

# Assessing society-wide national climate change mitigation scenarios using a warming-equivalent model to aggregate greenhouse gases including methane<sup>1</sup>

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Global climate action is *not* currently aligned with staying within remaining global carbon budgets (GCBs) corresponding to the Paris Agreement temperature limits of “well below 2°C” and making efforts to limit to 1.5°C over pre-industrial. Estimated CO<sub>2</sub>-only GCBs critically depend on achieving reductions in nitrous oxide (N<sub>2</sub>O) and in short-lived methane (CH<sub>4</sub>). Therefore, a nation’s “low carbon transition” needs to be completed within its ‘fair share’ quota of the aggregate global greenhouse gas (GHG) budget. For Ireland, assessing climate action including these non-CO<sub>2</sub> gases is important because a comparatively large fraction of reported emissions is due to N<sub>2</sub>O and CH<sub>4</sub>, arising primarily from ruminant agriculture. However, the warming commitment of mitigation scenarios that include CH<sub>4</sub> has been difficult to evaluate as the standard GHG equivalence metric, called GWP<sub>100</sub>, crucially fails to reflect the physical reality that sustained reductions in CH<sub>4</sub> *flow* can result in a substantial reduction in its total warming-equivalent contribution within 10 to 20 years. A new metric, called GWP\*, accurately approximates changes in the warming-equivalent (CO<sub>2</sub>-we) contribution of short-lived climate pollutants such as CH<sub>4</sub>. Incorporating the GWP\* methodology, we have developed an open source model to project GHG warming-equivalent commitments (by gas and in aggregate) of policy-relevant national mitigation scenarios to 2100, relative to a Paris-aligned national GHG quota. Comparing illustrative scenarios for effective climate change mitigation reveals significant implications for Paris-aligned climate action. Complex but critical trade-offs between GHGs and sectors are clarified. Supplementing the primary requirement for radical CO<sub>2</sub> mitigation, substantial and sustained reduction in total national methane emissions appears to be critical to the feasibility of achieving net zero CO<sub>2</sub>-we by 2050. In addition to radically limiting fossil fuel usage, reducing total usage of reactive nitrogen in agricultural and biogas production is argued to have a key role in overall climate mitigation for Ireland.

**Keywords:** climate action, Paris Agreement, transition, climate modelling, methane, GWP\*.