect of avoided leaks offsets the permanent warming caused by the continued burning of the remaining gas. This is in effect what some influential academic supporters of the livestock industry outside the UK have done. They have combined a temporary reduced warming effect of methane reductions measured using GWP* with a subtle re-definition of the term 'climate neutral' to misleadingly claim that livestock sectors are or could easily be climate neutral. Even if we accept the position that the reduced warming effect of methane reductions off-sets the warming effect of on-going CO_2 and nitrous oxide emissions resulting in 'climate neutrality', this off-setting effect relates to a point in time and is temporary. Temporary 'climate neutrality' is an oxymoron. One of the peer-reviewed publications we have examined claims that the US dairy industry could reach climate neutrality by 2050 from annual methane emissions reductions of 1.0-1.5%. Another declares that some US livestock sectors are "already part of a climate solution" and that the Californian dairy industry could "induce cooling" under annual methane reductions above 1%. These false claims are also relevant to consumers who can read for example that Australian beef and lamb has a negative climate footprint despite substantial methane emission and increasing CO_2 emissions.[12] Even though the makers of GWP* agree with us that these claims are wrong (see Professor Allen's position reported by Fassler),[13] academic advocates of GWP* continue to endorse them.

[12] Ridoutt et al. (2021) Diets within environmental limits: The climate impact of current and recommended Australian diets. Nutrients, 13, doi: 10.3390/nu13041122.

[13] Fassler, J. (2023). The livestock industry's "climate neutral" claims are too good to be true. DeSmog. www.desmog.com/2023/12/14/the-livestock-industrys-climate-neutral-claims-are-too-good-to-be-true/

7. GWP* has impacted on public debate in the United Kingdom.

The UK has strengths in climate science and in food systems research. Our observation is that the public debate about the use of GWP* in agriculture is less distorted in the UK than it has been in Ireland, the United States, Australia, and New Zealand. An assessment from the Agriculture and Horticulture Development Board (AHDB)[14] illustrates well the profound implications that GWP* can have for efforts to motivate and monitor mitigation below the global level. It shows that the warming potential of emissions from agriculture of nearly 50 million tonnes CO_2e (GWP_{100}) becomes a negative (reduced warming or 'cooling') warming equivalent of about -10 million tonnes CO_2we when assessed using GWP*. With GWP*, declining methane emissions from land-fill turn a total UK GHG emission of 450 million tonnes CO_2e into a warming impact of only 110 million tonnes warming equivalent (CO_2we). Despite these striking results, the AHDB seems not to have engaged in the irresponsible communication tactics we have observed in other countries. The off-setting effect of using GWP* is temporary and the AHDB might also be wary of the application of GWP* to businesses and sectors serving as a type of production quota at individual farm level. Contrary to the position of academic advocates of GWP* who advise farmers to lobby policymakers to adopt GWP* because GWP_{100} "gives the wrong answer", the AHDB stresses the need for dual reporting. There is however evidence of confusion about GWP* in the wider agricultural community. The National Farmers Union (NFU) wisely acknowledges the risk of unintended policy consequences but seems to expect that GWP* would show that farming makes no contribution to UK's GHGs.[15] The confusion is confirmed by the contradictory call to use GWP* while at the same time asking for "solutions for incorporating GWP* into on-farm GHG calculators so individual producers are not disadvantaged for expanding when national herd/flock emissions remain unchanged or are decreasing due to uptake of new tools and technology".[16]

Some UK scientists, including some involved in developing GWP*, have assessed the use of GWP* in the environmental assessment of food production using life-cycle assessment, or 'carbon foot-

[14] AHDB (undated). Applying GWP* to UK national GHG emissions. https://ahdb.org.uk/knowledge-library/applying-gwp-to-uk-national-ghg-emissions

[15] National Farmers Union (2023). Everything you need to know about GWP* methane accounting. https://www.nfuonline.com/updates-and-information/everything-you-need-to-know-about-gwp-methane-accounting/

[16] National Farmers Union (2023). NFU calls for new methane metric to be used in GHG calculations. https://www.nfuonline.com/updates-and-information/nfu-calls-for-new-methane-metric-to-be-used-in-ghg-calculations/

printing'.[17] However, it is not clear how this would be implemented in practice to compare production systems or products given that GWP* treats sources of methane differently depending on the emission dynamics of the source, as discussed above. To our knowledge, GWP* is not used by active LCA practitioners and it is not supported by LCA specialists. The cost and the public confusion outweigh any potential benefits.

8. The mitigation potential of new farming technologies is often over-estimated: large methane reductions require changes to the agri-food system.

We want to comment briefly on the Committee's questions 16 – 20 related specifically to agriculture.

Feed additives to reduce methane emissions have been the subject of research for several decades. Other scientists are better qualified to comment, but we draw attention to the history: the rumen has proved a very difficult environment to manipulate in the long-term using additives other than antibiotics. At the 2023 'State of the Science' summit on feed additives at the University of California Davis, experts reported a lack of evidence of the impact of feed additives in the long-term.

Slurry management in itself, especially the extension of slurry storage using the Slurry Infrastructure Grants, is unlikely to have a significant impact on emissions. However, the anaerobic digestion of slurry, producing and capturing methane as biogas that is used as an energy source, can reduce methane emissions. Because slurry storage is mostly a winter activity in the UK, the methane mitigation potential of anaerobic digestion of slurry is lower in the UK compared with warmer places where cattle are housed year-round, for example in California, where the mitigation impact of anaerobic digestion has thus far been overstated. A range of other technical interventions might be expected to reduce emissions such as improved animal health, adjusted calving intervals, and extending the life of dairy cows. Their mitigation impact depends on these technologies enabling a contraction in livestock production.

[17] McAuliffe, G et al (2023). Are single global warming potential impact assessments adequate for carbon footprints of agri-food systems? Environmental Research Letters. 18 084014 doi.org/10.1088/1748-9326/ace204

Overall, there is the risk of over-estimating the methane mitigation gains that can be made using individual farm technologies. If large reductions from agricultural emissions are required (in line with the goal for all methane emissions and the Paris Agreement), a whole agri-food system approach is needed with a rebalancing of agriculture and the food system, starting with consumption. This is not about veganism or vegetarianism vs the typical mixed diet; it is largely about aligning all diet types to long-standing public dietary guidelines and reducing consumption that exceeds what is healthy. Whole system modelling of agri-food systems, (e.g., Westhoek et al.)[18] shows that reductions in the consumption of animal-sourced foods in line with public dietary guidelines could have a huge agricultural impact in Europe with several synergistic environmental effects and opportunities, especially related to land use and the nitrogen cycle. Whether such reductions result in reduced production domestically or internationally will depend on market forces and the development of government policy. Such a rebalancing would open up opportunities to reduce the UK's reliance on imports of plant protein (soya), boost horticultural production, and provide more space for nature and carbon sequestration.

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[18] Westhoek, H., Lesschen, J., Rood, T., Wagner, S., De Marco, A., Murphy-Bokern, D., Leip, A., van Grinsven, H., Sutton, M., Oenema, O. 2014. Food choices, health and environment: effects of cutting Europe's meat and dairy intake. Global Environmental Change 26, 196-205. http://www.sciencedirect.com/science/article/pii/S0959378014000338