SUBMISSION

New Zealand's Zero Carbon Bill – getting the Paris Agreement right

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SUMMARY

New Zealand's proposed Zero Carbon Bill

The New Zealand government's proposal for a Zero Carbon Bill aims at aligning its national policies with the goals of the Paris Agreement. The draft Zero Carbon Bill has the following options:

1. Net zero carbon dioxide by 2050: this target would reduce net carbon dioxide emissions in New Zealand to zero by 2050 (but not other gases like methane or nitrous oxide, which predominantly come from agriculture).
2. Net zero long-lived gases and stabilised short-lived gases by 2050: this target would reduce emissions of long-lived gases (including carbon dioxide and nitrous oxide) in

New Zealand to net zero by 2050, while stabilising emissions of short-lived gases (including methane).
3. Net zero emissions by 2050: this target would reduce net emissions across all greenhouse gases (GHGs) to zero by 2050.

This submission assesses these options for compatibility with the Paris Agreement and finds that only the third option can be compatible with the Paris Agreement's long-term temperature goal.

On Option 1 we find:

- Achieving net zero CO_2 emissions by 2050 could be consistent with the Paris Agreement for domestic CO_2 emissions alone
- If the net zero CO_2 emissions by 2050 target is not to be achieved strictly through domestic emissions reductions, but instead through a combination of domestic reductions and international emissions reductions acquired by NZ, then an earlier target date may need to be set
- Zero carbon legislation must also set targets for non-CO_2 gases otherwise targets at the national level in New Zealand will not be compatible with pathways for achieving the Paris Agreement goals.

On Option 2 we find:

- By only stabilising short-lived GHGs such as methane (CH_4), this option is also not consistent with the Paris Agreement goals.
- Failure to reduce methane emissions globally would breach the Paris Agreement's 1.5°C limit - stabilisation of CH_4 emissions at around present levels would cause an additional 0.3-0.5°C of warming by 2100 compared to Paris-Agreement-compatible pathways scenarios where CH_4 is reduced.
- Methane needs to be reduced globally by 30-50% below 2010 levels by 2030 and around 50% by 2050.

On Option 3 we find:

- <u>A goal of net zero emissions by 2050 for all domestic GHG emissions could be fully consistent with the Paris Agreement and establish a global benchmark</u>.
- If the net zero GHG emissions by 2050 target is not to be achieved strictly through domestic emissions reductions, but instead through a combination of domestic reductions and international emissions reductions acquired by NZ, then an earlier target date may need to be set.

In summary, Zero Carbon legislation that excludes action on non-CO_2 GHG, or merely stabilises emissions of short-lived gases like methane will not set the comprehensive policy targets required, and will not be consistent with achieving the Paris Agreement goals

The Paris Agreement context of the New Zealand Zero Carbon Bill

In this submission, we outline the context of the Paris Agreement and the implications of the proposed options in this context.

The long-term temperature goal (LTTG) of the Paris Agreement is expressed in Article 2:

Article 2.1(a): *"This Agreement, in enhancing the implementation of the Convention, including its objective, aims to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, including by: (a) Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change"*

Article 4 sets out to operationalise the LTTG in terms of a global emissions pathway to be set based on the best available science and towards which all Parties are meant to contribute with progressively more ambition via their successive nationally determined contributions (NDCs) which are to be communicated every five years:

Article 4. 1 states *that "In order to achieve the long-term temperature goal set out in Article 2, Parties aim to reach global peaking of greenhouse gas emissions as soon as possible, …, and to undertake rapid reductions thereafter in accordance with best available science, so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century… "*

Key considerations on these interlinked articles include the following (Schleussner *et al* 2016):

- Article 2 expresses the purpose of the Agreement. Article 4 is set out 'to achieve' Article 2.1(a). It is therefore clear that **Article 4 must not be interpreted in isolation** and that the only valid interpretations of Article 4 are those that can comply with the best available science on how to achieve the long-term temperature goal in Article 2.1(a).
- Under Article 4, the pathway of global emissions reductions is to be set in accordance *with best available science* so that the LTTG of the Paris Agreement is met. The timing of when a balance between *anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century* is met is part of this science-based pathway.

The NZ Zero Carbon Bill is clearly designed to operationalise these and other elements of the Paris Agreement in domestic law. Its provisions therefore need to be consistent with all relevant elements of the Paris Agreement. One key issue in this context is the timing of when zero GHG emissions are to be achieved.

The reference in Article 4.1 to "*a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases*" is equivalent to <u>zero globally aggregated</u> human caused GHG emissions and removals**.** Note that this refers to the global scale so that some regions (and sectors) may have positive emissions and others negative, but at the globally aggregated level the sum of all anthropogenic emissions and removals needs to be zero. Beyond the point at which <u>zero globally aggregated GHG emissions occur, as described above, there will need to be globally aggregated</u> negative emissions involving carbon dioxide removal through storage in plants and soils and through technological means.

The timing of reaching global zero GHG emissions in the second half of the 21st century is to be established consistent with best available science and, as described above, is intrinsically linked to the technically and economically feasible pathways assessed in IPCC reports that meet the Paris Agreement LTTG.

It is particularly important to understand that when the Paris Agreement was negotiated, the scientific basis for the global emissions pathways available to Parties and that underpinned the provisions of Article 4 were in the form of GWP100 weighted multi-gas GHG pathways. It is these pathways assessed in the IPCC AR5 and which include CO_2, CH_4, N_2O and the F-gases (HFCs, etc.) that provide the scientific basis for the timing of the zero globally aggregated human caused GHG emissions and removals in the second half of the century.

Since 1995 the UNFCCC has formally adopted and applied to all emission national reporting Global Warming Potentials evaluated over 100 years (GWP100) to compare non-CO_2 greenhouse gas emissions with CO_2 emissions. Integrated Assessment Models used to evaluate the technically and economically feasible pathways to meet climate goals also use the GWP100 weighting to describe their results in terms of total GHG pathways, although physical emissions are used to evaluate the climate consequence of these pathways.

In addition to the so-called well-mixed GHGs, these models also account for aerosols and pollutants that affect the climate either directly or that act as chemical precursors for gases that affect the climate. While there are estimates for the GWP of these compounds, they are highly uncertain, often regionally-specific and as a consequence are not applied in the UNFCCC reporting systems, nor are they included in the multi-gas GHG pathway results describing pathways to meet climate goals. It is important to realise however that these climatically active pollutants are accounted for in the evaluation of the emissions pathways above and do influence the rate of emissions reductions needed and the timing of when zero globally aggregated is required for the well mixed GHGs to meet climate goals.

Under virtually any GHG weighting scheme, meeting the Paris Agreement LTTG will require globally zero GHG emissions and implies negative CO_2 emissions to compensate for remaining non-CO_2 emissions such as methane from agricultural processes and/or remaining CO2 emissions from some sectors (Schleussner *et al* 2016). Ongoing negative emissions would eventually lead to a slowly declining global mean temperature (Mengel *et al* 2018). The Paris Agreement therefore sets up conditions that warming would return to below 1.5°C even if a temporary overshoot occurs.

Implications for the proposed options of New Zealand's Zero Carbon Bill

1. Net zero carbon dioxide by 2050

Achieving net zero CO_2 emissions by 2050 could be consistent with the Paris Agreement for CO_2 alone, where pathways show this needs to be achieved globally in the period 2045-2055. One important caveat for New Zealand is that the document "Our Climate. Your say" mentions that a portion of the zero target could be met by buying international emissions reductions from other countries. A full spectrum of equity considerations from the scientific literature shows that New Zealand and other developed countries would need to achieve faster and deeper emissions reductions (including both domestic reductions and those supported internationally) compared to developing countries, so that developed countries reach zero emissions earlier than needed globally.

Importantly, if the final legislation does not include non-CO_2 GHG emissions the legislation will not be consistent with the Paris Agreement.

Article 4.1 of the Paris Agreement refers to all GHGs including CO_2, methane, nitrous-oxide and so-called F-gases. Achieving net-zero carbon dioxide emissions without addressing non-CO_2 greenhouse gases does therefore not comply with the Paris Agreement. This is in particular the case in the New Zealand context, as the country has substantial emissions of non-CO_2 greenhouse gases, predominantly from agriculture.

Methane and nitrous-oxide are potent greenhouse gases that contribute significantly to global warming and therefore need to be robustly addressed in any climate mitigation policy. The scientific literature is clear that, in parallel to CO_2, non-CO_2 emissions need to be substantially reduced to achieve the Paris Agreement goals: the most recent energy-economic scenarios, which form the backbone of the upcoming IPCC Special Report on 1.5°C, show that methane is reduced substantially to about 30-50% below 2010 by 2030 and to roughly 50% below 2010 by 2050 (See Figure 1 drawing from Rogelj et al 2018 – SI Figure 3 panel a).

It is important to emphasise that this strong reduction in methane emissions needs to be in parallel to reducing CO_2 emissions to zero by 2050. Both are needed to achieve overall global zero total-greenhouse-gas emissions by around 2065 and to achieve the long-term temperature goal of the Paris Agreement. Clearly then, reaching the CO_2 target alone, without strong reductions in emissions of methane and other non-CO_2 greenhouse gases, will be insufficient.

Another way to put this is that failure to include non-CO_2 gases in the legislation would in effect place additional burdens on other countries to compensate for the lack of action by NZ to reduce non-CO_2 gases and would not be consistent with its obligations under the Paris Agreement.

Zero carbon legislation that does not set reduction goals for non-CO_2 gases will therefore not set the comprehensive policy targets required and not be consistent with achieving the Paris Agreement goals at the national level in New Zealand.

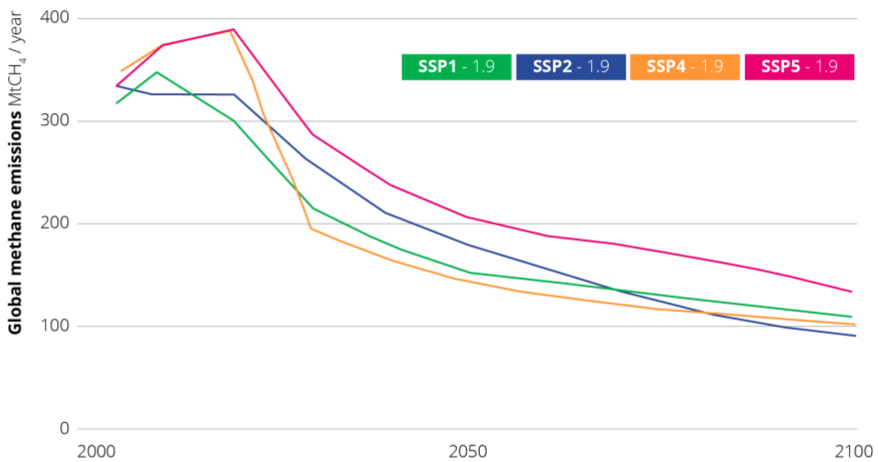

Figure 1. Methane emissions underlying Paris Agreement- compatible pathways. Emissions are shown for a range of energy-economic models and 'marker scenarios' of socio-economic development (SSPs). From Rogelj et al 2018 (see its Supplementary Information).

2. Net zero long-lived gases by 2050 and stabilised short-lived emissions

This second option is also not consistent with the Paris Agreement as failure to reduce so called short-lived emissions globally would result in breaching of the 1.5°C limit. Under the new set of Paris-Agreement compatible pathways, for example, warming is limited to around 1.3°C by 2100 after peaking at about 1.6°C mid-century (Figure 2). However, a mere stabilisation of CH_4 emissions at year-2020 levels – instead of the required reduction in future CH4 emissions – would cause an additional warming of around 0.4°C, with warming not falling below about 1.7°C by 2100 (Figure 3).

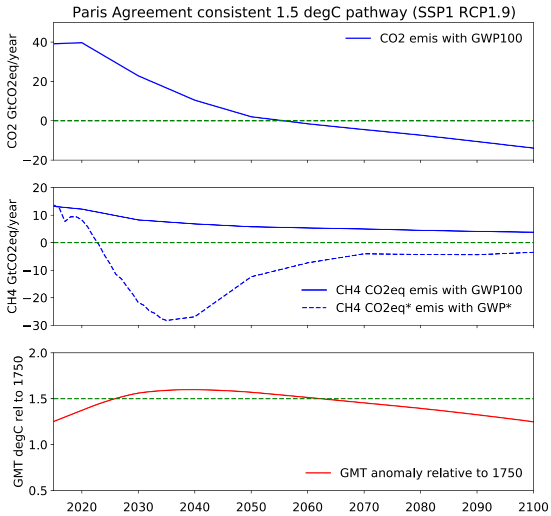

Figure 2. Projected annual CO_2 emissions (top panel), CH_4 emissions in CO_2 equivalents based on GWP100 and GWP accounting (middle panel), and Global Mean Temperature (GMT) anomalies relative to 1750 for a Paris-Agreement consistent emissions pathway, limiting warming to 1.5°C relative to pre-industrial. The scenario SSP1 RCP1.9 is published as part of a larger set of pathways based on the Shared Socio-Economic Pathways (SSPs), achieving a radiative forcing of 1.9 Wm^{-2} in 2100 (Rogelj et al 2018). Shown temperature projections are based on the simple climate carbon cycle model MAGICC (Meinshausen et al 2011).*

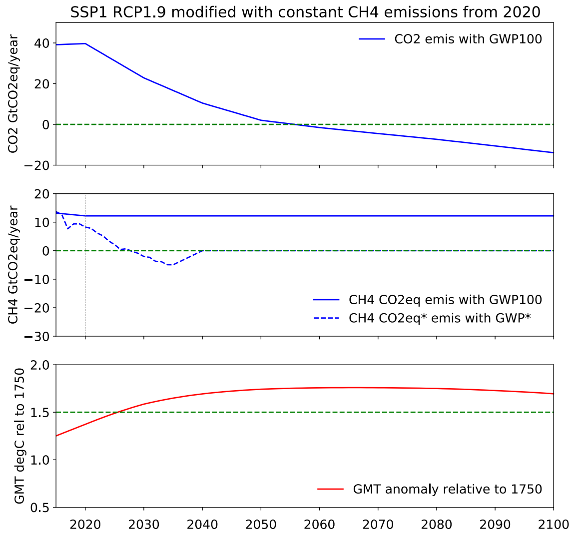

Figure 3. As Figure 2, but for constant CH4 emissions from 2020 onwards.

It would appear that the proposed separation of the effect of short-lived and long-lived gases can be related to a proposal of a different global warming potential, GWP* (Allen *et al* 2016, 2018). Under such a metric, the 'balance' could hypothetically be achieved by zero emissions of long-lived gases and a stabilisation of concentrations of short-lived gases such as methane in the atmosphere (Fuglestvedt et al 2018).

Option (2), however, does not address atmospheric concentrations of methane, but speaks of 'stabilised emissions'. If emissions are higher than the atmospheric decay of methane, this would not lead to stabilised concentrations, but to a continuous accumulation in the atmosphere and therefore further warming. **Since the proposal does not speak to the level at which methane emissions should be stabilised (they could also be at present-day levels), qualitatively, it is no different to option (1).**

Even if a stabilisation of *concentrations* were to be achieved, this is not consistent with the Paris Agreement. Such an interpretation of 'balance' has recently been promoted, combined with the usage of the GWP* metric[1] this is not consistent with the Paris Agreement for the following reasons:

- Achieving a balance in GWP* would not lead to declining, but rather stabilised temperatures. This means that achieving this balance would not guarantee that warming returns to below 1.5°C after a potential temperature overshoot. The only way the 1.5°C limit of the Paris Agreement could be ensured is by not overshooting this warming level. However, achieving a GWP* 'balance' in 2050 is insufficient to guarantee a non-overshoot (see below). Since Article 4.1 is set out 'in order to achieve the long-term temperature goal', this interpretation is not consistent with the Paris Agreement.

[1] https://www.carbonbrief.org/guest-post-a-new-way-to-assess-global-warming-potential-of-short-lived-pollutants

- Due to a change in accounting, the timing of achieving a 'balance' is moved forward by several decades if GWP* was used instead of GWP100. Under GWP100, achieving net zero emissions around 2060-2080 is in accordance with pathways that return warming to 1.5°C by 2100 and end of century with 2°C pathways. Under GWP*, a balance for 2°C pathways would need to be achieved in most cases before 2070 (Fuglestvedt *et al* 2018), implying that for 1.5°C-compatible pathways the balance would be necessary before 2050.
- The UNFCCC commonly uses GWP with an integration time horizon of 100 years (GWP_{100}). This metric has also been used to translate adopted Paris Agreement climate targets into consistent multi-gas pathways and emission budget estimates. Simply applying GWP* with pathways based on GWP_{100} is not feasible as it would introduce inconsistencies, e.g., with reported Nationally Determined Contributions that are not based on GWP*.
- Adopting a GWP* accounting metric for greenhouse gases appear incompatible with the need for consistency between Article 4 and Article 2 of the Paris Agreement.
- Finally, as outlined above, and referring to Figure 1, in energy-economic scenarios that achieve the Paris Agreement goals, short-lived gases such as methane are reduced substantially, with methane emissions dropping to 30-50% below 2010 levels by 2030.

More detail on the effects of different global warming potentials is given separately below in the **Technical Background on Global Warming Potentials**.

These issues also underscore the importance of having common rules under the Paris Agreement which provide for use of common metrics including GWP metrics. This will be essential for purposes of comparability and aggregation of emissions and removals, needed to track collective progress against the Paris Agreement goals. In this context it is important to note that the Paris Agreement rule set will build upon existing reporting guidelines under the Convention. Parties are required to promote consistency and comparability in their NDC accounting and are now working on the adoption of common metrics for reporting, building upon reporting guidelines and methodologies previously adopted under the UNFCCC, which include the practice of applying 100 year GWPs to emission inventories. (see Paris Agreement Articles 13.3, 13.13, 4.13, 4.14).

New Zealand's NDC was based explicitly based on 100 year GWPs and it will need to report progress against its NDC using 100 year GWPs - the accounting guidance for NDCs to be agreed at UNFCCC COP 24 is to "ensure" that "Parties ensure methodological consistency, including on baselines, between the communication and implementation of nationally determined contributions" (1/CP.21, para 31(b).) Under UNFCCC Paris Decision 1/CP.21, para 27 (which addresses information to be communicated in NDCs) if Parties had intended to use a different metric than GWP100 this should have been set out in its NDC.

In summary, a Zero Carbon Bill that merely stabilises emissions of short-lived gases like methane will not set the comprehensive policy targets required, and will not be compatible with achieving the Paris Agreement goals.

3. Net zero greenhouse gas emissions by 2050

This goal for domestic GHG emissions could be fully consistent with the Paris Agreement. At the global level, reaching global zero greenhouse gas emissions (GWP100 weighted) by 2065 (2055-2075) is needed to meet the Paris Agreement LTTG (Rogelj et al 2018). Hence a 2050 timeline for the achievement of domestic net zero greenhouse gas emissions by 2050 (weighted by GWP100) would establish a global benchmark.

One important caveat is that the document "Our Climate. Your say" mentions that a portion of this net zero GHG target could be met by buying international emissions reductions from other countries.

Whether a reliance on international emission reductions would contribute to, or hinder, the achievement of globally aggregated zero emissions by 2065, will depend on the nature of the Paris Agreement rule set governing emission transfers between countries and how watertight this system is. Therefore, if the NZ government anticipates substantial reliance on international emission reductions, then this risk of a weak Paris rule set may need to be managed by NZ setting an earlier target date than 2050.

A full spectrum of equity considerations from the scientific literature shows that zero greenhouse emissions (including both domestic reductions and those supported internationally) would need to be achieved by New Zealand before 2050 on a global 1.5°C pathway (see green range in graph for 2050).

Importance of the definition of "net"

It would be important for the Zero Carbon Bill to define what New Zealand means by "net" – not only around its use of international credits, but also for the Land Use, Land Use Change and Forestry (LULUCF) sector. Because New Zealand is removing large quantities of GHG emissions from the atmosphere through exotic plantation forests, the Kyoto protocol accounting rules allow it to obtain credits that it can use to achieve its GHG targets, although its total sink is decreasing. According to the most recent national emissions projections, with currently implemented policies, the LULUCF sector, which historically has represented a big carbon sink, will see a progressive reduction (from -24 $MtCO_2e$ in 2015 to approximately -16 $MtCO_2e$ in 2020 and -4 $MtCO_2e$ in 2030), mainly due to increasing deforestation; a reduction in new forest plantings; and reduced absorption capacity of forests due to ageing.

New Zealand's LULUCF accounting approach remains unclear, but from statements about the 2030 target, it appears likely that New Zealand plans to exclude LULUCF emissions in the base year but account for them in the target year, which is known as a "gross-net" approach. This raises many questions in terms of the environmental integrity of the Paris Agreement target (Rocha *et al* 2015) However, the accounting rules that will be used under the Paris Agreement have not yet been defined and therefore the legal basis upon which New Zealand is seeking to rely upon such accounting rules is unclear.

The sheer volume of New Zealand's LULUCF credits relative to its emissions footprint has implications on mitigation efforts in other sectors of New Zealand's economy.

This lack of clarity opens up the possibility that New Zealand may seek to use LULUCF sector as a source of cheap credits, effectively masking an increase in its emissions in other sectors.

Therefore, clarity about the accounting rules for the LULUCF sector is essential to understand the implications of the "net-zero" target in other sectors, and ultimately the compatibility of the target with the Paris Agreement. Given that the "Kyoto forests" are now being harvested, it is also important that New Zealand retains the responsibility for those diminishing credits when it defines the "net" in "net zero".

Technical Background: Global Warming Potentials

Article 4.1 of the Paris Agreement implies globally aggregated zero GHG emissions in the second half of the 21st century. This criterion defines a finite time horizon in which the corresponding GHG emission budget can be spent.

While CO_2 is the dominant GHG, emissions of other GHGs with different radiative forcing characteristics and lifetimes - in particular the Short-Lived Climate Forcer (SLCF) Methane (CH_4) - also contribute to the depletion of the remaining GHG emissions budget.

Forcing contributions from non-CO_2 gases are related to CO_2 using the concept of CO_2-equivalent emissions. Under the UNFCCC, the Global Warming Potential with an integration time of 100 years (GWP_{100}) has been adopted as an emission metric to transform the radiative impacts of individual GHGs to a common CO_2 equivalent scale.

There is an ongoing scientific discussion on emission metrics, and the discussion acknowledges the fact that the metric choice always contains an implicit value judgment (Myhre *et al* 2013). It is to be noted however that Parties to the UNFCCC have debated these issues and settled on the (GWP_{100}) over twenty years ago as a compromise across different perspectives. All subsequent emissions reporting and climate policy, including national GHG targets and NDC commitments have been based on GWP_{100} emissions.

In recent years, a modification to the traditional GWP_{100} concept called GWP* has been presented (Allen *et al* 2016, 2018). It argues that the forcing impact of short-lived CH_4 emissions, in particular, has been overestimated by the GWP_{100} concept.

This new methodological proposal has to be treated with a lot of care in the context of Paris Agreement-consistent pathways or related emission budgets because it can easily introduce inconsistencies with previously adopted emission accounting methods and, as shown above, lead to policy approaches that are inconsistent with meeting the Long-term Temperature Target (LTTG) of the Paris Agreement.

In the following, details on the different GWP concepts are presented together with emissions budget implications and an outlook on consequences for national emission reduction policies.

GWP$_{100}$

To relate non-CO_2 emissions to CO_2 emissions, the GWP integrates the Radiative Forcing (RF) of a pulse emission of one mass unit of a GHG over a defined time horizon and relates this value to the corresponding radiative impact of one mass unit of CO_2. By definition, the time horizon of integration plays a crucial role for this concept. The UNFCCC has adopted a 100-year GWP time horizon for generating multi-gas emission pathways, emissions reporting and accounting, and target setting. The shorter the integration time horizon, the higher the relative impact of SLCFs, as the corresponding GWPs decrease rapidly over time due to the growing radiative forcing share of CO_2. As can be seen from Figure 4, a globally aggregated GHG balance (orange) for a RCP2.6 pathway under GWP$_{100}$ would only be reached at the end of the 21st century. For RCP1.9 pathways this balance needs to be reached in the 2060s.

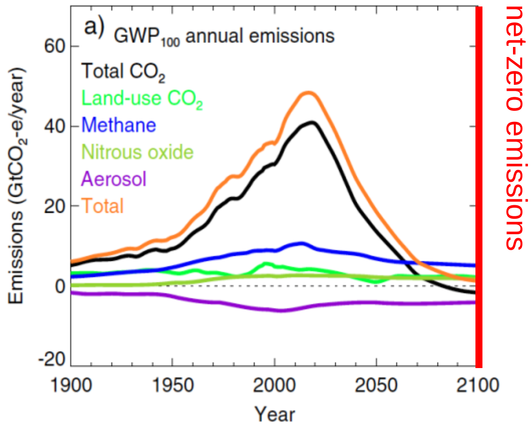

Figure 4: Annual CO_2-equivalent emissions based on GWP$_{100}$, showing historical emissions to 2015 and RCP2.6 data until 2100. Adapted from Allen et al. (2018).

GWP*

Compared to the GWP$_{100}$ concept, GWP* does not use a cumulative approach for SLCFs but an emissions rate rationale to reflect the faster atmospheric decay of these forcing agents. Instead of integrating SLCFs over the reference time frame, GWP* accounts for the temperature change caused by short-lived components by relating a persistent increase in SLCF emissions to a one-off pulse of equivalent CO_2 emissions and a persistent decrease in SLCF to a one-off removal of equivalent CO_2 emissions. Constant CH_4 emissions would lead to a zero CO_2-equivalent emissions contribution. A GWP* net-zero emission balance would lead to stabilising global mean temperatures, contrasting net-zero emission pathways based on GWP$_{100}$ leading to atmospheric cooling. Figure 5 illustrates resulting differences to the traditional GWP concept. GWP* yields 'negative' annual CH_4 CO_2-equivalent emissions (blue) under RCP2.6 despite a real-world atmospheric warming contribution from ongoing emissions of more than 200 Tg per year.

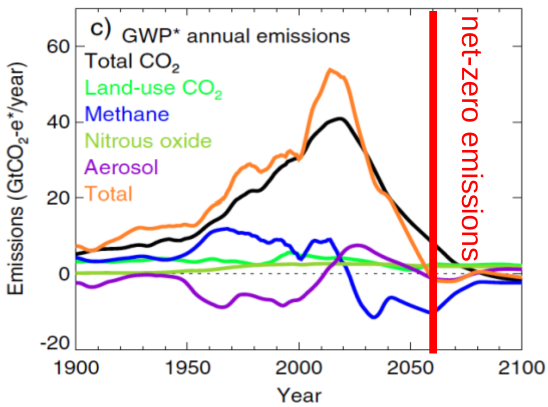

Figure 5: Annual CO_2-equivalent emissions based on GWP, showing historical emissions to 2015 and RCP2.6 data until 2100. Adapted from Allen et al. (2018).*

Emission budget implications

If the GWP* concept was applied to Paris Agreement consistent multi-gas emission pathways that have been designed based on the traditional GWP_{100} concept, it would increase the allowable overall emissions budget of non-CO_2 gases or lead to an earlier date of net-zero GHG emissions. Figure 6 shows that GWP* (green) generally shifts the date of net-zero emissions forward in time while the date of peak warming mostly occurs later than the date of net-zero GWP* emissions.

This marks a stark contrast to GWP_{100} based Paris Agreement consistent pathways (Rogelj *et al* 2018). Most of these trajectories show peak warming above the 1.5°C temperature limit and only reach or fall below this limit later in the 21st century via decreasing global mean temperatures. The GWP* concept does not allow for atmospheric cooling in a net-zero GWP* emissions case, which makes this concept incompatible with meeting the LTTG of the Paris Agreement. More specifically, applying the GWP* concept to UNFCCC emission pathways derived with GWP_{100} would introduce methodological inconsistencies between paragraph 17 of the Paris decision and Articles 2 and 4 of the Paris Agreement itself (Fuglestvedt *et al* 2018).

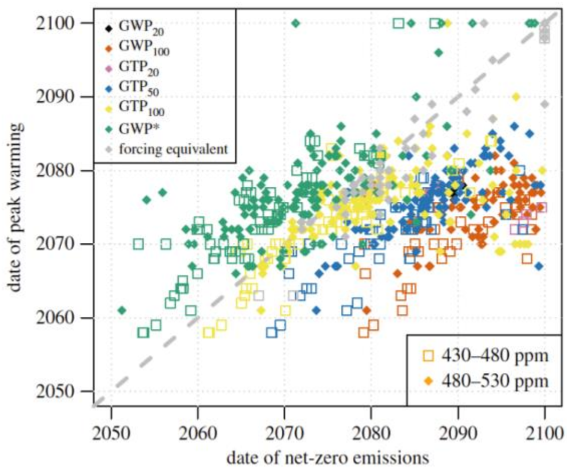

Figure 6: Correlation between time of net-zero emissions and time of peak warming for various metric choices, including CO_2-fe. Grey dashed line represents the 1:1 line. Different colours represent the different metric choices, with open squares denoting the 430–480 ppm scenarios and filled symbols the 480–530 ppm scenarios. From Fuglestvedt et al. (2018)

Discussion

GWP* represents an interesting contribution to the ongoing scientific discussion on emission metrics. As a new concept, it must be properly discussed and assessed by the scientific community, e.g. as part of the IPCC Sixth Assessment cycle, before being applied in conjunction with metrics used by the UNFCCC. If applied for future GHG emissions accounting, it would have significant implications for net-zero CO_2-equivalent emissions budget calculations and the timing of net-zero GHG emissions as it attributes significantly less weight to SLCFs like Methane.

The Paris Agreement targets and underlying pathways have been adopted based on the GWP_{100} emission metric and the available knowledge at that time. Paris Agreement emissions budgets cannot simply be re-interpreted by using a new metric as it would conflict with key scientific assumptions that have informed the adopted text.

Not surprisingly, a concept that suggests a weaker forcing impact of CH_4 emissions generates considerable attention from policymakers. A statement from a lead author of the main GWP* study shows how easily this issue can be presented without raising necessary caveats. The author was quoted suggesting that CH_4 emissions only have to be prevented from increasing further while we should focus on CO_2 emission reductions to stabilise global temperatures. There are several issues with a statement like this, mainly because it takes the metric implications out of context of the conceptual conditions of all underlying emissions budget considerations under the UNFCCC.

If taken literally that CH_4 emissions only have to be prevented from increasing further, this could add around 0.4°C to global temperature compared to Paris Agreement consistent pathways that limit warming to about 1.5°C and that all involve substantial CH_4 reductions.

Adopting a single metric whose effect would be to weaken incentives for deep CH_4 emission reductions would be highly damaging to efforts to meet the Paris Agreement temperature goal and its 1.5°C limit. As the IPCC AR5 states: "metrics do not define policies or goals but facilitate evaluation and implementation of multi-component policies to meet particular goals. All choices of metric contain implicit value-related judgements such as type of effect considered and weighting of effects over time" (Myhre *et al* 2013).

The warming impact of CH_4 is well understood and quantifiable. Constant CH_4 emissions would still contribute to elevated atmospheric temperatures. The current emissions metric discussion has the potential to divert attention from the urgent need to define mitigation policies that allow us to safely meet the Paris Agreement goals. These policies have to also include the relatively easy-to-mitigate CH_4.

Finally, a recent review assessed paleoclimatic information to elaborate on the link between atmospheric warming and radiative forcing changes (Fischer *et al* 2018). The study warns that current climate modelling may underestimate long-term warming for future radiative forcing changes by a factor of two. This would make the budget of allowable GHG emissions consistent with the Paris Agreement goals smaller than currently estimated and should encourage the most stringent and comprehensive mitigation policies.

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