# Extended Abstract
## Please do not add your name or affiliation

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| **Paper/Poster Title** | **Potential policy considerations revealed by alternative methane and carbon dioxide 'equivalences' – a Northern Ireland case-study** |

**Abstract prepared for presentation at the 98th Annual Conference of The Agricultural Economics Society will be held at The University of Edinburgh, UK, 18th - 20th March 2024.**


| **Abstract** | ***200 words max*** |
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A variety of methods exist to compare different greenhouse gases (GHGs) as 'carbon dioxide ($CO_2$)-equivalent' quantities. The 100-year Global Warming Potential (GWP100), is the *de facto* standard approach, but there is no physical reason to prefer this emission metric over alternatives.

This paper explores projected agricultural methane ($CH_4$) emissions in Northern Ireland to 2050, illustrating how their '$CO_2$-equivalent' valuation differs according to emission metric, exploring GWP100, GWP*, the 20-year Global Warming Potential (GWP20) and 100-year Global Temperature change Potential (GTP100). GWP*, enables a clearer link between emissions and temperature change, but also presents challenges, requiring separate treatment of shorter- and longer-lived gases.

The 'conventional' approaches show a large range in methane valuation, based on alternative temporal perspectives and impact assessment method. GWP* reveals that the overall warming contribution of Northern Ireland's agricultural methane will stabilise within a decade, and start declining thereafter: a temperature outcome equivalent to net-negative $CO_2$. However, GWP* also highlights that significant 'avoidable warming' is still caused by ongoing methane emissions: the near-term impact undervalued under all other metrics.

We then explore some potential policy implications, discussing where relative temperature change may be a salient point alongside other considerations in setting sector- and/or gas-specific emission reduction targets.



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| **Keywords** | Methane, climate policy, emission targets |
| **JEL Code** | Q. Agricultural and Natural Resource Economics • Environmental and Ecological Economics<br>**Q18**: Agriculture - Government Policy;<br>**Q54**: Environmental Economics - Climate |


| **Introduction** | ***100 – 250 words*** |
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Alternative means of comparing the impacts of different greenhouse gases (GHGs) have been proposed in light of 'net-zero' climate policy goals, and the Paris Agreement's focus on global temperature in determining overarching targets. The most established emission metric, the 100-year Global Warming Potential (GWP100), is typically used for most reporting and target-setting purposes, but has

been criticised in the contemporary context, as it cannot be used to translate reported emissions to their temperature outcomes. A novel approach, GWP*, has been developed to enable this link between emissions and temperature, but presents its own challenges. By design, GWP* necessitates separate approaches for shorter- and longer-lived GHGs. This makes it difficult to straightforwardly apply GWP* for conventional per-emission valuation. Furthermore, reporting the effects of short-lived gases in a way that corresponds to cumulative carbon dioxide emissions results in climate impacts being reported relative to a user-determined baseline, potentially raising equity concerns.

These points, and wider implications of how different emission metrics might differentially prioritise or penalise certain emitters, have led to public concern over how different greenhouse gas emissions are handled in national climate policies. This is starting to be reflected on some climate policies: the Climate Change Act (Northern Ireland) 2022, for example, has methane-specific reduction requirements, and government departments must "give due regard to the special economic and social role of agriculture, including the distinct characteristics of biogenic methane." This paper explores whether alternative emission metrics can reveal what this due regard might be, and implications for climate policy.

| **Methodology** | ***100 – 250 words*** |
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Recent and projected (to 2050) annual agricultural methane emissions for Northern Ireland were reported under a range of different greenhouse gas emission metrics, taking specific values from the latest (6$^{th}$) Intergovernmental Panel on Climate Change (IPCC) Assessment Report. Projections were based on Climate Change Committee (CCC) pathways of feasible emission reductions over this period.

Two different applications of GWP* were demonstrated. The 'conventional' form, following most recent versions of the method from the scientific literature, demonstrates relative temperature change year-on-year in '$CO_2$-warming-equivalent' terms. This reports methane emissions as a very large 'equivalent emission', followed by a large effective 'equivalent removal' 20-years later, to capture the fact that methane's impacts are large but automatically reversed (unlike those of $CO_2$) due to its short atmospheric lifetime. We also use an 'avoidable warming' application of GWP*, showing how much near-term warming could be avoided by eliminating each year's methane emissions, again in $CO_2$-warming-equivalents', calculated by taking only the initial, large 'equivalent emission' component of the GWP* equation (i.e. without the subsequent 'equivalent removal' of emissions from 20 years ago).

| **Results** | ***100 – 250 words*** |
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'Conventional' emission metric approaches taking a like-for-like valuation per emission show a large range in methane valuation, based on alternative temporal perspectives and impact assessment method. Under GWP100, the 2020 agricultural methane emissions of 148 kt are reported as 3994 kt $CO_2$-equivalent, declining to 99kt Methane in 2050, reported as 2676 kt $CO_2$-equivalent. Under GWP20, these are reported universally higher: 11791 kt $CO_2$e in 2020 to 7899 kt $CO_2$e in 2050; and universally lower under GTP100: 695 kt $CO_2$e in 2020 to 466 kt $CO_2$e in 2050.

An even starker difference is shown using GWP*, with annual '$CO_2$-warming-equivalent' emissions becoming negative in 2027, indicating that, at this point, the

overall warming contribution from ongoing methane emissions in Northern Ireland starts to decline. The cumulative $CO_2$-warming-equivalent emissions across the 2020-2050 period assessed is -52764kt: indicating that by 2050, agricultural methane in Northern Ireland causes substantially less warming than it did in 2020; a $CO_2$ emitter would have to actively remove this amount of carbon dioxide from the atmosphere to reduce its own global warming contribution by this degree. However, the 'avoidable warming' GWP* application highlights that there would still be significant benefits from not maintaining these methane emissions: by 2050 the 99kt methane emitted still causes 12122 $CO_2$-warming-equivalent worth of avoidable temperature increase in the near-term: significantly larger than that suggested even by the 20-year Global Warming Potential.

| **Discussion and Conclusion** | ***100 – 250 words*** |
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The wider metric appraisals as in this study could reveal additional insights, and may have relevance to policy making if there is interest in, for example, relative changes in warming contributions and legacies. Achieving 0 $CO_2$-warming-equivalent emissions (as defined using standard application of GWP*) is the minimum requirement for an individual actor (farm, sector, nation, etc.) to prevent their overall contribution to global warming increasing. This does not inherently mean that stabilising overall warming contribution is an appropriate or fair target. Further relevant considerations could be the avoidable warming from not continuing these methane emissions, as revealed across the other metrics (including the alternative application of GWP* here), or costs and capacity to reduce emissions. Other policy uses of emission metrics, such as setting relative emission taxes or determining investment in abatement technology, have largely been developed only using the GWP100, with some justifications but also criticisms, and limited exploration of other approaches.

Despite this broader context, and wide recognition of the limitations of standard 'equivalence' metrics for some purposes, overarching climate policy targets are still defined using GWP100. All GHG emissions ultimately need to sum to a UK-wide 'net-zero' in 2050, accounting using GWP100 within the current legislative framework, so less action on methane reductions would necessitate more effort elsewhere to achieve this accounting balance, which must be recognised in developing climate policy. Alternative approaches, as in this paper, may provide additional information on the physical implications or distributional aspects that are not clear when using a single metric.