Agricultural emissions and warming in Aotearoa New Zealand to 2050: Insights from the science

Summary of research prepared by
B+LNZ, Federated Farmers and DairyNZ

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beef+lamb new zealand

DairyNZ

FEDERATED FARMERS OF NEW ZEALAND

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About this study

Beef + Lamb New Zealand (B+LNZ), DairyNZ and Federated Farmers commissioned a report from climate change experts at University of Oxford and Cranfield University to discuss the concept of net zero emissions and what it means in the context of the warming from methane.

New Zealand has set targets of achieving net zero emissions of carbon dioxide (CO_2) and nitrous oxide (N_2O) by 2050 and to reduce biogenic methane (CH_4) emissions by 10% by 2030 and 24-47% by 2050.

The report assessed the methane targets for 2050 under the Climate Change Response (Zero Carbon) Amendment Act of 2019 (CCRA) in New Zealand and analysed what these targets, if achieved, would mean for the New Zealand economy's overall contribution to global warming.

It also looked at the contribution of the main gases emitted in New Zealand, based on warming to date, and ran some scenarios on what reductions in methane would be required for it to add no additional warming.

Under the CCRA, the Climate Change Commission is required to review the current targets and provide advice to the Government by the end of next year on whether these should be amended.

We commissioned this research to help inform this process and believe it provides significant and independent evidence for taking a warming- centred approach to emissions reductions.

The Paris Agreement's goal is to limit the global average temperature increase to well below 2 degrees C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 degrees C above pre-industrial levels. It therefore makes sense that a country's climate change objectives take a warming approach.

Professor Myles Allen, Jessica Zionts and Miyabi Barth of University of Oxford and Dr Michelle Cain of Cranfield University undertook this research. They used Ministry for the Environment (MfE) inventory data and modelled it using Finite-amplitude Impulse Response (FaIR) model, to run a range of scenarios.

Read the full report

The full report is available on B+LNZ's, Federated Farmers and Dairy NZ's respective websites. We have also produced FAQs.

Key points from the report

Greenhouse gas metrics

The report notes that, in 1997, the Kyoto Protocol standardised national emissions reporting by applying the Global Warming Potential (GWP) accounting metric and applying a 100-year time horizon so greenhouse gases could be combined into a single common unit. The authors of this study note there have been concerns as to the accuracy of GWP100 for decades, and that it has created distorting incentives.

This is because the amount of global warming caused by short-lived GHGs is largely driven by their annual emissions rate (i.e. the flow into the atmosphere of that gas). This contrasts with long-lived GHGs such as CO_2, as their contribution to global warming is dependent on the total cumulative emissions since pre-industrialisation (i.e. the stock of the gas in the atmosphere). GWP* is a 'flow-based' metric, which looks at the rate-of-change of short-lived GHG emissions, which contrasts with GWP and GTP which are both 'stock-based' (M. R. Allen et al. 2018; Smith, Cain, and Allen 2021).

Given the Paris Agreement's goal to limit warming to well below 2 degrees, the authors note that using a metric that measures the contribution of each gas to warming relative to that threshold would constitute a useful policy tool that more accurately represented progress towards the temperature target.

The authors note that, while countries are required to use GWP100 for international reporting of their emissions and NDCs, there is nothing to prevent them from also using other metrics as a basis for their emissions reduction policies.

They note that it could also be useful for countries to report GHGs separately and set separate targets alongside their GWP conversions. This would allow tracking of an entity's contribution to warming in addition to progress towards targets set using aggregate stock-based metrics.

Table 1 below expands on the differences between long- and short-lived greenhouse gases. This distinction is further illustrated by Figure 1.

Table 1: How long-lived and short-lived greenhouse gases affect the climate differently

Long-lived: carbon dioxide and nitrous oxide	Short-lived: methane
Eliminating emissions maintains contribution to global warming at a steady level (the temperature change caused by CO_2 plateaus)	Eliminating emissions leads to temperature declining from a peak, as contribution to global warming is driven by methane emissions rate (temperature change caused by methane declines until nearly all past warming has been reversed)
A constant rate of emissions leads to increased levels of global warming year-on-year (temperature change caused by CO_2 increases)	A constant rate of methane emissions maintains a constant level of warming relative to the base year, to first order. Including second order effects based on the present day and near future, temperature will increase slowly, as the climate is slowly responding to past increases in methane emissions (temperature change caused by methane increases slowly)
Reducing emissions slows the rate of increase of global warming (temperature change caused by CO_2 increases)	Reducing emissions can maintain methane's contribution to global warming at a constant level, if reductions are approximately 3% per decade. Reducing emissions faster than this can reduce global warming from methane (temperature change caused by methane stable or declines)

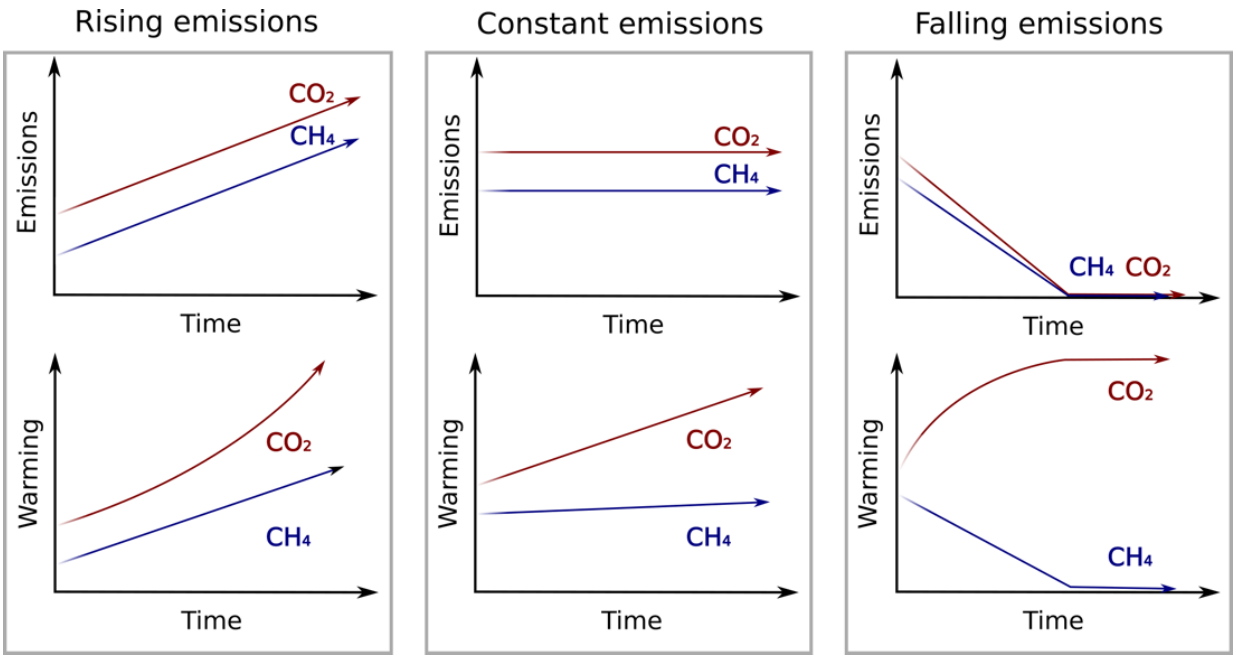

Figure 1: Figure from (M. Allen et al. 2022) showing the difference between the contribution to warming of methane and carbon dioxide under different emissions scenarios

Sectoral contributions to warming to date in New Zealand

The authors looked at the contribution to warming to date of the main gases in New Zealand.

They found that prior to 1990, methane was the dominant contributor to global warming, causing nearly 60% of New Zealand's contribution to global warming since 1850.

The authors note there has been a lot of discussion about historic warming and responsibility to reduce, and that most developed countries have opposed this. Countries with CO_2 as their predominant gas could only remove their historic warming by actively removing CO_2 from the atmosphere, and can only stop adding to additional warming by reaching net zero. As such, contributions to additional warming since 1990, arguably the earliest date of an emerging international consensus on the climate issue, are generally considered more relevant.

The report therefore assessed the relative contribution of each gas to warming since 1990 and found that energy had contributed the largest proportion (54%) and agriculture second at 37%. Of this methane was responsible for just 16% and nitrous oxide 20% of the 37% contribution to warming from agriculture over this period. The study showed that methane's contribution to ongoing warming has reduced significantly, particularly in the last decade, because methane emissions have been stable or declining.

The authors noted that, while agriculture was 51% of current annual emissions using GWP100, this was quite different to its current contribution to warming and this reinforced the importance of taking a warming approach to emissions.

New Zealand's current Zero Carbon Act targets

New Zealand's Zero Carbon Act (CCRA) requires that, by 2050, all long-lived greenhouse gases reach net zero, and biogenic methane reduces by 24-47% relative to 2017 levels, with a 10% reduction by 2030.

The authors noted that New Zealand's methane targets were derived from the IPCC special report on pathways towards 1.5 degrees that was released in 2018. This IPCC report acknowledged that methane does not need to go to net zero and that separate targets for methane were appropriate.

However, the authors of this report note the IPCC pathways were not supposed to be used directly by countries for their targets, quoting an extract from the IPCC report that the strategies "illustrate relative global differences in mitigation strategies, but do not represent central estimates, national strategies, and do not indicate requirements." In other words, they are just example strategies, chosen by the authors of the report, not representing a central forecast.

Assessment of the warming impact of New Zealand's current methane targets

The analysis found a 47% reduction in methane emissions by 2050, following a 10% reduction in methane emissions between 2020 and 2030, combined with linear reductions to net zero in CO_2 and N_2O emissions from 2020 to 2050, would see methane reductions essentially offsetting all future additional warming by CO_2 and N_2O emissions, bringing New Zealand's economy-wide cumulative warming back to 2022 levels by 2050.

In this pathway, New Zealand causes net zero warming between 2022 and 2050 as the additional warming after 2022 is reversed by 2050. This is because the "cooling" impact of the ambitious emission reductions in the agriculture and waste sectors compensates for ongoing additional warming caused by energy and transport emissions over this period.

This compensation for the warming impact of fossil-based emissions by mitigation in the agriculture sector raises concerns of fairness and equity, considering the cumulative nature of CO_2 and N_2O emissions. Such concerns cannot be addressed solely through a scientific analysis of the impact of emissions, but would also need to account, among other things, with the social, economic and other environmental impacts of emission reduction measures in different sectors.

The analysis also found that a 24% reduction in methane emissions by 2050, following a 10% reduction in methane emissions by 2030, combined with linear reductions to net zero in CO_2 and N_2O to net zero by 2050 from 2020, would see New Zealand achieve net zero additional warming as an economy between 2027 and 2050 (bringing cumulative warming back to 2027 levels by 2050), assuming the rest of the world pursues current policies up to that time.

If the rest of the world reduces its emissions faster than it is currently aiming to do, New Zealand would require faster emission reductions to achieve net zero additional economy-wide warming by 2050 because our emissions would have a slightly larger absolute impact.

In both cases, New Zealand's total contribution to global warming would peak in the mid- to late-2030s thanks to the combination of CO_2, N_2O and methane reductions.

Many developed countries have pledged to achieve net zero by 2050 at the latest. In countries where CO_2 is the dominant contributor to warming, which is the majority, their total contribution to global warming would peak around 2050 if these pledges are delivered.

Scenarios

The authors ran a number of scenarios of reductions in emissions by the various gases and their impact on warming by New Zealand.

No additional warming for methane

The study looked at what reduction in emissions would be required by 2050 to offset the additional warming from methane emissions from 2020.

It looked at two potential pathways for future warming using what are called Shared Socioeconomic Pathways (SSPs). SSPs can be used to demonstrate a range of international climate change scenarios, accounting for lower to higher levels of global action.

The two pathways that were modelled in the report were SSP-119 and SSP-245.

SSP-245 Scenario:

- SSP-245 is a moderate ambition scenario and is accepted as a reasonable proxy for current global policies to mitigate climate change: i.e. if countries reduce their emissions by the amount that they have currently committed then SSP-245 is a likely temperature increase outcome.
- If countries globally meet their existing commitments, a 15% reduction in methane would see New Zealand methane contributing net zero additional warming relative to a 2020 baseline (i.e. no additional methane-induced warming from 2020 levels from the agricultural sector).

SSP-119 Scenario:

- SSP-119 is a highly ambitious pathway where countries have significantly increased their current levels of ambition to reduce emissions in such a way that the global increase in temperature is held to 1.5 degrees above pre-industrial levels.
- Given the world to date has already warmed by 1.2 degrees above pre-industrial levels, many consider this unlikely.
- If countries were to significantly increase their current levels of ambition, and we can keep temperature increases below 1.5 degrees, then a 27% reduction in methane would see New Zealand methane contribute net zero additional warming relative to a 2020 baseline (i.e. no additional methane-induced warming from 2020 levels from the agricultural sector.).

The authors noted many developed countries have a target of net zero by 2050. Because CO_2 is the dominant gas (70-90% of emissions) these countries will be adding significant amounts of additional warming out to 2050. This puts New Zealand in a unique place because warming from methane in these scenarios would peak in the 2030s and return back to 2020 levels of warming by 2050.

The research also considered how much methane would need to reduce by to offset all of agriculture's expected warming from methane and nitrous oxide by 2050. It was noted, however, that there is already a target of net zero for nitrous oxide by 2050 in New Zealand's Zero Carbon Bill.

[1]AR6 synthesis report said that GHG emissions would need to reduce 43% by 2030 on 2019 levels to be consistent with achieving 1.5 degrees.