Assessing methane (CH_4) from Irish agriculture in climate policy 2005–2020 using the GWP_{100} and GWP* greenhouse gas (GHG) equivalence metrics

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Key Points:

- This analysis compares the use of the GWP_{100} and GWP* GHG metrics in the assessment of Irish agricultural CH_4 emissions. In 2018, 91% of this CH_4 is from cattle (35% from dairy, 56% from beef).
- For the period 2005 (EU ESD base-line year for the national climate target including agriculture) through 2020, the following two scenarios are compared:
  - **ACTUAL**: CH_4 emissions as recorded or projected to 2020 using EPA data.
  - **TARGET**: CH_4 as recorded for 2005–2011 then extrapolated from this period to 2020.
- GWP* emission accounting enables aggregation with other GHGs in all-GHG "CO_2 warming equivalent" ("CO2-we") carbon budgets on the basis of *cumulative CO2-we emissions* from a stated date, allowing for time lag effects.
- However, if this new GWP* GHG metric were to be used in meeting international climate targets then any cumulative basis requires *commonly agreed* conventions for base-year, scenario start and end year, and CH_4 GWP_{100} value.
- *Provided such conventions are made clear* then GWP* **cumulative CO2-we** can more accurately reflect CH_4 warming or warming reduction outcomes than GWP_{100}.
- Use of GWP_{100} and GWP* *both* clearly show a reduction in Irish agricultural CH_4 emissions up to 2011 and then a sharp reversal to rapidly increasing CH_4, resulting from government policy endorsement of sectoral agricultural strategy. Emissions are projected to rise further from 2020 due to further dairy expansion.
- Use of GWP* shows the extent of this national climate policy failure since 2010 more starkly than GWP_{100}. In effect the policy change has undone 20 years of mitigation effort, delaying agricultural transition.
- **The current flow of Irish agricultural methane is responsible for an ongoing contribution to global warming that has the equivalent warming to over 1,300 $MtCO_2$, a level equivalent to 30 years of Ireland's current energy CO_2 emissions.**
- Achieving substantial and sustained reductions in aggregate ruminant CH_4 emissions and fugitive manure and biomethane anaerobic digestion is therefore a very important mitigation lever that Ireland can utilise in climate action policy to constrain emissions.
- Policy to ensure substantial reductions in total reactive nitrogen inputs can drive CH_4 (and N_2O) reduction.
- **This analysis confirms the crucial role of sustained agricultural CH_4 mitigation as an essential policy lever in effective societal climate action for Ireland aligned with the Paris Agreement and the SDGs.**

Context:

Irish agricultural CH_4 resulted in emissions of 519 $ktCH_4$ in 2018 (462 $ktCH_4$ from enteric fermentation and 57 $ktCH_4$ from manure management) – almost entirely from 1.5 million dairy cows, 5.8 million beef cattle, and 5.1 million sheep. Multiplied by a GWP_{100} value of 25 (as currently used in UNFCCC reporting) this equates to 13 $MtCO_2eq$ in reported EPA inventory of GWP_{100} emissions [5].

GWP_{100} metric values are directly related to the annual quantity of CH_4 released, so they usefully show the annual emissions to be reduced through policy and measures. However, GWP_{100} incorrectly suggests CO_2-like warming behaviour for CH_4, so it does not accurately show the rapid near-term global warming response resulting from changes in CH_4 emissions, nor does it show the large warming reduction potential that can be enabled by sustained CH_4 emission reductions over time. Sustained CH_4 mitigation at a faster reduction rate than about -0.3%/yr results in warming reduction equating to CO_2 removals. It is incorrect to refer to such a reduction in CH_4 warming as "cooling".

Due to these deficiencies in using GWP_{100} for CH_4 and other short-lived climate pollutants, a GHG metric called GWP* has been developed by an Oxford University group [1]. GWP* does not provide any new climate science understanding of CH_4's climate behaviour, rather it provides a new formula that enables the resultant warming or warming reduction impact of CH_4 to be estimated directly from the existing national GWP_{100} CO_2-eq time series data in a way that approximates the climate system response, *on the basis of cumulative CO_2 warming equivalent emissions* [1]. A change to use of the GWP* metric rather than GWP_{100} to report CH_4 emissions has been advocated by Oxford scientists [2]. However, recent work at Dublin City University [3] does not support this view for international GHG accounting at this time, though the DCU work does support the use of GWP* for national or sectoral policy comparison of scenarios including CH_4. Others have also suggested the naïve use of the GWP* metric in international emissions accounting could result in unintentional unfairness [4].

Using the GWP* metric it is trivial to show that the ongoing global warming contribution from methane in CO_2 warming equivalent terms is approximately 80 times its current year's GWP_{100} value. This gives an approximate estimate of the maximum potential mitigation available from a permanent cut in this flow. Based on the GHG_{100} value of 32 used by Lynch et al. (2020) and the 2018 EPA-reported GWP_{100} value, the current flow of Irish agricultural methane is responsible for an ongoing contribution to global warming that has the equivalent warming of over 1,300 $MtCO_2$. This warming level is equivalent to over 30 years of Ireland's current energy CO_2 emissions, indicating that achieving near-term substantial and sustained reductions in agricultural CH_4 emissions is a very important potential mitigation lever that Ireland can utilise in climate action to limit imminent overshoot of Ireland's Paris-aligned, all-GHG national carbon quota [3].

Analysis of Irish agricultural CH_4 scenarios, 2005–2020, using GWP_{100} and GWP*:

Based on EPA inventory and projections of agricultural CH_4 data (5), two scenarios are compared: an ACTUAL scenario for the actual pathway of agricultural CH_4 emissions from 2005 to 2020; and, a comparison, counterfactual TARGET scenario assuming that the actual straight line annual CH_4 emission reduction as achieved from 2005 to 2011 continued by extrapolation through to 2020. This target scenario would result in an emission reduction slightly greater than the 20% *pro rata* reduction for 2020 relative to 2005 under the national EU climate target. As in Ref [1] a GWP_{100} of 32 is used.

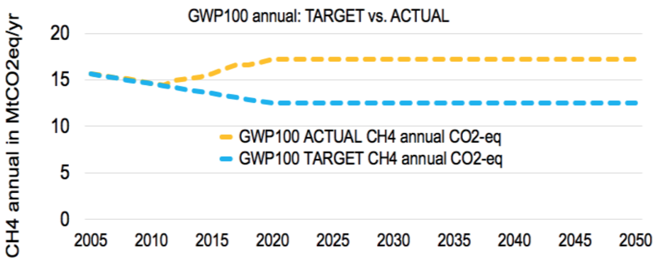

Figure 1: Scenarios by annual CH_4 using GWP100

In Figure 1, from 2005 to 2011 the ACTUAL CH_4 emissions and TARGET pathway are the same but they diverge sharply from 2011 onward. For this scenario, comparison emissions are assumed to level out at the level reached in 2020, the scenarios' end-year.

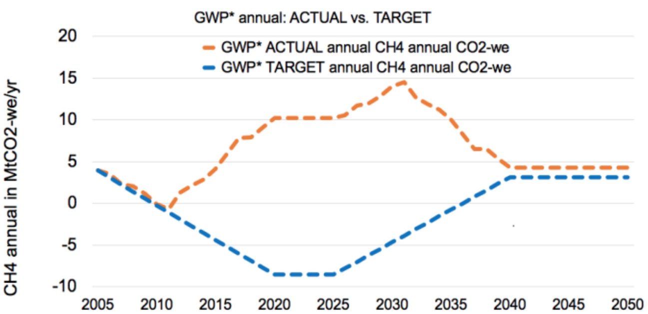

Figure 2: Scenarios by annual CH_4 using GWP*

Figure 2 shows the same scenario emissions pathways as in Figure 1, but here using the GWP* formula whereby CO_2-we values are calculated from GWP_{100} CO_2-eq time series of annual emission values. GWP* annual values are affected by the GWP_{100} value 20 years previously. To prevent this *20-year lag effect* due to prior years from influencing the analysis, all 20 years prior to 2005 are assumed to have the same annual CH_4 emissions as 2005, thereby setting the change in CH_4 flow prior to 2005 to zero for the compared scenarios.

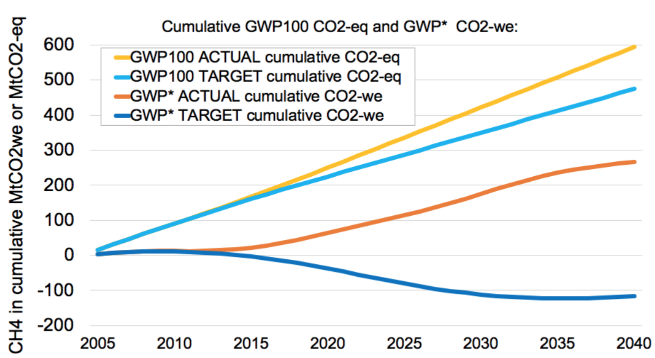

Figure 3: Scenarios by cumulative CO_2-eq and CO_2-we

Figure 3, above, shows cumulative emissions from 2005 using GWP_{100} and GWP* for both scenarios for the period 2005 to 2020. Note, the 2005 start value is set to zero but the GWP* 2005 global warming contribution of Irish agriculture CH4 is ~1500 $MtCO_2$-we. Emissions are run to 2040 to show the full 20-year lag effect on resultant warming due to the comparison period emissions. Even though the **TARGET** scenario's annual CH_4 emissions decrease over time, the cumulative GWP_{100} pathway incorrectly shows increased resultant warming, whereas GWP* correctly shows reduced warming for this scenario. The GWP* metric reveals an even larger degree of divergence between the target (mitigation) and actual (emissions increase) pathways than through use of GWP_{100}. Following the **TARGET** scenario to 2020 would have resulted in a *warming reduction* equivalent to a one-off removal of 115 $MtCO_2$ by 2040, whereas **ACTUAL** CH_4 emissions resulted in a warming increase equivalent to one-off emissions of 265 $MtCO_2$ by 2040: a total GWP* scenario difference by 2040 equating to one-off emission of 380 $MtCO_2$ (~10 years of Ireland's fossil carbon emissions, three times larger than the 120 $MtCO_2$-eq scenario difference indicated by the GWP_{100} metric.

Discussion:

This analysis of CH_4 emissions shows that Irish Government policy endorsement of agri-food industry-led agri-strategy since 2010 has resulted in increasing agricultural CH_4 emissions, contrary to national climate objectives. Ireland's agricultural sector *had* been aligned with meeting a *pro rata* EU national mitigation target pathway from 2005 to 2011, but this was reversed thereafter by policy. **Both GWP_{100} and GWP* show that the 13 years of mitigation over 1997–2011 has been more than completely cancelled out due to dairy expansion and agricultural intensification since 2010**. Greater use of nitrogen fertiliser, enabling more grass feedstock growth, has resulted in increased cattle CH_4 emissions. Use of either GHG metric shows how agricultural strategy in Ireland since 2010 has resulted in an ill-advised reversal in climate action policy in Ireland, completely undoing prior mitigation achieved in agriculture. As shown here, a GWP* warming equivalent analysis simply shows this reversal even more starkly.

As yet, the use of GWP* is insufficiently developed to be applied to international accounting. Single year or short-run annual CO_2-we values are not meaningful in policy analysis. Nonetheless, GWP* is useful for comparison of alternative climate mitigation plans *from a given base year* as it enables inclusion of the **cumulative CO_2-we** warming or warming reduction impact of CH_4 into policy carbon budgets and national quota fair shares related to the Paris temperature targets [3]. **Therefore, when GWP* is used, it is particularly important to focus on the policy outcome based on *cumulative* CO_2-we emissions. As is evident from use of GWP* in this analysis, this *requires* a common base reference year, such as the EU target's reference to 2005 as used in this briefing, including the full 20-year lagged effect of CH_4 forcing.**

References:

1. Lynch J et al. (2020) Demonstrating GWP*. Env Res Lett
2. Oxford Martin School (2020) Get the maths right on emissions or risk missing temperature target.
3. McMullin B, Price P (2020) Assessing society-wide national climate change mitigation scenarios including methane
4. Rogelj J, Schleussner C-F. (2019) Unintentional unfairness when applying new GHG metrics at country level. Environ Res Lett
5. Duffy P, et al. (2020) IRELAND NATIONAL INVENTORY REPORT 2020.