

Carbon budgeting literature review: AR6-WGI addendum

an update to the [April 2021 carbon budgeting literature review](#)

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Key Messages

- In the new IPCC Working Group I report (AR6-WGI), confidence in CO₂ carbon budgets in projecting warming has increased and the importance of methane mitigation is highlighted.
- Therefore, based on AR6-WGI, the earlier literature review's proposed ranges for Ireland's "fair share", remaining multi-gas national carbon quota (from 2015) have been tightened.
- Overshoot of this quota is imminent, tacitly requiring planning for and costing of net warming reduction, by additional methane (CH₄) mitigation and/or carbon dioxide removal.
- The use of "step-pulse" GHG equivalence metrics, such as GWP*, is noted by AR6-WGI as being more accurate than GWP₁₀₀ in assessing warming outcomes due to emissions, therefore these metrics are useful in assessing consistency with Paris Agreement goals.
- However, under Ireland's Climate Act, the required 51% emission reduction by 2030 is assumed to be expressed on a GWP₁₀₀ basis. This should remain the gauge of action to 2030 because using step-pulse metrics in this context for all GHGs, or for CH₄-only, would undermine the scale and ambition of the understood statutory commitment.
- AR6-WGI confirms that cutting CO₂ emissions is more effective than carbon dioxide removal (sequestration). CDR also has problematic land, biodiversity, and cost issues.
- AR6-WGI does not evidence any substantive "distinct characteristics of *biogenic* CH₄" relative to fossil CH₄ that would materially alter the assessed benefits of mitigating agricultural or other CH₄ emissions in Ireland. A minor accounting adjustment (+10%) to GWP₁₀₀ could be applied to the relatively small amount of fugitive *fossil* CH₄.

Addendum to "Assessing Ireland's fair contribution" literature review

This addendum to the [earlier literature review \(April 2021\)](#), provides an update based on the [IPCC AR6 Working Group I](#) report (AR6-WGI, released August 2021) findings on the physical climate science, particularly as they relate to preparation of Ireland's 5-year carbon budgets by the Council and Government under the [new Climate Act \(2021\)](#). In the text below, references to AR6-WGI are placed in square brackets. The AR6-WGI Summary for Policymakers [SPM] presents scientific statements that have been politically endorsed by all UNFCCC parties. The SPM is supported by the referenced scientific evidence in the [Technical Summary \[TS\]](#) and in the report's twelve individual [subject chapters](#) and [Interactive Atlas](#). A Glossary, common to all three IPCC working groups, is also included with the full report. The AR6 Working Group II and III reports, on impacts and mitigation, respectively, will be released next year, followed by a Synthesis Report.

1. Carbon budgeting within a long-term climate action strategy

- AR6-WGI [SPM.D.1] reiterates the requirement to reach at least net zero global CO₂ emissions as soon as possible, in parallel with deep reductions in anthropogenic emissions of other GHGs. Compared to AR5, AR6-WGI places increased emphasis on 'strong, rapid and sustained reductions in CH₄ emissions' [SPM.D.1.7] in addition to CO₂ and N₂O mitigation.
- Therefore, action aligned with Paris temperature targets requires strictly limiting *total* future cumulative net CO₂ and nitrous oxide (N₂O) emissions from fossil fuel, cement, fertiliser, and land use, and substantially reducing the annual emission *rates* of CH₄ and other short-lived climate pollutants (black carbon from fossil fuel combustion and F-gases from industry).
- Increased AR6-WGI certainty in quantifying the CO₂-only remaining global carbon budgets (rGCBs) related to the Paris Agreement Article 2 (PAA.2) global temperature limits [Table

SPM.2] enables a preliminary updating (pending AR6-WGIII) of the literature review values for Ireland's "fair share" (quota) of the national carbon quotas in multi-gas CO₂we (NCQ*) terms.

- **Using GWP***, to aggregate [CO₂+N₂O+CH₄] GHG emissions into a common CO₂ warming equivalent (CO₂we) carbon budget framework – to give a '[c]lear and transparent representation of the global warming implications of future emission pathways' [Box 7.3] – and sharing on an equal global per capita basis, estimated ranges for Ireland's NCQ*, the national cumulative GHG quota from 2015 to align with Paris targets are provisionally tightened to:
 - **1.5°C low overshoot: 400–440 MtCO₂we [CO₂+N₂O+CH₄]**
 - **Well below 2°C: 570–710 MtCO₂we [CO₂+N₂O+CH₄]**
- For **2021** onward, **subtract 310 MtCO₂we**, emitted 2015–2020 inclusive, from these values:
 - **1.5°C low overshoot: 90–130 MtCO₂we [CO₂+N₂O+CH₄]**
 - **Well below 2°C: 260–400 MtCO₂we [CO₂+N₂O+CH₄]**
- Ireland's 2018 annual GWP* emissions were approx. 53 MtCO₂we/yr. Even with linear reductions in annual mass emissions of all three gases by 51% by 2030, Ireland is likely to overshoot the mid-range 1.5°C value by 2024 and the low end 2°C value by 2028. Only early, deep, and sustained reductions in all GHGs, including CH₄, can limit the amount of such overshoot and its tacit commitment to subsequent *reversal* via *further* CH₄ emission rate reduction and/or CO₂ *removal* (CDR) to stabilise at a net cumulative emissions level consistent with an equitable national contribution to meeting the Paris temperature goals.
- WGI does not examine climate justice in sharing the rGCB but the included AR6 Glossary notes that the 'distribution of global budgets across individual different entities and emitters depends strongly on considerations of equity and other value judgements'. This implies that the forthcoming statutory national carbon budget programme cannot be assessed for costs or consistency with PA A.2 goals unless some specific estimate of the remaining global carbon budget is explicitly adopted – to reflect a concrete judgement of prudence (application of the precautionary principle) combined with an articulated global basis for equitable "fair sharing".

2. National carbon budgeting to 2030 and the 2023 global stocktake

- AR6-WGI does not give specific guidelines for national carbon budgeting as this is subject to value judgements by decision makers but does detail WGI material relevant to the forthcoming 2023 global stocktake [Cross-Chapter Box 1.1] that can guide evaluation of collective progress by nations in aligning action with PA goals, in a 'comprehensive and facilitative manner... and in the light of equity and the best available science' (PA Article 14).
- Ch. 7-126 notes that 'the Paris Agreement Rulebook asks countries to report emissions of individual greenhouse gases separately for the global stocktake'. Therefore, it is important that Ireland's statutory, 5-year *aggregate* carbon budgets be supplemented with a (non-statutory) *breakdown* into separate components for CO₂ emissions, CO₂ removals (CDR), N₂O emissions and CH₄ emissions, all expressed in GWP₁₀₀ (or, equivalently, absolute mass) terms. Government-determined sectoral ceilings should ideally do likewise to align with each 5-year, society-wide, multi-gas budget. To assess such budgets for consistency with long-term, Paris-aligned climate action will require analysis using step pulse metrics (such as GWP* or CGTP) and/or the use of suitable global climate models, using a common base year.
- However, as the Council has previously concluded, the Climate Act requirement for the carbon budget programme to 'provide for' a 51% reduction in total national emissions by 2030 relative to 2018, implicitly refers to aggregation on a GWP₁₀₀ basis. Any change away from GWP₁₀₀ or change in base year, for example setting a separate annual target for CH₄ based on GWP*, could result in a significantly reduced mitigation of the global warming impact relative to the statutory "51%" reduction in annual territorial emissions in GWP₁₀₀ terms. In conclusion, GWP* or similar "step-pulse" analysis should be used to assess budgets for consistency with long-term, Paris-aligned climate action, but not to measure the annual mitigation contribution of separate gases, including CH₄, to the 51% reduction target.

3. Carbon budget calculation and accounting

Emissions

- AR6-WGI [Box 7.3] guides emission metric choices, but stresses that the ‘report does not recommend any particular emission metric because the appropriateness of the choice depends on the purposes for which gases or forcing agents are being compared.’
- AR6-WGI highlights that the standard GWP₁₀₀ metric is a poor instrument for connecting multi-gas budgets with temperature rise, particularly because it does not reliably reflect warming reductions related to cutting the emission rate of CH₄ and other short-lived climate pollutants.
- AR6-WGI confirms that, in a defined equity context, “step-pulse” GHG metrics like CGTP and GWP* can be useful in assessing the warming due to existing CH₄ sources, their mitigation, and in quantifying any separate CH₄ target within an aggregate fair share multi-gas quota (as estimated above). This is especially relevant to Ireland, given that CH₄ represents a relatively high fraction of total CO₂eq emissions (in GWP₁₀₀ terms or in related mass terms).

Removals

- CO₂ removal (CDR) leading to net negative emissions would reduce warming, at a 10% lower value than warming from equivalent emissions [SPM D.1.5], but ‘there could be a substantial delay between the initiation of CDR and net CO₂ emissions turning negative’ [4-81].
- CDR has highly context-specific effects, with both negative and positive potential outcomes.
- Globally, higher total future CO₂ emissions result in more warming per tonne of CO₂ emitted, due to a reduction in the proportion of CO₂ taken up by land and ocean sinks [Figure SPM.7].

4. Methane (biogenic and fossil) in carbon budgeting

- The SPM makes no distinction between biogenic and fossil sources of anthropogenic CH₄ (the word “biogenic” is not mentioned). The TS only notes that ‘[m]ethane from fossil fuel sources has slightly higher emission metric values than those from biogenic sources since it leads to additional fossil CO₂ in the atmosphere’.
- AR6-WGI gives a base CH₄ GWP₁₀₀ value of 28 including both chemical and carbon cycle feedbacks. This is coincidentally the same value as the AR5 value *not* including carbon cycle feedbacks. In [Table 7.15] adjusted GWP₁₀₀ values of 27 for biogenic CH₄ and 30 for fossil CH₄ are given. In Irish national carbon accounting the larger value would be potentially applicable only to the relatively small fraction of anthropogenic CH₄ emissions from fossil sources (energy fugitive, 0.5%; residential, 1.1%), with the remainder being from biogenic sources (agriculture, 93%; waste, 5%) where the smaller GWP₁₀₀ value would be appropriate.
- Other than these relatively minor accounting differences, AR6-WGI does not evidence any substantive “distinct characteristics of *biogenic* CH₄” relative to fossil CH₄. All GHG emissions from agriculture are classed as *anthropogenic*, and thus subject to applicable mitigation policy and technology choices.
- Of course, biogenic CH₄ does share the “distinct” characteristics common to *all* anthropogenic CH₄ emissions when considered *relative to* non-CH₄ climate pollutants (such as CO₂ or N₂O). The main such distinction, applying equally to both fossil and biogenic CH₄, is its comparatively short atmospheric lifetime that provides a substantial mitigation opportunity for warming reduction if a pathway of permanent cuts in the rate of annual CH₄ emissions is targeted and achieved in the context of national carbon budgeting consistent with the Paris Agreement temperature limit and equitable implementation goals.
- Revised values for all greenhouse gases using GWP₁₀₀ and other GHG metrics are given in Table 7.SM.7. For GWP₁₀₀: CO₂ = 1; CH₄ = 28; N₂O = 273. For CH₄ CGTP values are: CGTP(50) = 2730; CGTP(100) = 3320.