Ministry for the Environment
Manatū Mō Te Taiao

OIAD-425

s 9(2)(a)

Tēnā koe s 9(2)(a)

Thank you for your email of 12 August 2022 to the Climate Change Commission requesting the following under the Official Information Act 1982 (the Act):

> *What is the scientific basis for the adoption of the so called "Split-Gas" approach which has resulted in the different treatment of the gases, in the CCRA? I would appreciate being supplied with the scientific basis for the separation of methane and other GHGs in the CCRA), and any policy papers which outline any agreement between Government, Primary Industry, and the Climate Commission which specify the basis of the different treatment of methane and other GHGs.*

On 24 August 2022, the Climate Change Commission transferred your request to the Ministry for the Environment (the Ministry), as the information you requested is more closely connected with the functions of the Ministry.

We acknowledge that the Ministry's response to your request was due on or before 21 September 2022. We apologise for the administrative oversight that resulted in your request failing to be logged, and the resulting lateness of this response.

There are six documents in scope of your request.

Three documents are being released to you in full.

Three documents are being released to you with some information withheld under the following sections of the Act:

- 9(2)(f)(iv), to maintain the constitutional conventions for the time being which protect the confidentiality of advice tendered by Ministers of the Crown and officials; and
- 9(2)(g)(i), to maintain the effective conduct of public affairs through the free and frank expression of opinions by or between or to Ministers of the Crown or members of an organisation or officers and employees of any public service agency or organisation in the course of their duty.

Some information within these documents has been redacted as out of scope of your request.

In terms of section 9(1) of the Act, I am satisfied that, in the circumstances, the withholding of this information is not outweighed by other considerations that render it desirable to make the information available in the public interest.

Of the documents being released to you, the following contain explanations of the scientific basis for the separation of methane and other GHGs in the CCRA:

- Documents 1, 4, 5 and 6.

You may also find the following publicly available papers of interest:

- ENV-18-MIN-0053 - Proposed Climate Change Bill
- Biogenic methane reductions required under the climate change Bill
- ENV-19-MIN-0015 - Biogenic Methane Reductions Required Under the Climate Change Bill

You have the right to seek an investigation and review by the Office of the Ombudsman of my decision to withhold information relating to this request, in accordance with section 28(3) of the Act. The relevant details can be found on their website at: www.ombudsman.parliament.nz.

Please note that due to the public interest in our work the Ministry for the Environment publishes responses to requests for official information on our OIA responses page shortly after the response has been sent. If you have any queries about this, please feel free to contact our Ministerial Services team: ministerials@mfe.govt.nz.

Ngā mihi

Electronically signed by Stephen Goodman

Stephen Goodman
Manager – Mitigation Policy
Ministry for the Environment | Manatū Mō Te Taiao

Document schedule

Doc no.	Document date	Content	Decisions	OIA sections applied
1	26 June 2018	*18-B-04702 - The role of methane emissions in mitigating climate change*	Release in part	9(2)(f)(iv)
2	28 March 2019	*2019-B-05461 – Climate Change Bill: Advice on target formulation and legal accountability*	Release in part	9(2)(g)(i)
3	4 April 2019	*2019-B-05486 – Biogenic methane reductions required under the Zero Carbon Bill (second draft of the Cabinet paper)*	Release in part	9(2)(f)(iv)
4	26 June 2019	*2019-B-05733 – Climate Change Response (Zero Carbon) Amendment Bill – Draft responses to the Environment Committee's questions on science*	Release in full	N/A
5	26 June 2019	*2019-B-05734 – Summary of Scientific aspects of New Zealand's 2050 emission targets (Reisinger & Leahy)*	Release in full	N/A
6	11 July 2019	*2019-B-05777 – Climate Change Response (Zero Carbon) Amendment Bill: supplementary information for the Environment elect Committee*	Release in full	N/A

To Hon James Shaw, Minister for Climate Change			Tracking #: 18-B-04702
Security Level	UNCLASSIFIED	Number of Attachments	NA
Date Submitted:	26 June 2018	Response needed by:	N/A
MfE Priority:	Non-Urgent	Action Sought:	N/A

The role of methane emissions in mitigating climate change

Context

1. This briefing provides you with information on the scientific basis for reducing methane emissions, as requested on Friday 22 June.
2. In determining New Zealand's approach to its emissions targets, there are a range of considerations to be made from a policy perspective which are not discussed here.

The 'two baskets' approach recognises that different gases affect the climate differently

3. Different greenhouse gases (GHGs) have different potency and atmospheric lifetimes, and therefore different impacts on the climate. For mitigation purposes, including setting targets and policies, it is useful to compare the effects of different gases. This involves making value judgments about the relative significance to humans of greenhouse gas impacts over time, which is fraught with uncertainty.
4. Different gases can be compared in "one basket" by using a "metric" or factor that expresses emissions of each gas as a "carbon dioxide-equivalent". This is described in paragraphs 13 to 18 below.
5. An alternative to a single type of metric for all gases is to adopt a 'multi-basket' approach in which gases are grouped according to their contributions to short and long term warming. This may solve some problems associated with using a single metric, but the question remains of what relative importance to attach to reducing GHG emissions in the different groups.
6. Separating short-lived and long-lived gases can be considered a 'two baskets' approach. Methane is a short-lived greenhouse gas. More than half the methane in the atmosphere decays after 12 years, and after 50 years about 98% is gone. In contrast, about half of each carbon dioxide emission is removed within a few decades, but the remainder stays in the atmosphere for much longer. About 15 to 40% is still in the atmosphere after 1000 years.

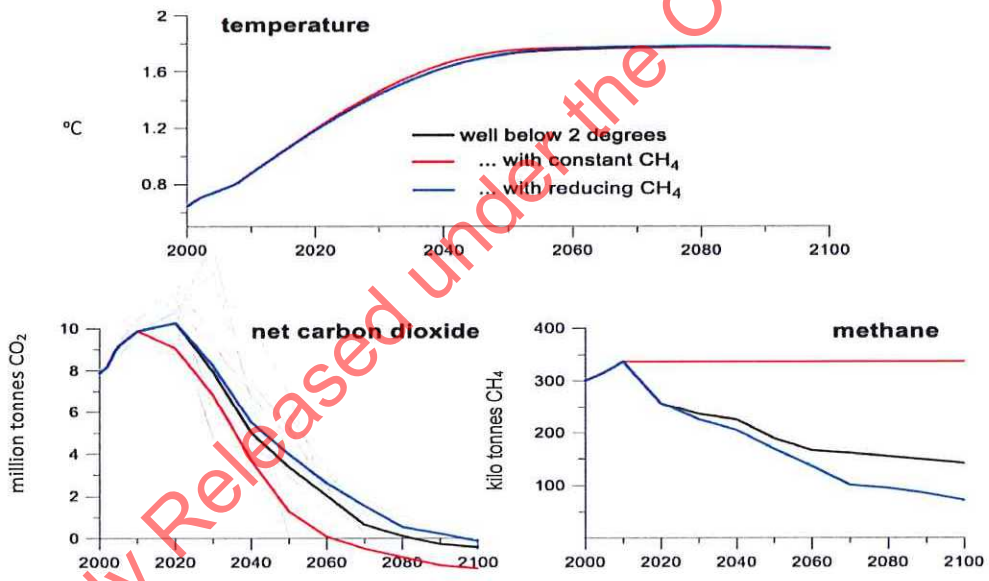
A reduction in methane is expected to be necessary to limit warming to 2 or 1.5 degrees

7. To limit warming below 1.5°/2°C, emissions of short-lived GHGs must stabilise at a 'sustainable' level and emissions of long-lived gases must be reduced. There is no consensus on what that 'sustainable' level is, and it is not a scientific question - it depends on political, economic and social choices, as well as technological developments and progress on reducing long-lived GHGs.
8. The published literature on mitigation of non-CO_2 gases is relatively sparse, but because agriculture and related land use change contributed about 23% of global anthropogenic GHG emissions in 2010 (based on the existing one-basket approach), reduction below current emissions levels is widely agreed to be necessary for meeting the Paris Agreement's temperature goals.

9. For example, one of the future emissions scenarios assessed by the IPCC, RCP2.6, is consistent with the goals of the Paris Agreement. With 66% likelihood, it would limit warming in 2100 to below 2 °C above pre-industrial, or with about 50% likelihood, below 1.5 °C. It should be emphasised that this is not a prescriptive scenario, but represents a group of scenarios with similar climate outcomes. In this scenario, global methane emissions from agriculture in 2050 are about 25% below 2010 levels, and continue to decline until 2100. This is in strong contrast to global fossil methane emissions from the energy sector, which decrease by about 65% below 2010 levels in 2050, and 85% in 2060.
10. The scenario provides regional, but not country-level detail, and OECD90 countries' agricultural emissions in 2050 are reduced more than the global average, to 35% below 2010 levels. It should be noted, however, that New Zealand is an atypical member of this group, as far as methane emissions are concerned.

There are trade offs between reductions of methane and carbon

11. If strong reductions in methane are made, this could allow more time for reducing carbon dioxide and vice versa – strong reductions in carbon dioxide could allow for a higher flow rate of methane. However, a focus on reducing methane could result in carbon dioxide emissions growing while reducing methane emissions, which would ultimately lead to a warmer world in the long term.
12. *Figure 1:* Different pathways (combinations of methane and carbon dioxide emissions) consistent with 2°C. [1]



The GWP_{100} metric is used to compare greenhouse gases in international accounting

13. To enable comparison of emissions targets and to prioritise policies, greenhouse gases are converted to their carbon dioxide equivalent values using metrics.
14. Although metrics are based on science, the choice of which one to use is not a purely scientific decision. They all have strengths and weaknesses, and the suitability of a particular metric depends on what it will be used for.
15. The 'GWP-100' (Global Warming Potential) metric compares the amount of heating caused by different gases over 100 years. Specifically, it is a measure of how much energy the emissions of 1 tonne of a gas will absorb over a given period of time, relative to the

[1] Source: https://motu.nz/assets/Uploads/Andy-Reisinger-Mitigation-in-the-Land-Sector-Challenges-and-choices6.pdf

emissions of 1 tonne of carbon dioxide. It takes into account the different lifetimes of gases.]A criticism of GWP is that it focuses on cumulative warming effect rather than the temperature outcome.

16. The GWP_{100} is used to calculate and account for New Zealand's emissions as required by international agreements. The GWP_{100} is likely to remain the internationally agreed metric for the foreseeable future, although there has been and will continue to be discussions around and proposals for alternative metrics.

17. A recent study introduces a new method to compare how methane and other gases contribute to greenhouse gas emissions budgets. Compared to the currently adopted metric, this new method reduces the significance of methane in all-gases budgets or targets proposed to achieve the goals of the Paris Agreement. It also supports stabilisation targets for short-lived gases and zero-emissions targets for long-lived gases. The study was co-authored by Professor Dave Frame (VUW) with colleagues from the UK and Norway.

18. These issues have been discussed in both the Productivity Commission report and the discussion document for the ZCB consultation, and the separate treatment of methane is already a key component of the consultation on New Zealand's approach to its domestic target. 9(2)(f)(iv) [redacted]

Feedback from ZCB consultation process

19. The role of the different greenhouse gases in the global and New Zealand context and implications for choice of a 2050 target has featured prominently in ZCB consultation events (including the DairyNZ led climate workshops) to date. Discussion of the "net zero long-lived gases and stabilised short-lived gases" target option has seen some understanding of the environmental and economic implications (for other parts of the economy) of stabilising methane at a reduced level. Opinions differ as to what an appropriate level of reduction for stabilisation would be.

Signature

Mark Storey
Manager, Climate Change Policy
Climate Change Directorate

Ministry for the Environment contacts

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Climate Change Bill: Advice on target formulation and legal accountability

Date Submitted:	28 March 2019	Tracking #: 2019-B-05461	
Security Level	In confidence	MfE Priority:	Non-Urgent

	Action sought:	Response by:
To Hon James Shaw, Minister for Climate Change	Decisions	

Actions for Minister's Office Staff	**Return** the signed report to MfE.
Number of appendices and attachments: 1	1. Comparison of NDC and proposed new targets 2005-2050
Note any feedback on the quality of the report	

Ministry for the Environment contacts

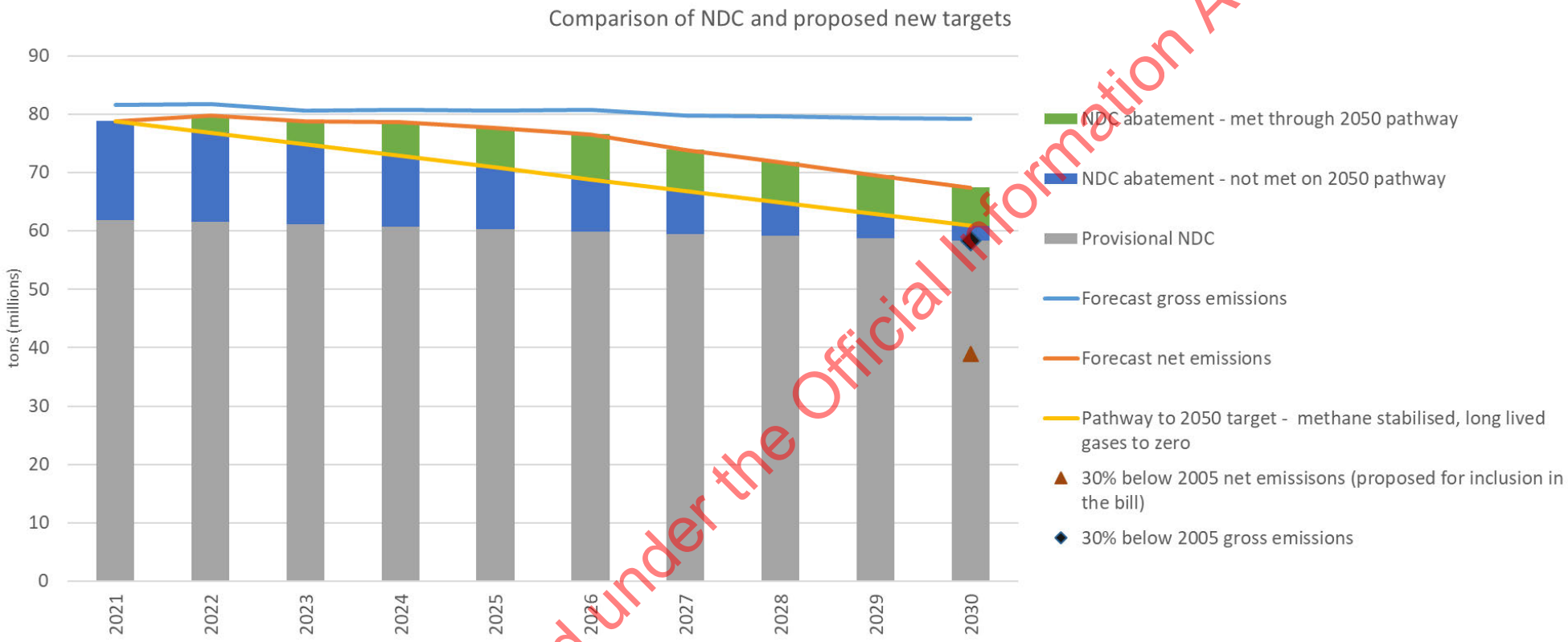
Position	Name	Cell phone	1st contact
Principal Author	Lewis Stevens	0204 009 5469	✓
Responsible Manager	Bridget Fraser		
Director	Janine Smith		

Climate Change Response (Zero Carbon) Amendment Bill: Advice on target formulation and legal accountability

1. As requested by your office, this briefing provides you with:
    a. Advice on the implications of including a target to reduce net emissions of greenhouse gases by 30% below 2005 levels by 2030 in the proposed new climate change legislation.
    b. Options for how to proceed in respect of legal accountability under the proposed new legislation. This advice follows conversations with your office and the Parliamentary Counsel Office on the drafting of the bill.
2. These points are dealt with in turn below.

Target formulation

3. We understand you are considering legislating a target for 2030 through the Climate Change Response (Zero Carbon) Amendment Bill ("Bill") to reduce net emissions of greenhouse gases to 30% below 2005 levels by 2030; including a 10% reduction in biogenic methane emissions below 2005 levels by 2030.
4. This approach presents four key issues:
    a. Consistency of the proposed target with our first Nationally Determined Contribution (NDC) under the Paris Agreement, and the impact of multiple targets on the certainty of direction for our low emissions transition
    b. Distribution of effort across the economy
    c. Timing of effort to reach the proposed 2050 target
    d. Compatibility with the central range of IPCC scenarios consistent with limiting global warming to 1.5°C with limited or no overshoot.
5. These points are dealt with in turn below. The plot below shows the difference between the various components of the target that are under discussion, and how this compares to our first NDC. The appendix presents this same plot over the period 2005 to 2050 for context.



The impact of multiple targets on the certainty of direction for our low emissions transition

6. The overall net emissions component of the proposed target appears similar to our first NDC under the Paris Agreement, but differs in three important ways which would cause it to drive materially different outcomes. The following table sets out these differences.

Target formulation	**Gross or net baseline?**	**Emissions budget or point in time?**	**Treatment of forestry**
NDC	Gross	Budget	Averaging
A 30% reduction in net greenhouse gas emissions below 2005 levels by 2030	Net	Point in time	Not specified[1]

7. Achieving the proposed point-year target domestically would mean our emissions in 2030 would be significantly below the trajectory indicated by the proposed formulation for the 2050 target. Please refer to the plot above for illustration.

8. An efficient transition depends on a clear and stable long-term signal of the emissions reductions required across the economy. Adopting and legislating multiple targets reduces this clarity and stability, and would compromise the efficiency of the transition.

9. It is important to note that regardless of what target is legislated through the Bill, New Zealand remains committed to its NDC.

Distribution of effort across the economy

10. The proposed target form will impact how the burden of meeting it is spread across the economy. If the 10% reduction in gross emissions of biogenic methane emissions is met, this would require us to offset or reduce 44% of our gross emissions levels of other greenhouse gases in order to meet the proposed overall 30% reduction target.

11. If such a target formulation is progressed, we recommend explicit consideration is made of how impacts are likely to be distributed across the economy.

Timing of effort to meet the 2050 target

12. Achieving a 30% reduction in emissions on a 2005 baseline by 2030 by domestic emissions reductions and removals alone will put us on a much steeper emissions reduction trajectory than that implied by the proposed target for 2050.

13. The plot in the appendix to this paper illustrates this point.

14. Making deeper reductions earlier could increase the overall costs to the economy, and pre-empt technology development that could support a gradual and efficient transition. While this could result in better climate outcomes though us reducing emissions earlier, it constrains the choices we have in how we achieve a transition that is just and efficient.

15. If such a target formulation is progressed, we recommend explicit consideration is made of the timing and impact of emissions reductions across the economy.

Compatibility with the central range of IPCC scenarios consistent with limiting global warming to 1.5°C with limited or no overshoot.

16. The proposed formulation of the 2050 target for biogenic methane calls strongly on the

[1] We have assumed UNFCCC reporting approach in our calculations as this is the data we have for 2005

IPCC's central range of scenarios consistent with limiting global warming to 1.5°C with limited or no overshoot.

17. The IPCC reports global emissions reductions in 2030 under the same scenarios. These indicate a central range of reductions in agricultural methane emissions between 11% and 30% on 2010 levels.

18. Converting these figures to a baseline of New Zealand's 2005 biogenic methane emissions (in line with the proposed target for 2030) gives an emissions reduction range of 16% and 34%.

19. The IPCC does not prescribe any policy approach or target, and the global emissions reductions do not necessarily apply to an individual country, but given the weight placed on its scenarios in the 2050 target formulation we recommend that this be considered in any decision on a 2030 target.

Legal accountability

20. We have been working with your office and the Parliamentary Counsel Office on clauses which seek to limit legal accountability under the Bill. This reflects the paper ENV considered in December last year, which set out that the intention was for the Bill to, as far as appropriate, provide primarily political accountability rather than legal, and for mitigation for those risks to be considered in the drafting process.

21. We understand that you are considering how any legal liability should be treated under the Bill, and in particular if the Bill should remain silent on this point.

22. Out of scope [redacted]

23. s 9(2)(g)(i) [redacted]

Recommendations

25. We recommend that you:

a. **Discuss** the advice on the target formulation with officials

Yes/No

b. Out of scope

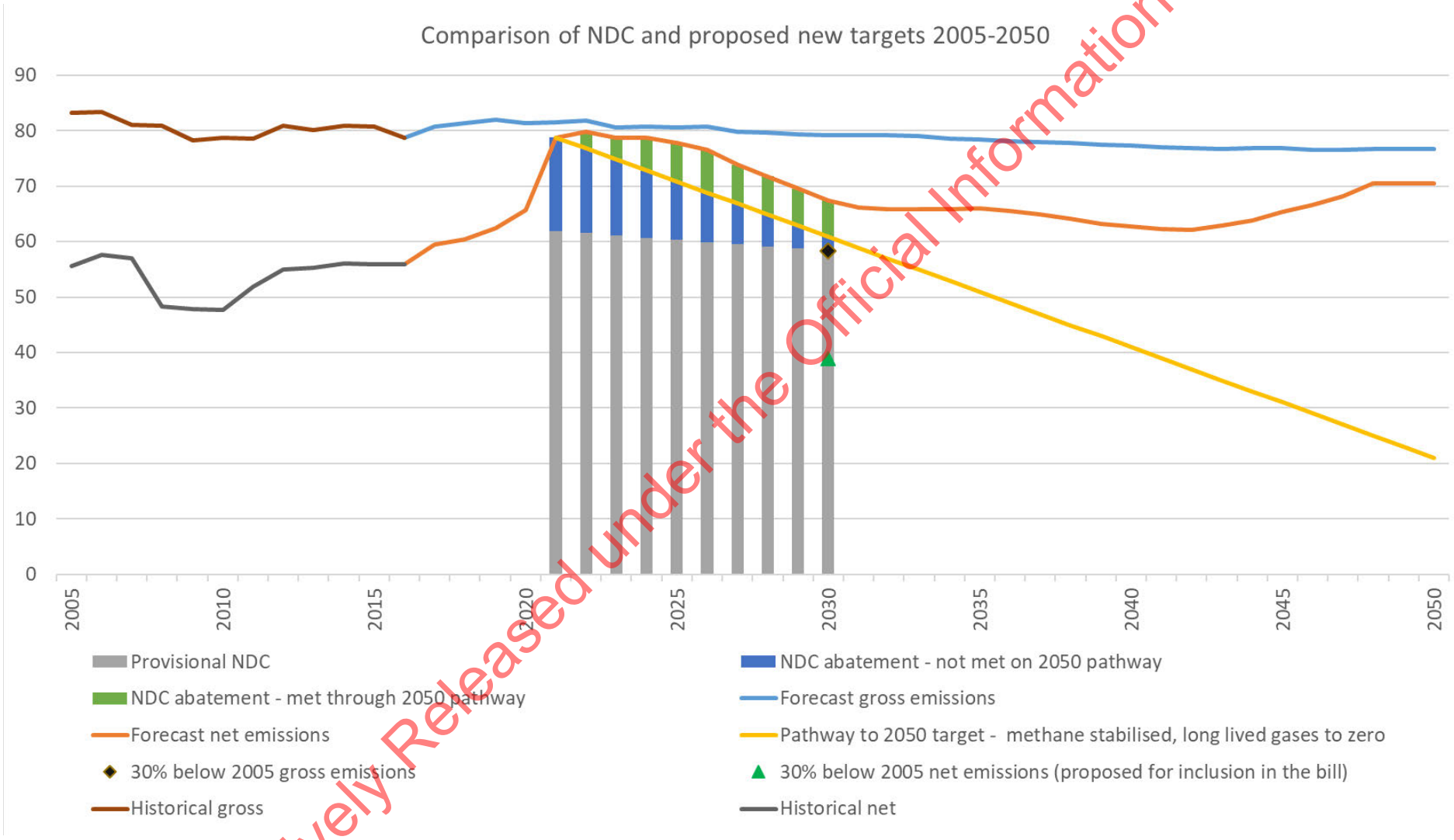
c.

Signature

Janine Smith
Director
Climate Change

Hon James Shaw
Minister for Climate Change **Date**

Appendix: Comparison of NDC and proposed new targets 2005-2050



Biogenic methane reductions required under the Zero Carbon Bill (second draft of the Cabinet paper)

Date Submitted:	4 April 2019	Tracking #: 2019-B-05486	
Security Level	In-confidence	MfE Priority:	Non-Urgent

	Action sought:	Response by:
To Hon James Shaw, Minister for Climate Change	Note this briefing and discuss with officials	**8 April 2019**

Actions for Minister's Office Staff	**Return** the signed report to MfE.
Number of appendices and attachments #1	Appendix A: Cabinet paper: Biogenic methane reductions required under the Zero Carbon Bill
Note any feedback on the quality of the report	

Ministry for the Environment contacts

Position	Name	Cell phone	1st contact
Principal Author	Jemima Jamieson	027 536 5265	
Responsible Manager	Lewis Stevens	0204 009 5469	✓
Director	Janine Smith	021 144 7617	

Biogenic methane reductions required under the Zero Carbon Bill (second draft of the Cabinet paper)

1. On 3 April 2019, you discussed possible target formulations with officials (2019-B-05483). In light of this conversation, you requested a number of changes to the paper that seeks Cabinet approval to the reductions of biogenic methane emissions required under the Climate Change Response (Zero Carbon) Amendment Bill (**the Bill**).

The Cabinet paper has been updated as requested

2. This briefing appends the draft Cabinet paper, which reflects your requested changes and now includes:

    - a biogenic methane component of the 2050 target that will reduce emissions of biogenic methane to 24-47 per cent below 2017 levels by 2050, and includes an additional requirement to reduce emissions of biogenic methane to 10 per cent below 2017 levels by 2030;
    - a 2017 baseline that applies to the biogenic methane component of the 2050 target, including the reductions that are required by 2030; and
    - the ability for the Climate Change Commission (**Commission**) to review any or all aspects of the 2050 target when it provides its advice on the fourth emissions budget, including the 2030 reductions in biogenic methane.

Drafting of the target in legislation

3. You have requested an indication of how the target could be drafted in the Bill. Drafting is the purview of the Parliamentary Counsel Office, who will prepare the draft legislation consistent with the decisions taken by Cabinet on the target. We are not able to provide indicative wording prior to Cabinet's decisions.

4. The drafting of the target is not likely to be complicated, although it may require consequential amendments to the emissions budgets part of the Bill.

5. s 9(2)(f)(iv) [redacted]

6. The current drafting of the bill also provides for the Commission to review any or all aspects of the target. This includes the year by which the target must be reached, and consequently provides scope to recommend a later target as 2050 approaches. Such a review could be at the request of the Government, or included in one of the Commission's periodic reviews of the target.

7. s 9(2)(f)(iv) [redacted]

Next steps

8. Please provide your comments on the Cabinet paper by Monday, 8 April. We will then make any necessary changes prior to lodgement.

Recommendations

9. We recommend that you:

   a. **Discuss** your comments on the Cabinet paper at your meeting with officials on Monday, 8 April

Yes/No

Signature

4/4/19

Janine Smith
Director
Climate Change

Hon James Shaw
Minister for Climate Change **Date**

In Confidence

Office of the Minister for Climate Change

Chair, Cabinet

Biogenic methane reductions required under the Zero Carbon Bill

Proposal

1. On 19 December 2018, the Cabinet Environment, Energy and Climate Committee (**ENV**) agreed to set a long term emissions reduction target for 2050 (**2050 target**) in the proposed Zero Carbon Bill (**the Bill**). The target will require New Zealand to:
   1.1. reach net zero emissions for all greenhouse gases, except biogenic methane, by 2050
   1.2. reduce emissions of biogenic methane (including, if necessary, to net zero) by 2050.
2. Consideration of the level of the biogenic methane component of the 2050 target was deferred, however, and I was invited to report back with recommendations on the biogenic methane target settings and supporting text in early 2019.
3. I now seek your agreement to a 2050 target that will reduce gross emissions of biogenic methane within the range of 24-47 per cent below 2017 levels by 2050. This will include a requirement to reduce emissions of biogenic methane to 10 per cent below 2017 levels by 2030.
4. Following agreement from Cabinet, the 2050 target will be drafted into the proposed Bill, which I intend to introduce to the House of Representatives in May 2019.

Context

5. In December 2018, ENV agreed that the Bill will provide a framework under which New Zealand can develop and implement clear and stable climate change policies that contribute to the global effort to limit global average temperature rise to 1.5 degrees Celsius above pre-industrial levels [ENV-18-MIN-0053 refers].
6. The agreed framework includes:
   6.1. a new greenhouse gas emissions reduction target for 2050;
   6.2. a series of emissions budgets to support achievement of the 2050 target;
   6.3. a range of adaptation measures; and
   6.4. an independent Climate Change Commission.
7. It was further agreed that the 2050 target would contain two components: one for biogenic methane, and another for all other greenhouse gases [ENV-18-MIN-0053

refers]. This approach acknowledges the different atmospheric lifetimes, potency, and warming effects of different greenhouse gases.

8. ENV agreed that the first component of the 2050 target would reduce all greenhouse gases, except biogenic methane, to net zero by 2050. Consideration of the level of the biogenic methane target component was deferred, however, and I was invited to report back with recommendations on target settings for biogenic methane for inclusion in the Bill, and supporting text [ENV-18-MIN-0053 refers].

Analysis

9. Following consultation with my Ministerial colleagues, and consideration of economic impacts, technological advancements, and scientific advice, I recommend that the Bill includes a 2050 target that specifies the reductions of biogenic methane that will be required by 2030 and 2050.

The reductions of biogenic methane required by the 2050 target should align with global scenarios consistent with limiting warming to 1.5 degrees Celsius

10. I recommend that the 2050 target should reduce gross emissions of biogenic methane within the range of 24-47 per cent below 2017 levels by 2050. This reflects the Intergovernmental Panel on Climate Change (**IPCC**) special report, which found that in scenarios limiting warming to 1.5 degrees with limited or no overshoot, the central range of reductions in agricultural methane emissions is 24-47 per cent below 2010 levels.

11. Requiring biogenic methane emissions to reduce to 24-47 below 2017 levels by 2050 would also be consistent with our obligations under the Paris Agreement, which oblige us to pursue efforts to limit temperature increase to 1.5 degrees Celsius above pre-industrial levels by the second half of the century. However, it has other advantages too.

12. The proposed reductions would reflect a strong commitment to limiting global warming to 1.5 degrees. It would also send a strong signal to New Zealand's waste and agricultural sectors, thereby encouraging innovation and investment and potentially positioning us at the forefront of technological developments.

13. Evidence and analysis shows that reducing biogenic methane emissions by between 24 and 47 per cent will be challenging, but achievable. For example:

    13.1. The Biological Emissions Reference Group report (**BERG**) (December 2018) set out that current and potential future emissions reduction technologies (e.g. methane vaccines and methane inhibitors), could potentially reduce overall biological emissions by 22-48 per cent by 2050.

    13.2. Reducing biogenic methane emissions by 24-47 per cent aligns with New Zealand's historic efficiency improvement. If current trends continue, greenhouse gas emissions per unit of meat and milk production between 2016 and 2050 could reduce by approximately 29 per cent, assuming production levels remain constant.

    13.3. Some members of the agricultural sector are already takings steps to reduce emissions. For instance, Synlait committed to a set of sustainability targets and actions across on-farm and off-farm emissions in June 2018.

These include a pledge to reduce its emissions intensity (per kilogram of milk solids) by 35 per cent on-farm by 2028.

13.4. Since 2002, the waste sector has reduced its methane emissions by 15 per cent, and there are opportunities for further reductions (e.g. via landfill gas recovery for energy and the diversion of organic waste).

14. Finally, the latest IPCC report shows that a failure to limit global average temperature rise to 1.5 degrees Celsius will result in greater risks to our ecosystems and marine biodiversity, species loss, adverse impacts to health, food security and economic growth, and other irreversible impacts from climate change. I therefore consider it critical that our emissions of biogenic methane reduce in line with the central range of global scenarios that limit global temperature rise to 1.5 degrees Celsius.

The 2050 target will also stipulate the reductions in biogenic methane that are required by 2030

15. The target will include a goal to reduce gross biogenic methane emissions to 10 per cent below 2017 levels by 2030. While the New Zealand Greenhouse Gas Inventory for 2017 is not yet available, the results of the 2016 Inventory provide a useful guide. This shows that, if 2016 was used as the baseline, emissions of biogenic methane would need to reduce from [32.7] Mt CO_2-e in 2016 to [29.4] Mt CO_2-e in 2030 [figures to be updated to reflect 2017 greenhouse gas inventory data when released]. The evidence outlined below indicates that this is achievable.

16. The BERG reported that total biological emissions from agriculture (of all gases, including methane, nitrous oxide and carbon dioxide) could reduce by 10-21 per cent by 2030 relative to baseline projections, if a range of mitigation options is implemented in packages.

17. The report discussed the potential to reduce emissions through measures that are currently available.

17.1. BERG suggests that there is potential to increase the uptake of on-farm mitigation measures. In a survey of 68 farmers, 64 per cent of respondents believed that New Zealand's agricultural emissions should be reduced, but 42 per cent were unaware of available mitigation strategies (other than planting trees).

17.2. Modelling suggested that widespread adoption of currently available mitigation options (primarily farm management practices) could result in reductions of total (all-gases) emissions of up to 10 per cent.

18. The report also referenced work by the New Zealand Agricultural Greenhouse Gas Research Centre (**NZAGRC**), which assessed the likelihood of new technologies reducing agricultural methane specifically. These included:

18.1. a methane vaccine. NZAGRC indicated a low confidence that a methane vaccine would be available and could deliver a 30 per cent reduction by 2030 (but medium-high confidence that it would be available by 2050); and

18.2. a grazing system methane inhibitor. NZAGRC indicated a medium-high confidence that a grazing system methane inhibitor would be available by 2030 and deliver a 10-30 per cent reduction in biogenic methane.

19. On average, greenhouse gas emissions per unit of meat and milk produced on New Zealand farms have dropped by around 1 per cent per year for at least the past 20 years. Despite these efficiency improvements, emissions have increased over this period due to an increase in production. While I expect that emissions per unit of production will continue to decrease, to achieve real emissions reductions and meet the 2030 target, leaders in the agricultural sector will need to set goals to improve the efficiency of their operations, and reduce their overall emissions.

Emissions budgets will support achievement of the 2050 targets, including the reductions in emissions of biogenic methane required by 2030

20. ENV agreed that emissions budgets will be set with a view to meeting the 2050 target [ENV-18-MIN-0053 refers]. The additional requirement to reduce emissions of biogenic methane to 10 per cent below 2017 levels by 2030 will be included in the 2050 target. This means that the first two emissions budgets, which will run from 2022-2025 and 2026-2030, must seek to achieve the reductions required in 2030.

The 2050 target will be reviewed by the Climate Change Commission

21. In December, ENV agreed that any and all aspects of the 2050 target will be reviewed by the Climate Change Commission in conjunction with its advice on the fourth, fifth and sixth emissions budgets, or at the request of Government [ENV-18-MIN-0053 refers]. In the absence of a Government request, the first review will take place in 2024. The 2030 reduction in biogenic methane would be within the scope of this review and, if revised, may require changes to the second emissions budget.

Consultation

22. To be completed.

Financial implications

23. There are no financial implications beyond those agreed by Cabinet on 19 December 2018 [ENV-18-MIN-0053].

Legislative implications

24. There are no legislative implications beyond those agreed by Cabinet on 19 December 2018 [ENV-18-MIN-0053].

Regulatory impact analysis

25. This paper has no regulatory impacts beyond those discussed in the Regulatory Impact Analysis considered by ENV on 19 December 2018.

Human rights

26. The proposals in this paper are consistent with the New Zealand Bill of Rights Act 1990 and the Human Rights Act 1993.

Publicity and public release

27. The Bill has been widely discussed amongst New Zealanders and in the media, both before and during consultation on the discussion document, *Our Climate, Your Say,* in June and July 2018.

28. I propose to release this Cabinet paper on the Ministry for the Environment's website no later than when the draft Bill is introduced into the House of Representatives in mid-2019.

Recommendations

The Minister for Climate Change recommends that the Committee:

1. **note** that on 19 December 2018, the Cabinet Environment, Energy and Climate Committee agreed (ENV-18-MIN-0053 refers) that the Climate Change Bill will set a greenhouse gas emissions reduction target for New Zealand to achieve:
    1.1. net zero emissions for all greenhouse gases, except biogenic methane, by 2050
    1.2. a reduction in emissions of biogenic methane (including, if necessary, to net zero) by 2050
2. **agree** that the biogenic component of the 2050 target (recommendation 1.2) will require a reduction in gross emissions of biogenic methane within the range of 24-47 per cent below 2017 levels by 2050, and require gross emissions of biogenic methane to reduce to 10 per cent below 2017 levels by 2030
3. **agree** that the Climate Change Commission will review all aspects of the 2050 target in conjunction with its advice on the fourth emissions budget in 2024, including the reduction of biogenic methane emissions required by 2030
4. **note** consequential amendments to other parts of the Bill may be required as a result recommendation 3
5. **agree** that the Minister for Climate Change may make this Cabinet paper publicly available, subject to appropriate redactions, no later than when the draft Bill is introduced into the House

Authorised for lodgement.

Hon James Shaw

Minister for Climate Change

Climate Change Response (Zero Carbon) Amendment Bill – Draft responses to the Environment Committee's questions on science

Date Submitted:	26 June 2019	Tracking #: 2019-B-05733	
Security Level	In-Confidence	MfE Priority:	Urgent

	Action sought:	Response by:
To Hon James Shaw, Minister for Climate Change	**Provide feedback** on the draft responses	**5pm, 26 June 2019**

Actions for Minister's Office Staff	**Return** the signed report to MfE with your feedback.
Number of appendices and attachments #1	Titles of appendices and attachments (ie separate attached documents): 1. Draft responses to the Environment Committee's questions on science – for your review
Note any feedback on the quality of the report	

Ministry for the Environment contacts

Position	Name	Cell phone	1st contact
Principal Author	Dominic Thorn		
Responsible Manager	Scott Gulliver		
Director (acting)	Lewis Stevens		✓

Climate Change Response (Zero Carbon) Amendment Bill – Draft responses to the Environment Committee's questions on science

1. This briefing provides you with draft responses to 14 questions received from the Environment Committee on Thursday 20 June 2019 (see Appendix 1).
2. These questions relate to the science underpinning the Climate Change Response (Zero Carbon) Amendment Bill, in particular with respect to:
    - advice on nitrous oxide
    - the split gas approach
    - the pathways under the *Special Report on Global Warming of 1.5 °C* by the Intergovernmental Panel on Climate Change.
3. We seek your feedback on these draft responses **by 5pm today, 26 June 2019**.
4. Note that we will also seek comments today from the Parliamentary Commissioner (PCE) for the Environment on these draft questions.
5. We aim to provide our responses back to the Committee by Friday 12 July 2019, as agreed with the Environment Committee.

Recommendations

6. We recommend that you:
    a. **read** the draft responses provided in Appendix 1 and **provide any comments** back to MfE officials by 5pm today, 26 June 2019
    b. **note** that we are forwarding these questions to PCE today for comments.

Signature

pp

Lewis Stevens
Acting Director
Climate Change Directorate

Date 26/6/19.

Hon James Shaw
Minister for Climate Change

Date

Appendix 1. Draft responses to the Environment Committee's questions on science – for your review

Climate Change Response (Zero Carbon) Amendment Bill
Supplementary Information for the Environment Select Committee
Prepared by the Ministry for the Environment

On 24 June 2019, the Environment Committee asked the following questions of officials:

	Question	Answer
1	The Explanatory Note for the Bill (page 4) states that the IPCC 1.5C report concluded that in the central range of global scenarios consistent with staying within 1.5C, with limited or no overshoot, required CO2 to reduce to zero and methane to reduce 24 – 47%, what did the IPCC report say for nitrous oxide?	The IPCC assessment describes scenarios consistent with limiting global warming to 1.5 degrees Celsius with limited or no overshoot. As stated in the quote from the report in your Q9, they do not indicate requirements. In these scenarios, the central range of reductions in nitrous oxide emissions is -26% to +1% relative to 2010 levels by 2050
2	Why has the IPCC report not been used to set the target for nitrous oxide?	Nitrous oxide is included alongside the other long-lived gases in the target for "all other gases", reflecting that emissions of these gases need to be reduced to net zero overall in order to limit their effect on the climate. Combining these emissions into a single target also allows flexibility in how the target is met.
3	Why have we split short and long lived gases in setting a target?	Short and long-lived gases behave differently in the atmosphere and have different contributions to warming. Splitting the gases into two groups allows us to ensure our targets are consistent with the 1.5°C temperature target. The long-lived gases are exchangeable with regard to their effect on temperature. Combining them in a single target allows the emissions reductions to be made in the most cost-effective way.
4	In calculating the pathways for different gases, does the IPCC use a split gas approach for short and long-lived gases?	No, the scenarios assessed in the IPCC report treat individual greenhouse gas emitting activities separately. These are then aggregated to produce the reported pathways for each gas.

5	Has the belief that short-lived gases do not need to reduce to zero been based on the IPCC 1.5C report, if so, what page number?	The understanding that emissions of short-lived gases do not need to reduce to zero pre-dates the IPCC 1.5 C report. But it is also clearly stated there in Cross-Chapter Box 2: "Measuring Progress to Net Zero Emissions Combining Long-Lived and Short-Lived Climate Forcers", on page 66. An extract from this box says: "Natural processes that remove CO_2 permanently from the climate system are so slow that reducing the rate of CO_2-induced warming to zero requires net zero global anthropogenic CO_2 emissions, meaning almost all remaining anthropogenic CO_2 emissions must be compensated for by an equal rate of anthropogenic carbon dioxide removal (CDR). ... In contrast, sustained constant emissions of a SLCF such as methane, would (after a few decades) be consistent with constant methane concentrations and hence very little additional methane-induced warming." (extract simplified by removing references)
6	Does the IPCC report state that nitrous oxide emissions need to reduce to zero to avoid 1.5C of warming, if so, what page number?	The report does not make that statement.
7	If the assumptions in the IPCC models were changed to assume nitrous oxide could be mitigated at a lower cost, would that impact the calculated pathway for methane? (i.e. are reduction inter changeable)	There are a number of pathways outlined in the report, all with different inputs and assumptions, and all producing different trajectories for each gas. The biogenic methane target in the Zero Carbon Amendment Bill is based on the ensemble of model pathways in the IPCC report limiting warming to 1.5 C with no or limited overshoot, that takes into account a range of assumptions. There is a trade-off between the emissions reductions of different

		greenhouse gases, with respect to achieving a warming goal. Different long-lived gases are directly exchangeable: for example, a reduction target could be achieved by reducing only CO_2 emissions, or only N_2O, or a combination of the two. All three options have essentially the same temperature benefit. But the trade-off between methane and nitrous oxide is not a straightforward exchange: the temperature contribution from long-lived gases depends on the total cumulative emissions, while the temperature contribution from short-lived gases depends primarily on current and recent annual emission rates. The complexity of this comparison (cumulative emissions vs recent rates) is a fundamental reason for adopting a split target.
8	Why have we on one hand made a decision to take a split gas approach, but on the [other] hand based the level of our targets (for some gases) on models that allow different reductions in different gases to be interchanged?	The question seems to be based on a misunderstanding about the interchangeability of gases in these models. As identified in the answers to Q3 and Q7 above, we have adopted a split gas approach in order to align our target with a global temperature goal. Global emissions of long lived gases need to be reduced to net zero in order to stay within a temperature goal. Emissions of short-lived gases can be maintained at a level above zero. The climate components of the models in the IPCC report represent our current understanding of the global temperature response to greenhouse gas emissions. We cannot pick and choose models/scenarios. There are many ways to reduce emissions. The IPCC report made this clear, and it is robust to base

		mitigation pathways on the range of scenarios in that report.
9	In regards to all of the pathways presented in the IPCC report, why did the IPCC state, "These pathways illustrate relative global differences in mitigation strategies, but do not represent central estimates, national strategies, and do not indicate requirements"?	That statement in the IPCC 1.5 C report refers to the four Illustrative Pathways in Figure SPM.3b. It is also generally true of any individual pathway. The emissions pathways, and IPCC products in general, are "policy-relevant but not policy-prescriptive" The IPCC states of its reports: "*They may present projections of future climate change based on different scenarios and the risks that climate change poses and discuss the implications of response options, but they do not tell policymakers what actions to take*"
10	What level of reduction in each of the three main gases would be required to have no further warming from 2050?	There is no single answer to that question, but the extract from the IPCC 1.5 C report provided in the answer to Q5 is a good explanation.
11	The IPCC report presents representative pathways for four different global scenarios, including one scenario described as a "Middle of the road scenario". Some scenarios have 'overshoot' of a 1.5C and require negative emissions in the second half of the century. Why have we used only those scenarios that have "limited or no overshoot"?	The "middle of the road" scenario refers to the underlying assumptions of this pathway, drawn from the so-called "Shared Socio-economic Pathways" (SSPs). See Table 2.3 of the IPCC 1.5 C report (page 110) for more information about the different pathways. The choice of referring to pathways with no or limited overshoot is not a question of science. The range for 1.5 C scenarios with "no or limited overshoot" is cited in the Figure SPM.3b of the IPCC 1.5 C report. This reflects the Government's ambition for limiting global warming, as stated in Part 1 of the Bill. The central range of emissions reductions in 2050 for methane from agriculture in all 1.5 C scenarios including those with

		high overshoot is 11 to 41 percent below 2010 levels.
12	Does the Paris Agreement address the issue of if temperature limits are to be achieved with limited or no overshoot?	No, there are no time constraints associated with the temperature goals in the Paris Agreement.
13	The IPCC 1.5 report states that available pathways that achieve a 1.5C limit with limited or no overshoot keep global CO2e emissions to 25 – 30 Gt by 2030, this contrasts to median estimates for Paris targets (NDCs) of 52-58 Gt by 2030 (page 95) – in other words, in order to be on a pathway with limited or no overshoot global emissions would need to be near half those countries have pledged. We understand that countries will resubmit targets by 2020 following the Talanoa Dialogue, but is it reasonable to base New Zealand policy on a pathway that is so far off where countries have thus far indicated they are willing to go?	Signatories to the Paris Agreement committed to pursue efforts to stay within 1.5°C of pre-industrial levels. The target in the Zero Carbon Amendment Bill aims to set New Zealand on a path to reduce emissions consistent with this global goal.
14	Were pathways with overshoot considered and, if so, why were they rejected?	The range for 1.5 C scenarios with "no or limited overshoot" is cited in the Figure SPM.3b of the IPCC 1.5 C report. This reflects the Government's ambition for limiting global warming, as stated in Part 1 of the Bill.

Ministry for the Environment
26 June 2019

Summary of *Scientific aspects of New Zealand's 2050 emission targets* (Reisinger & Leahy)

Date Submitted:	26/6/2019	Tracking #: 2019-B-05734	
Security Level	In confidence	MfE Priority:	Non-Urgent

	Action sought:	**Response by:**
To Hon James Shaw, Minister for Climate Change	None	

Actions for Minister's Office Staff	**Return** the signed report to MfE.
Number of appendices and attachments 1	Titles of appendices and attachments (ie separate attached documents): 1. *Scientific aspects of New Zealand's 2050 emission targets*
Note any feedback on the quality of the report	

Ministry for the Environment contacts

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Director (Acting)	Lewis Stevens-Rembe	020 4009 5469	✓

Summary of *Scientific aspects of New Zealand's 2050 emission targets* (Reisinger & Leahy)

1. This briefing summarises a note by Andy Reisinger and Sinead Leahy (New Zealand Agricultural Greenhouse Gas Research Centre) on scientific and technical issues related to the Zero Carbon Bill published on 24 June 2019.
2. The note draws on the same expertise that led Andy to be consulted by the Parliamentary Commissioner for the Environment (PCE) and Productivity Commission, and employed by the Interim Climate Change Committee. Because of this, there is a risk that this will be seen as "the Government view" rather than independent commentary, however, Andy has not been a direct advisor to the Government regarding the 2050 target.
3. The note has two aims:
    a. to calculate the temperature implications of the emission targets in the Zero Carbon Bill
    b. to provide additional explanation of the findings from the recent IPCC special report on global emission pathways that would limit warming to 1.5°C relative to pre-industrial levels, with a focus on agriculture.

Comments on key points in the note

4. The following paragraphs are copied from the Executive summary of the note followed by our comments on each point.
    a. New Zealand's total gross greenhouse gas emissions to date (fossil carbon dioxide, nitrous oxide, and biogenic methane) are estimated to have contributed a little over 0.0028°C to the observed global warming of about 1°C above pre-industrial levels. While small in absolute terms, New Zealand's share in global warming to date is more than 4 times greater than its share of the global population and about 1.5 times greater than its share of the global land area.
        - These are simple scientific facts. They suggest arguments for New Zealand's level of ambition compared to other countries, although that is not a matter of science.
    b. New Zealand's biogenic methane emissions currently make a bigger estimated contribution to global warming than cumulative emissions since 1840 of fossil carbon dioxide and nitrous oxide combined. If gross emissions of those three gases continued at current rates, biogenic methane would remain New Zealand's largest single contributor to global warming for the next six decades despite its relatively short lifetime in the atmosphere compared to carbon dioxide and nitrous oxide.
        - This conclusion depends on assessing emissions since 1840. Limiting it to 1990 onwards, carbon dioxide is the biggest contributor.
    c. Reducing net emissions of long-lived greenhouse gases to or below zero as quickly as possible is essential to support the temperature goal of the Paris Agreement. The net-zero target proposed in the Zero Carbon Bill could be achieved in different ways, such as reducing all gases individually to zero, or offsetting nitrous oxide emissions with additional carbon dioxide removals. The climate outcomes under different approaches would be very similar if the Global Warming Potential is used to compare nitrous oxide and carbon dioxide emissions.
        - This is a very helpful demonstration of how carbon dioxide and nitrous oxide

fungibility is well justified within the net zero target.

d. Reducing New Zealand's biogenic methane emissions creates unambiguous and substantial benefits to the climate, in addition to the benefits of reducing long-lived gases. However, methane reductions should occur only *in addition, not as a substitute* to reducing emissions of long-lived greenhouse gases to net zero. Otherwise the cumulative warming from long-lived gases could eventually outweigh any benefit from methane reductions. The Zero Carbon Bill's provision of a separate target for biogenic methane emission helps avoid perverse outcomes that could occur from trade-offs between those gases under an all-gases target.

    - This provides support for the split-gas approach.

e. Climate science cannot tell us how much New Zealand should reduce its emissions: the lower all emissions including methane can go, the better for the climate. The question for agriculture is what methane emission reductions are possible while still helping to sustain and support New Zealand's economy and maintaining viable and vibrant rural communities and businesses.

f. The IPCC identified a range of 24-47% global agricultural methane emission reductions by 2050, relative to 2010, in emission pathways that keep warming to 1.5°C. This wide range reflects different scenarios, strategic choices, and economic assumptions to achieve the temperature limit at the least cost globally. While this range can serve as reference point, it does not in itself prescribe a specific target for methane emissions reduction by any individual country. A national target necessarily depends on national value judgements around what is an appropriate contribution by New Zealand and the economic cost of reducing emissions in New Zealand.

    - These two points emphasises that we should not be blindly following the IPCC pathways. This is also the Government's view. Although using the same range in the Bill weakens the perception that economic and technical advice aligns with this.

g. Some stakeholders have advocated an alternative methane target, with reductions set such that future methane emissions do not create additional warming above current levels. For this goal to be met, New Zealand's biogenic methane would need to be reduced by 10-22% below current levels by 2050, depending on future changes in global methane emissions. Whether this approach is more equitable depends on whether equity is defined as causing the same additional warming or as making the same effort to reduce future emissions. The two are not the same. For short-lived gases like methane, a target based on 'not causing additional warming' amounts to a grand-parenting approach, i.e. an entitlement to continue to emit methane in future at a level that is determined solely by past emissions regardless of abatement potential or cost. Like all grand-parenting approaches, this raises equity issues that cannot be resolved by climate science.

    - This aligns with the Ministry's view. We have been anticipating making similar statements in response to questions from the Environment Committee.

Other comments on the note

5. The temperature calculations in the note are particularly helpful as the Ministry for the Environment does not have the capability to do this. We expect similar calculations to be published soon by Dave Frame.

6. The note acknowledges the concerns in the PCEs *Farms, forests and fossil fuels* report about the effect of carbon forestry on the New Zealand landscape, but separates scientific evidence

for setting emissions targets from the "broader social, economic and risk management perspective" for achieving them.

7. Regarding the agricultural methane pathways in the IPCC 1.5°C scenarios, the note says -

> "Reductions of agricultural emissions in these scenarios are thus significantly less stringent than for other sectors. This reflects an assumption common across most integrated assessment models that it is significantly more expensive and less feasible to make deep emission reductions in the agriculture sector than in most other sectors. *None of these scenarios assume novel mitigation technologies for agriculture such as methane inhibitors or vaccines, or nitrification inhibitors for nitrous oxide.*" (emphasis added)

8. Regarding the fairness of the methane target, the note says -

> "From a societal perspective, the question is whether we consider that the goal of 'treating sectors equally' is best served by ensuring that all sectors do not create additional warming above whatever warming they are contributing currently, or by undertaking similar effects to reduce their emissions."

This seems to directly address statements from agriculture sector leaders and Dave Frame, among others.

9. A final quotation worth noting: "How fast and how deep New Zealand can reduce its emissions is a question of economics, social and distributional impacts, not of climate science."

Signature

Lewis Stevens-Rembe
(Acting) Director
Climate Change

26/6/19

Hon James Shaw
Minister for Climate Change **Date**

Appendix 1: *Scientific aspects of New Zealand's 2050 emission targets*

NEW ZEALAND
AGRICULTURAL GREENHOUSE GAS
Research Centre

Scientific aspects of New Zealand's 2050 emission targets

A note on scientific and technical issues related to the Zero Carbon Bill

Andy Reisinger, Sinead Leahy
New Zealand Agricultural Greenhouse Gas Research Centre, Palmerston North

This note seeks to clarify the scientific basis and climate outcomes of emission reduction targets for New Zealand proposed in the Zero Carbon Bill and of alternative targets for methane emissions.

The note evaluates climate outcomes of the emission targets in the Zero Carbon Bill and clarifies key findings and assumptions in the recent IPCC report on global warming of 1.5°C referred to in the Bill. It also seeks to clarify assumptions that underpin alternative emission targets for methane that have been proposed.

We hope that the information in this note helps decision-makers separate the roles of climate science and of value judgements in setting emission targets for New Zealand. Both play necessary but distinct roles.

Contents

June 2019

The work in this note builds on earlier work commissioned by the Parliamentary Commissioner for the Environment (see Reisinger, 2018) and the authors are grateful for the stimulus that this initial work provided. Funding for this note has been provided by the NZAGRC.

This note was peer reviewed by Dr Joeri Rogelj, coordinating lead author for Chapter 2, "Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development", in the recent Special Report on Global Warming of 1.5°C by the Intergovernmental Panel on Climate Change. However, responsibility for any judgements, omissions or errors remaining in this note rests solely with its authors.

Executive summary

- New Zealand's total gross greenhouse gas emissions to date (fossil carbon dioxide, nitrous oxide, and biogenic methane) are estimated to have contributed a little over 0.0028°C to the observed global warming of about 1°C above pre-industrial levels. While small in absolute terms, New Zealand's share in global warming to date is more than 4 times greater than its share of the global population and about 1.5 times greater than its share of the global land area.
- New Zealand's biogenic methane emissions currently make a bigger estimated contribution to global warming than cumulative emissions of fossil carbon dioxide and nitrous oxide combined. If gross emissions of those three gases continued at current rates, biogenic methane would remain New Zealand's largest single contributor to global warming for the next six decades despite its relatively short lifetime in the atmosphere compared to carbon dioxide and nitrous oxide.
- Reducing net emissions of long-lived greenhouse gases to or below zero as quickly as possible is essential to support the temperature goal of the Paris Agreement. The net-zero target proposed in the Zero Carbon Bill could be achieved in different ways, such as reducing all gases individually to zero, or offsetting nitrous oxide emissions with additional carbon dioxide removals. The climate outcomes under different approaches would be very similar if the Global Warming Potential is used to compare nitrous oxide and carbon dioxide emissions.
- Reducing New Zealand's biogenic methane emissions creates unambiguous and substantial benefits to the climate, in addition to the benefits of reducing long-lived gases. However, methane reductions should occur only *in addition, not as a substitute* to reducing emissions of long-lived greenhouse gases to net zero. Otherwise the cumulative warming from long-lived gases could eventually outweigh any benefit from methane reductions. The Zero Carbon Bill's provision of a separate target for biogenic methane emission helps avoid perverse outcomes that could occur from trade-offs between those gases under an all-gases target.
- Climate science cannot tell us how much New Zealand should reduce its emissions: the lower all emissions including methane can go, the better for the climate. The question for agriculture is what methane emission reductions are possible while still helping to sustain and support New Zealand's economy and maintaining viable and vibrant rural communities and businesses.
- The IPCC identified a range of 24-47% global agricultural methane emission reductions by 2050, relative to 2010, in emission pathways that keep warming to 1.5°C. This wide range reflects different scenarios, strategic choices, and economic assumptions to achieve the temperature limit at the least cost globally. While this range can serve as reference point, it does not in itself prescribe a specific target for methane emissions reduction by any individual country. A national target necessarily depends on national value judgements around what is an appropriate contribution by New Zealand and the economic cost of reducing emissions in New Zealand.
- Some stakeholders have advocated an alternative methane target, with reductions set such that future methane emissions do not create additional warming above current levels. For this goal to be met, New Zealand's biogenic methane would need to be reduced by 10-22% below current levels by 2050, depending on future changes in global methane emissions. Whether this approach is more equitable depends on whether equity is defined as causing the same additional warming or as making the same effort to reduce future emissions. The two are not the same. For short-lived gases like methane, a target based on 'not causing additional warming' amounts to a grand-parenting approach, i.e. an entitlement to continue to emit methane in future at a level that is determined solely by past emissions regardless of abatement potential or cost. Like all grand-parenting approaches, this raises equity issues that cannot be resolved by climate science.

1. Purpose

The Government recently introduced the Climate Change Response (Zero Carbon) Amendment Bill, with the purpose "*to provide a framework by which New Zealand can develop and implement clear and stable climate change policies that contribute to the global effort under the Paris Agreement to limit the global average temperature increase to 1.5° Celsius above pre-industrial levels*".

The purpose of this technical note is twofold:

1) to provide a scientific evaluation of the climate implications of the emission targets contained in the Zero Carbon Bill, and
2) to provide additional explanation of the findings from the recent Special Report by the Intergovernmental Panel on Climate Change (IPCC, 2018) on global emission pathways that would limit warming to 1.5°C relative to pre-industrial levels, with a focus on agriculture.

The note also considers the scientific basis and assumptions implicit in other targets that have been proposed for New Zealand's methane emissions.

2. Introduction and Context

The Zero Carbon Bill includes new greenhouse gas emission reduction targets for the year 2050:

- To reduce gross emissions of biogenic methane to 24% to 47% below 2017 levels by 2050, with an interim requirement to reduce emissions to 10% below 2017 levels by 2030, and
- To reduce net emissions of all other greenhouse gases to zero by 2050.

In setting those targets, the Zero Carbon Bill refers explicitly to the findings in the recent IPCC Special Report on Global Warming of 1.5° (IPCC, 2018).

Agreeing on any national policy framework to achieve long-term climate change outcomes, and setting emission reduction targets, inevitably will require balancing a complex set of objectives and value judgements. However, natural and social science can help inform such judgements by quantifying the climate outcomes from different targets and clarifying underlying assumptions by:

- quantifying the climate outcomes from the Zero Carbon Bill's targets
- clarifying the methodology and assumptions in the recent IPCC Special Report on Global Warming of 1.5° (IPCC, 2018), which the Government has used to set the indicative emission reduction target range for biogenic methane
- clarifying the implicit or explicit assumptions necessary to move from emission reduction ranges in global emission scenarios to national targets, and the assumptions inherent in alternative emission targets that have been proposed especially for New Zealand's agricultural methane emissions.

The NZAGRC has not been involved in the setting of targets in this Bill and the authors of this note make no judgement as to whether the targets are appropriate.

3. Climate consequences of New Zealand's 2050 emission targets

3.1 New Zealand's contribution to climate change from emissions to date

The Paris Agreement, which the Zero Carbon Bill seeks to support, aims to limit the increase in global average temperatures 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*".

New Zealand's current total contribution to global warming is dominated by historical carbon dioxide emissions and removals from land-use change (see Figure 1). A significant fraction of these emissions occurred during the first few centuries of human settlement, well before the global industrial revolution (PCE, 2019).

Given the uncertainties and distant historical legacy relating to emissions from land-use change, we focus in the remainder of this note only on the warming caused by New Zealand's gross emissions from fossil carbon dioxide, biogenic methane, and nitrous oxide. These emissions started largely only after European settlement and accelerated during the 20th and early 21st century (see e.g. Ausseil *et al.*, 2013). The biggest contribution to global warming from New Zealand's gross emissions of these gases currently comes from biogenic methane (mainly from ruminant livestock but also landfill waste), followed by fossil carbon dioxide and nitrous oxide. [1]

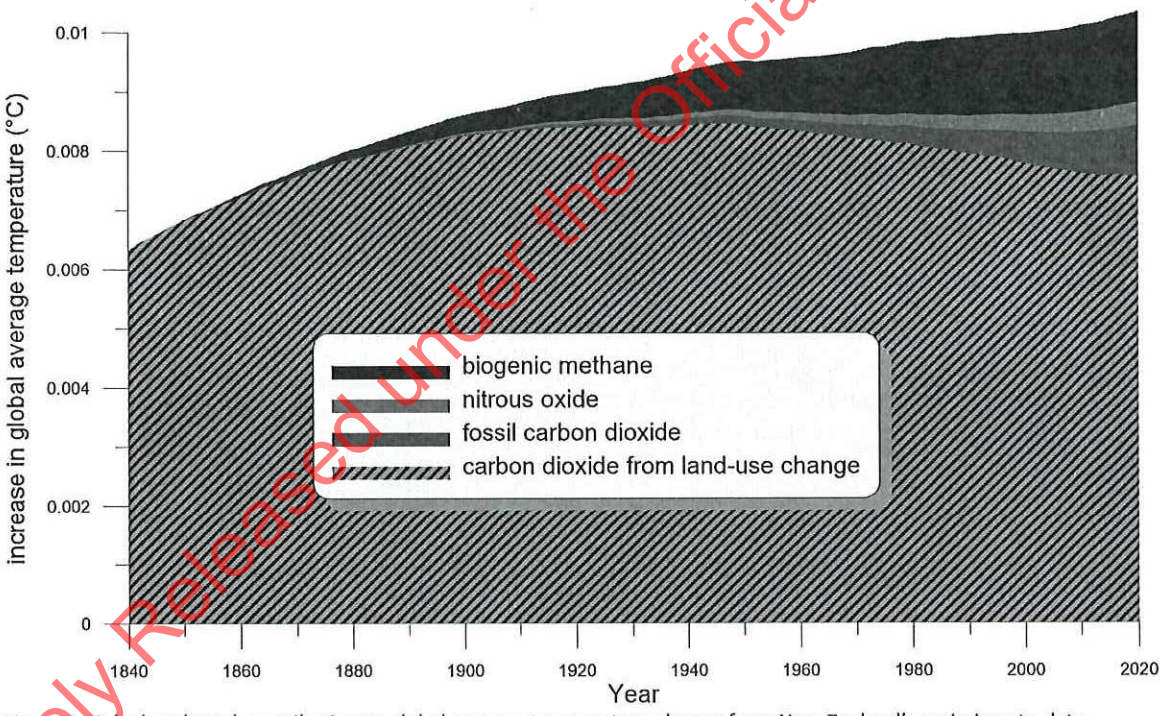

Figure 1. Calculated total contribution to global average temperature change from New Zealand's emissions to date. Emissions and associated warming of carbon dioxide from historical land-use change, fossil carbon dioxide, nitrous oxide, and biogenic methane from livestock are based on (PCE, 2019). Emissions of biogenic methane from waste were estimated using the national greenhouse gas emissions inventory and extrapolated back to 1840, and were added to methane emissions from livestock before calculating the resulting warming using the methodology in Reisinger (2018).

[1] We have not included in our calculations for this note any emissions of fossil methane or synthetic greenhouse gases (mainly hydrofluorocarbons). These gases currently contribute about 3.2% of New Zealand's total gross emissions. While clearly not irrelevant, their inclusion would not have fundamentally changed the broad results in this note.

The total amount of warming in the year 2019 estimated to have been caused by New Zealand's gross emissions of fossil carbon dioxide, nitrous oxide and biogenic methane to date is just under 0.0028°C. Global temperatures increased during the same period by about 1°C; this increase broadly matches the warming expected as a result of human activities over this period (IPCC 2018).

New Zealand's share in the observed global warming is small (about 0.28%), but more than 4 times greater than its share of the global population (about 0.06%) and about 1.5 times greater than its share of the global land area (about 0.18%).

Given the long lifetime of carbon dioxide and nitrous oxide in the atmosphere, past and current emissions of these gases will contribute to keeping Earth at elevated temperatures throughout the next few centuries and, in the case of carbon dioxide, millennia. Future emissions of these long-lived gases will add further to the warming caused already until those emissions are reduced to net zero.

By contrast, the warming caused by past and current biogenic methane emissions will largely disappear within the next few decades, given the shorter lifetime of methane in the atmosphere. The contribution from biogenic methane to future global warming therefore depends almost entirely on future emissions of this gas.

3.2 Achieving "net zero" emissions of long-lived greenhouse gases

One of the two emission targets of the Zero Carbon Bill is to achieve "net zero" emissions of all gases other than biogenic methane by 2050. The long-lived gases carbon dioxide and nitrous oxide make up the bulk of these emissions (see footnote 1).

The Bill's provision for a "net zero" target for these gases leaves it open whether this goal is reached by reducing emissions of each gas to zero individually, or whether some emissions that are difficult to avoid entirely would be offset by additional carbon removals.

Purely from a climate perspective, it makes no difference whether some on-going fossil emissions are offset by active removal of carbon dioxide from the atmosphere (via afforestation or any other means). The consequences for the climate would be virtually identical.

However, as noted e.g. by the Parliamentary Commissioner for the Environment (PCE, 2019), offsetting large quantities of fossil carbon dioxide emissions through large-scale afforestation may have important and unintended consequences for rural communities and may present risks to the future climate given the vulnerability of forests to fire, pests and diseases and hence impermanence of carbon removals via afforestation. If fossil carbon dioxide emissions continue at significant rates and carbon removal is undertaken only by afforestation, rather than more technological approaches such as bioenergy combined with carbon capture and storage or direct air capture and storage, this would also raise serious concerns about the availability of land in the longer term.

These concerns are relevant and important for any political decisions to manage the use of carbon offsets, but they do not change the results presented and discussed in this note, which focuses on scientific and technical aspects of emission targets, not how to best meet net emission targets from a broader social, economic and risk management perspective.

Another question is whether on-going emissions of nitrous oxide can be effectively offset by additional carbon dioxide removals. This is highly relevant since it will be virtually impossible for nitrous oxide emissions to be reduced to zero. Even the most efficient agricultural production systems result in some nitrous oxide being lost to the atmosphere.

Figure 2 illustrates different scenarios in which the goal of "net zero" emissions by 2050 could be achieved for nitrous oxide and carbon dioxide emissions. One hypothetical scenario would be that emissions of both gases are reduced to zero. Another scenario would be that nitrous oxide emissions remain at current levels and are offset entirely by additional carbon dioxide removals. A third, probably most likely scenario, would be some combination of these two.

The actual warming caused by these different scenarios is very similar, although the relative contribution from nitrous oxide and carbon dioxide differs. Total warming would be slightly less if nitrous oxide emissions could be reduced to zero, rather than offset by carbon dioxide removals. However, the difference in outcomes is small (about 3% of the total warming caused by both gases together in 2050, and about 6% by 2100). If this balance between nitrous oxide emissions and carbon dioxide removals were retained post-2050 through to the 22nd century, the difference would not increase further, and would in fact shrink and reverse again during the 23rd century.

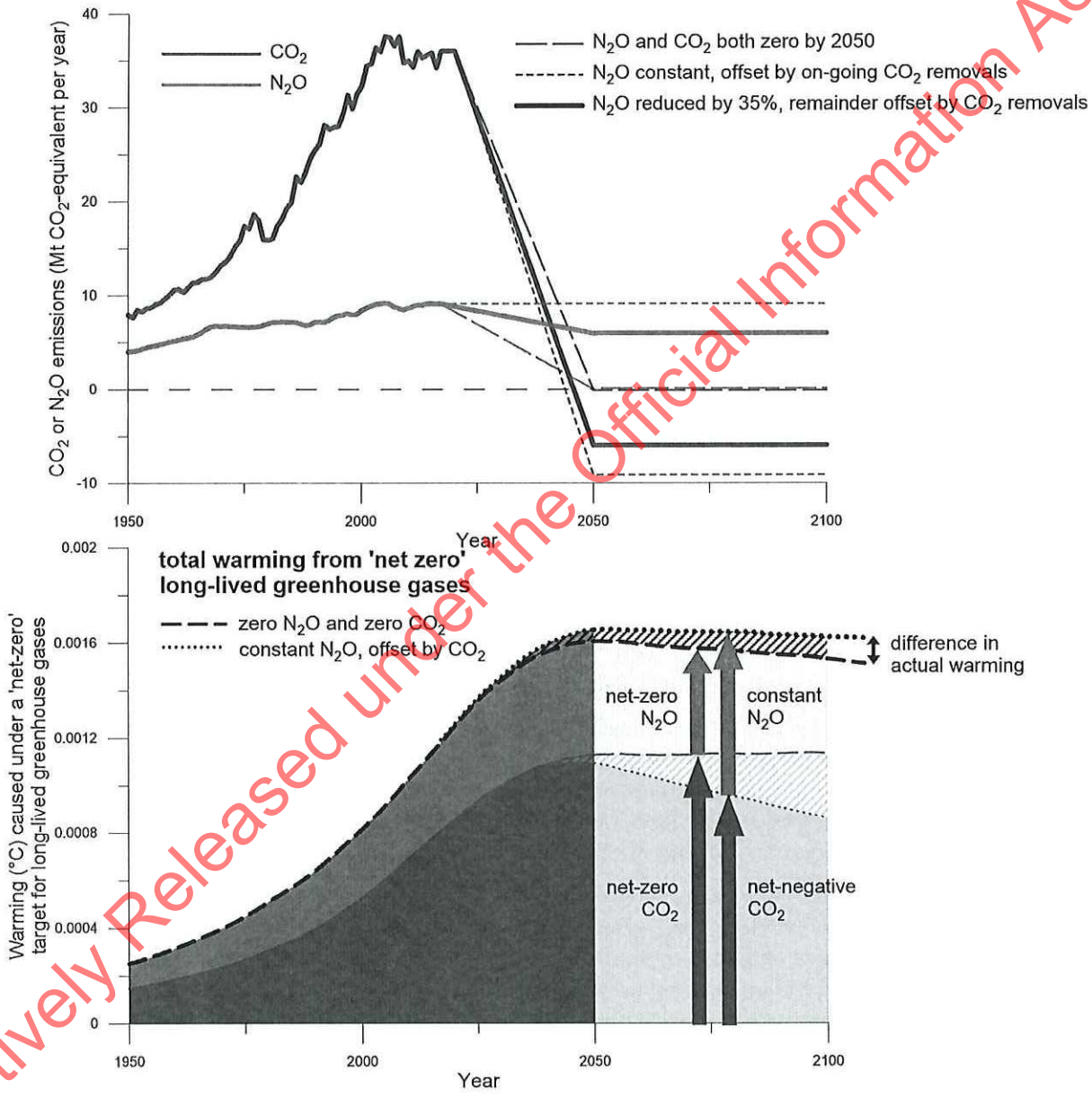

Figure 2. Illustrative scenarios of reaching net zero emissions of fossil carbon dioxide (red) and nitrous oxide (green) by 2050. All scenarios satisfy the goal of "net zero" emissions by 2050. The upper panel shows emissions, the lower temperature change. Dashed lines are for a scenario where both nitrous oxide and carbon dioxide emissions reach zero by 2050; dotted lines are for a scenario where nitrous oxide emissions remain constant and are offset by on-going carbon dioxide removals. Solid lines represent an intermediate scenario where nitrous oxide emissions are reduced by 35% and the remainder offset by carbon removals. Vertical arrows illustrate the contributions from nitrous oxide and carbon dioxide to the total warming from long-lived gases under the different scenarios. Emissions are assumed to remain constant beyond 2050 in each scenario. Note that this assumption is made only for illustrative purposes, as all emissions scenarios consistent with a 1.5°C goal require further global emission reductions (and additional carbon removals) beyond 2050.

These results indicate that from a climate perspective, there is only a minor difference whether the "net zero" target is achieved by reducing nitrous oxide and carbon dioxide both to zero, or by net removals of carbon dioxide compensating for on-going nitrous oxide emissions. In other words, actually achieving "net zero" emissions of these two gases is much more important for the climate than how the net-zero goal is achieved.

The relatively similar outcomes are to be expected, given that nitrous oxide has a lifetime in the atmosphere of more than 100 years and hence behaves similarly (though not identically) to carbon dioxide over this time frame. Using GWP_{100} to translate nitrous oxide into "CO_2 equivalent" emissions therefore appears defensible at least over the time frame of a few centuries.

3.3 Climate outcomes from the 2050 emission reduction targets

Figure 3 shows the emissions and resulting warming over the 21st century from past and future emissions of fossil carbon dioxide, nitrous oxide, and biogenic methane individually if emissions follow the targets proposed in the Zero Carbon Bill.[2]

In the absence of longer-term targets, we assume emissions to remain constant at the levels proposed in the Bill from 2050 onwards, but note that global pathways that limit warming to 1.5°C or well below 2°C have emissions of all gases falling further after 2050 (see Section 4). To illustrate the climate benefits of the emission reductions proposed in the Bill, we also show outcomes if emissions of all gases remained constant from 2017 onwards.

Figure 3 demonstrates that biogenic methane currently makes New Zealand's biggest contribution to global warming and constant emissions would result in an increasing contribution. Reducing emissions in line with the target range proposed in the Zero Carbon Bill would roughly stabilise the warming from biogenic methane at current levels (for a 24% reduction by 2050) or reduce it below current levels (for a 47% reduction by 2050).

New Zealand's fossil carbon dioxide emissions contribute less warming currently, but their contribution is increasing more rapidly than the warming from methane, given the cumulative warming effect from this long-lived gas. If carbon dioxide emissions remained constant at current levels, their warming would eventually exceed the warming due to New Zealand's biogenic methane emissions by about 2080 and continue rising thereafter.

New Zealand's nitrous oxide emissions make the smallest contribution to warming of these three gases, but the contribution is rising. Warming from nitrous oxide will continue to rise even if its emissions are reduced substantially (e.g. the contribution to warming increases even if nitrous oxide emissions were reduced by 35% by 2050, which would mirror the mid-range of the Zero Carbon Bill's emission reduction target for biogenic methane).

If nitrous oxide emissions were reduced to zero, their contribution to warming would decline slowly over the coming centuries. However, reducing emissions anywhere close to zero is not practically possible (even with new mitigation technologies under development) while New Zealand retains any agricultural activity. Achieving the "net zero" goal will inevitably have to rely on some amount of additional and sustained carbon dioxide removals to compensate for nitrous oxide emissions that cannot be avoided, but how much nitrous oxide might reduce within this goal is an open question.

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[2] The warming shown and discussed in this Section has been calculated on the assumption that the world as a whole will reduce emissions by 2050 consistent with the goal of the Paris Agreement to limit warming to well below 2°C. Lesser global action would result in greater global warming but would slightly reduce the warming caused by New Zealand's emissions (see Section 5.1). This would not fundamentally change the overall picture in terms of the contributions of different gases emitted by New Zealand, but it can change outcomes at the margin. Appendix I presents Figure 3 and Figure 4 calculated for a scenario where the world fails to meet the temperature goal of the Paris Agreement.

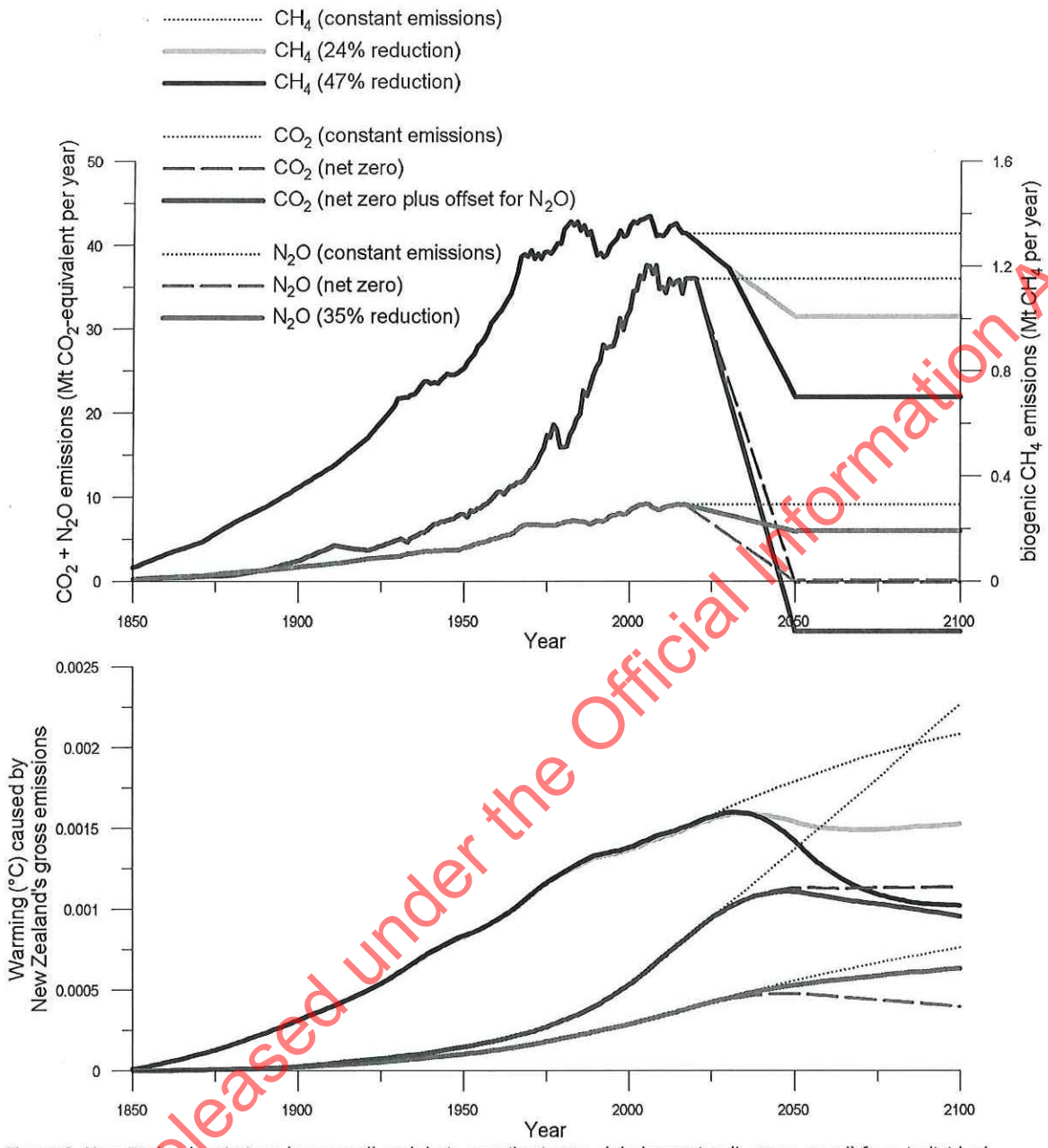

Figure 3. New Zealand emissions (top panel) and their contribution to global warming (bottom panel) from individual greenhouse gases for emissions consistent with the Zero Carbon Bill. For nitrous oxide, we assume a 35% reduction by 2050, with remaining emissions offset by additional carbon removals, but also show results if emissions were reduced to zero. Dashed lines show emissions and warming if emissions were held constant from 2017 onwards.

Figure 3 illustrates that there are clear and substantial benefits to the climate from reducing methane emissions. Compared to constant emissions, reducing New Zealand's biogenic methane emissions by 47% by 2050 (the upper end of the range proposed in the Zero Carbon Bill), and keeping emissions constant thereafter, would avoid almost the same amount of warming in 2100 as reducing New Zealand's fossil carbon dioxide emissions to zero by 2050.

Figure 4 shows the total contribution to warming from New Zealand's gross emissions of fossil carbon dioxide, nitrous oxide, and biogenic methane for the targets set out in the Zero Carbon Bill.

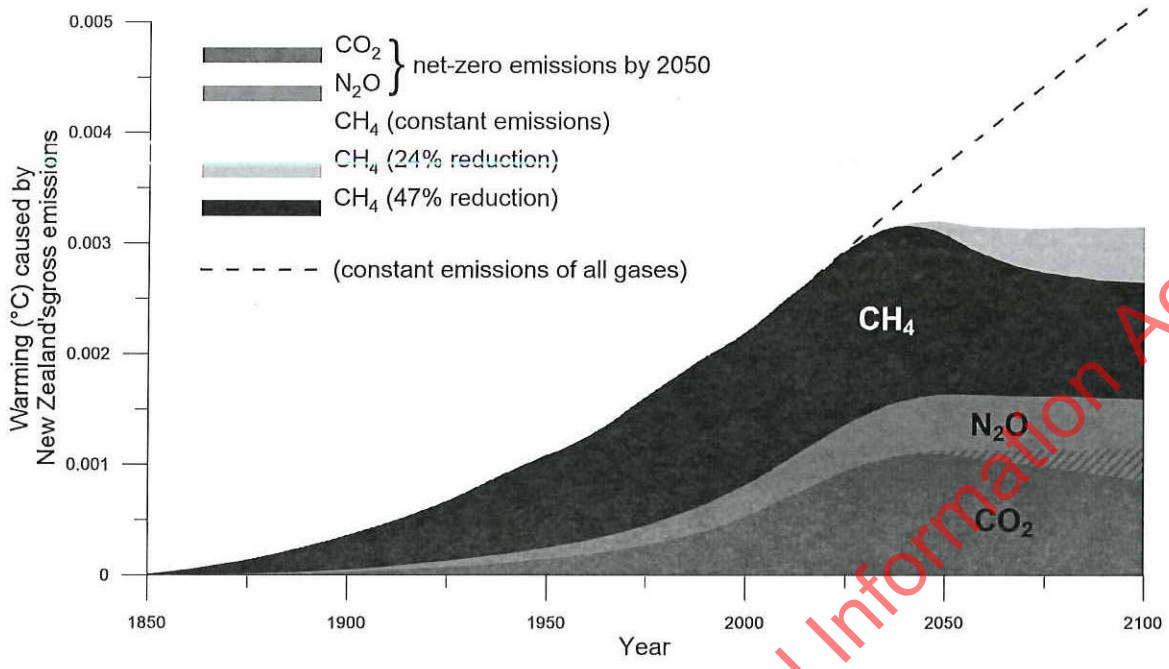

Figure 4. Combined contribution to global average temperature change from New Zealand's gross emissions of fossil carbon dioxide, nitrous oxide, and biogenic methane. Shaded areas represent the warming for the emission targets proposed in the Bill, with constant emissions after 2050. The dashed line shows the warming from constant emissions at 2017 levels. Different ways of reaching net-zero carbon dioxide and nitrous oxide emissions would not affect the overall warming but alter the relative contributions of those gases (see Section 3.2) as indicated by the red-green hatched area.

Reducing fossil carbon dioxide and nitrous oxide emissions to net zero by 2050 would result in additional warming from those gases combined above current levels until that time. After 2050, their contribution to warming would stabilise and decline very slowly if emissions remain constant after 2050 levels. However, if biogenic methane emissions remain at current levels, New Zealand's overall contribution to climate change would still continue increase well beyond 2050.

If, in addition, biogenic methane emissions were reduced by 10% below 2017 levels by 2030, and by 24% by 2050, this would result in additional warming from all emissions until 2050. If emissions of all gases then continue at the same level after 2050, New Zealand's contribution to global warming would remain at approximately the same level for the second half of the 21st century.

If biogenic methane were reduced by 47% below 2017 levels by 2050, this would see the total warming caused by New Zealand peak around 2040 and decline thereafter. If emissions of all gases then continue unchanged, New Zealand's contribution to global warming by the end of the 21st century would be slightly below the warming caused today.

In combination, these results illustrate that there are clear benefits, in terms of avoided climate change, from reducing net emissions of fossil carbon dioxide and nitrous oxide to zero, as well as from reducing biogenic methane emissions as much as possible. However, this should not be used to pick one target over the other: the climate benefits of reducing biogenic methane are effective only as *in addition to* reducing emissions of long-lived greenhouse gases to net zero, since any continued emissions of long-lived gases would continue to add to warming indefinitely. The dual target contained in the Zero Carbon Bill is consistent with this basic scientific perspective.

Climate science on its own cannot tell us how quickly we should reduce long-lived gases to net zero, or how low we should reduce biogenic methane emissions. The earlier net emissions of long-lived gases are reduced to zero, and the lower biogenic methane emissions can be reduced, the less New Zealand will contribute to future climate change. How fast and how deep New Zealand can reduce its emissions is a question of economics, social and distributional impacts, not of climate science.

4. Findings from the IPCC Special Report on 1.5 °C

4.1 High-level summary

The Zero Carbon Bill explicitly refers to the findings from the IPCC's Special Report on Global Warming of 1.5° (IPCC, 2018). This report provides a comprehensive assessment of the scientific literature on how the world could limit global warming to 1.5°C above pre-industrial levels, as this is part of the goal set out in the Paris Agreement. The report also assessed the impacts of this amount of warming and compared it to impacts if the world warms by 2°C or even more.

The IPCC found that to limit warming to 1.5°C, the world as a whole would need to reach net-zero emissions of carbon dioxide by about 2050, along with deep reductions in non-CO_2 emissions. Emissions reductions would need to continue beyond 2050, with net removals of carbon dioxide from the atmosphere at the global scale. Achieving these outcomes would require rapid and far-reaching transitions in energy, land, urban and industrial systems including transport and buildings.

Figure 5 illustrates graphically the scale and pace required for reductions in global carbon dioxide emissions, for a wide range of scenarios that would all limit the global temperature increase to 1.5°C with no or limited overshoot. The rate of emission reductions globally would have to be significantly greater than the historical rate of emissions increase.

The Figure also shows that the world as a whole will have to achieve net negative carbon dioxide emissions (i.e. carbon dioxide removals greater than gross emissions) from about 2050 onwards to remain within the 1.5°C temperature limit. This is in part to compensate for emissions of other long-lived greenhouse gases that cannot be reduced to zero, and in part to compensate for any overshoot of the temperature limit resulting from the failure to reduce emissions during the early 21st century.

Given this global perspective, a goal of net zero emissions for a long-lived gas like carbon dioxide can thus only be viewed as an intermediate milestone, not as end-point of low-emissions development.

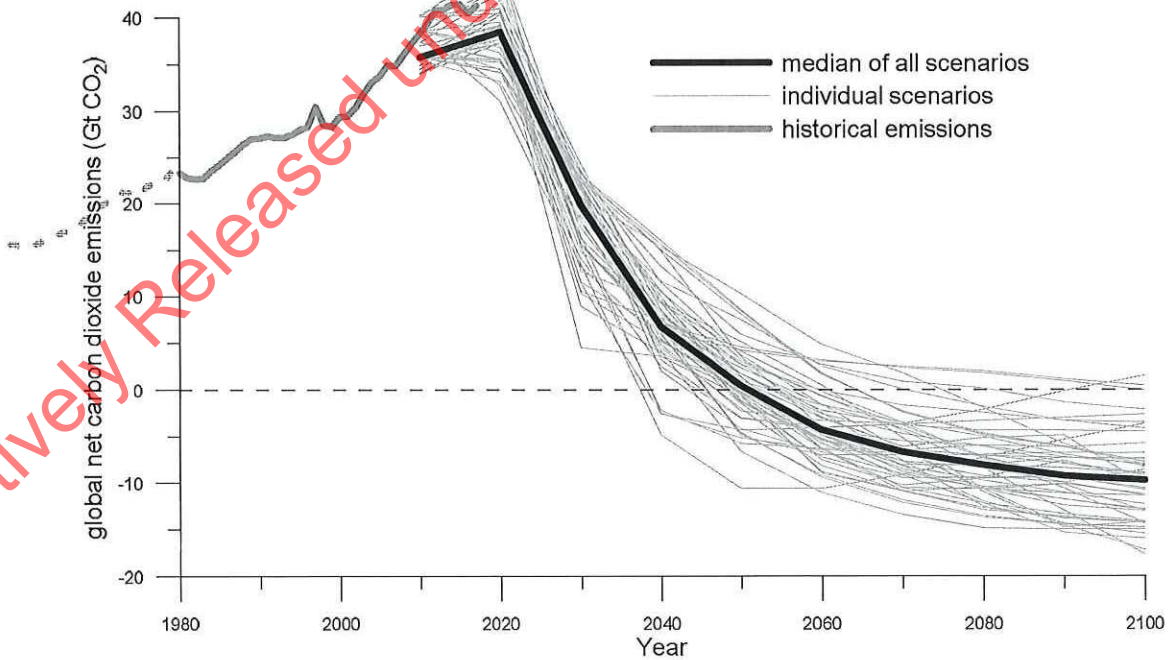

Figure 5. Global net carbon dioxide emission pathways that result in no or only limited overshoot of the 1.5°C temperature limit, taking into account the contribution from other greenhouse gases and aerosols. (Source: Huppmann, et al. (2018): *IAMC 1.5°C Scenario Explorer and Data hosted by IIASA.* Integrated Assessment Modelling Consortium & International Institute for Applied Systems Analysis, 2018. data.ene.iiasa.ac.at/iamc-1.5c-explorer).

4.2 Global agricultural emission pathways in scenarios that limit warming to 1.5°C

As part of its report, the IPCC compiled an extensive database of global emission pathways from the scientific literature that would limit the increase in average temperature to various levels.[3]

Out of 411 global scenarios, 74 would limit warming to well below 2°C (i.e. remain below 2° with greater than 66% probability), and 53 would limit warming to 1.5°C with no or limited overshoot. Here we summarise the biological greenhouse gas emissions from agriculture in these scenarios.

A key feature of the modelled global pathways is that they are all based on the objective of limiting the global temperature increase to a certain level, and to do so at the least global cost.

The models all recognise the different atmospheric behaviour of different greenhouse gases but differ in their assumptions about the availability and cost of different mitigation options. Consequently, they differ in the relative contributions from different sectors and technologies to greenhouse gas emissions and mitigation. Models also explored the consequences of additional constraints and assumptions about e.g. the deployment of nuclear power, renewables, bioenergy, global trends in dietary choices and calorie demand, and the consequences of delay or acceleration in climate policy in different sectors and world regions.

Figure 6 shows the modelled changes in global emissions of methane and nitrous oxide from agriculture, for scenarios that could be considered consistent with the Paris Agreement as they either limit warming to 1.5°C with no or limited overshoot, or to below 2°C with greater than 66% probability. Also shown are projected emissions in scenarios without any climate policy.

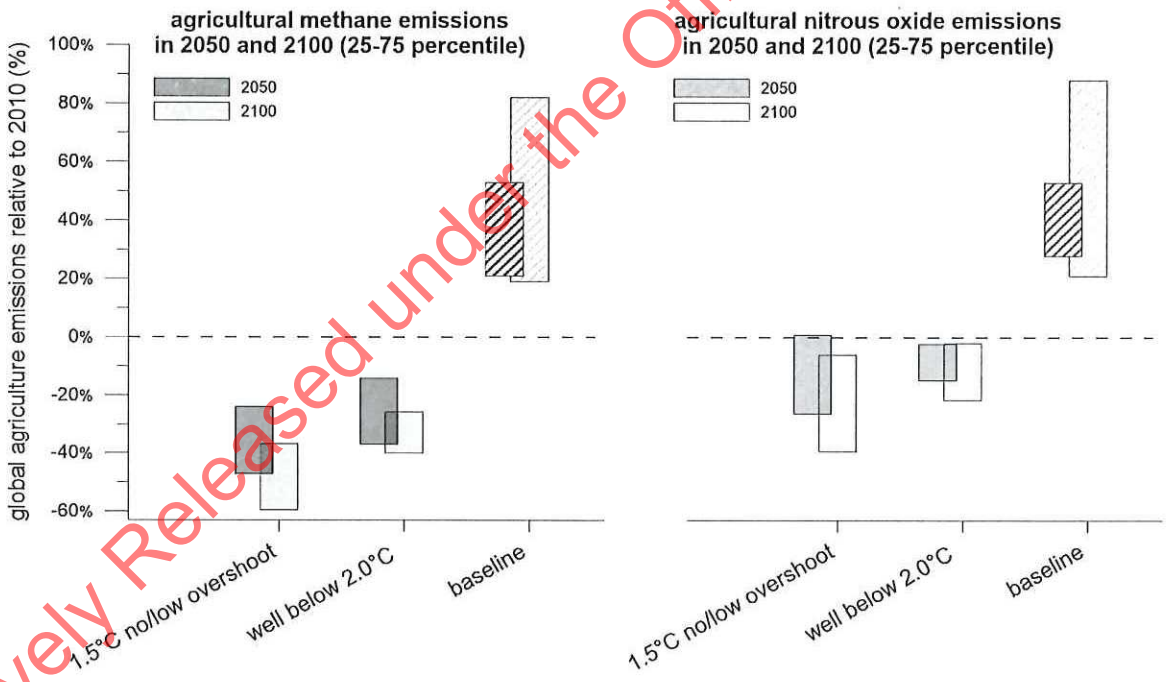

Figure 6. Changes in global emissions of methane (left) and nitrous oxide (right) from agriculture, forestry and other land-use (mainly agriculture) under scenarios that limit achieve global temperature outcomes consistent with the Paris Agreement. Hatched bands indicate projected emissions in baseline scenarios in the absence of climate policy in any sector.

[3] See: Huppmann, et al. (2018): *IAMC 1.5°C Scenario Explorer and Data hosted by IIASA*. Integrated Assessment Modelling Consortium & International Institute for Applied Systems Analysis, 2018. data.ene.iiasa.ac.at/iamc-1.5c-explorer. For more details, see Rogelj *et al.* (2018).

Emission are generally reduced even more by 2100 than by 2050, and emissions reductions are generally greater the lower the intended temperature limit. Emission reductions for nitrous oxide are generally less than for methane, reflecting the assumption in most models that there are fewer options to reduce nitrous oxide emissions from agriculture globally at a given cost than for methane.

For scenarios that limit global average temperature to 1.5°C with no or limited overshoot, the interquartile (25 to 75 percentile) range of scenarios has a reduction of methane emissions from agriculture by 24-47% in 2050 relative to 2010, with greater reductions of 37-60% by 2100.

By comparison, modelled changes in nitrous oxide emissions from agriculture in these same scenarios range from +1 to -26% by 2050, with greater reductions of 6-39% by 2100.

For context, methane emissions arising from the extraction and use of fossil fuels are reduced by 79-88% by 2050 relative to 2010, and carbon dioxide emissions from energy and industry are reduced by 82-99% by 2050 relative to 2010 (interquartile ranges). Reductions of agricultural emissions in these scenarios are thus significantly less stringent than for other sectors. This reflects an assumption common across most integrated assessment models that it is significantly more expensive and less feasible to make deep emission reductions in the agriculture sector than in most other sectors. None of these scenarios assume novel mitigation technologies for agriculture such as methane inhibitors or vaccines, or nitrification inhibitors for nitrous oxide.

Figure 7 shows in more detail the individual scenarios of global methane emissions from agriculture for pathways that limit the increase in global temperature to 1.5°C with no or limited overshoot, along with the median and interquartile range. Some scenarios reduce methane emissions by significantly more than 50% below 2010 levels by 2050, whereas others show virtually no reduction.

Scenarios that achieve the deepest emission reductions tend to assume not only changes in production systems but also changes in global dietary patterns as well as reduced food loss and waste and low population growth. While the assumptions in each individual scenario clearly are contestable, the range of emissions reductions across a diversity of models and scenarios with different assumptions is likely to be more robust than the results from any individual model.

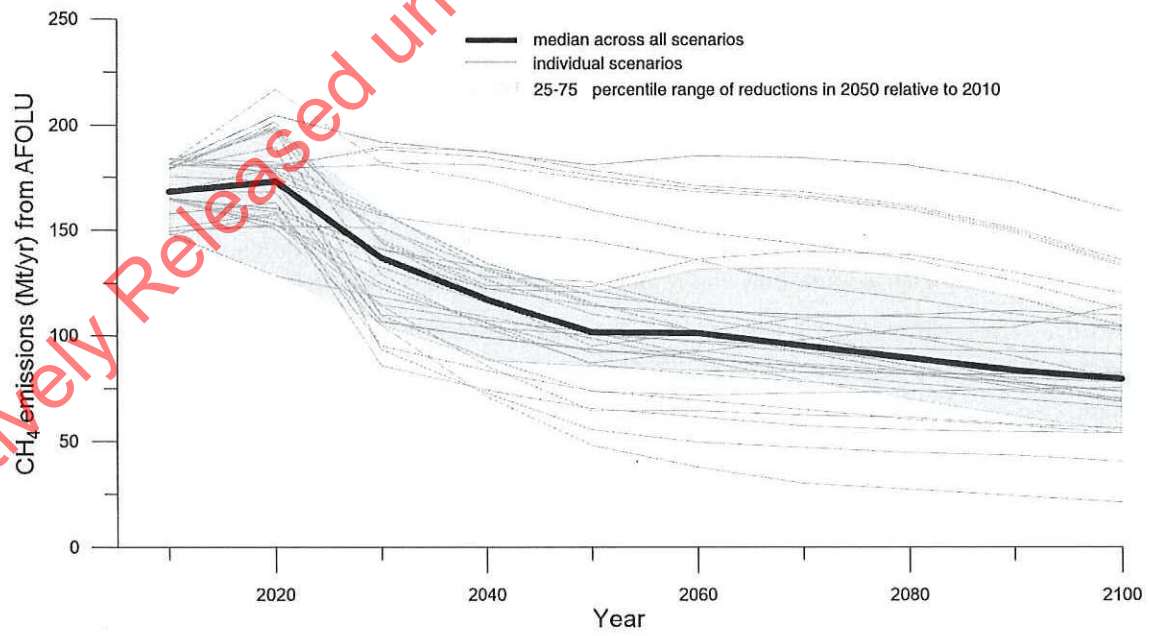

Figure 7. Individual scenarios and quartile ranges of global agricultural methane emissions in scenarios that limit the increase in global average temperature to 1.5°C with no or limited overshoot.

4.3 Interaction between carbon dioxide and methane in global scenarios

The IPCC report makes clear that globally, reducing carbon dioxide emissions to net zero by about 2050 is critical if the temperature increase is to be limited to 1.5°C. This is consistent with the fact that globally, carbon dioxide is the dominant driver of human-induced climate change and that there is a finite budget of carbon dioxide that can be emitted while remaining within this temperature limit. At current emission levels, the remaining global carbon budget of 570 to 770 Gt CO_2 for a 1.5°C limit will be depleted within 14-18 years, given current emissions of over 41 Gt CO_2 per year.

However, the above carbon budget assumes that emissions of other greenhouse gases and aerosols are reduced at the same time. Consequently, there is a clear interaction between the allowable global carbon budget and the emissions and contributions to global warming from other climate forcers (greenhouse gases other than CO_2, and aerosols such as black carbon). Within the range of scenarios assessed from the scientific literature, more ambitious action to reduce non-CO_2 emissions would increase the remaining allowable carbon budget consistent with the 1.5°C limit by about one third, whereas less ambitious action could decrease it by about one third.

In all modelled scenarios assessed by the IPCC that keep temperature to 1.5°C, methane emissions from all sources are reduced by *at least* 35% below current levels, but the median reduction across the range of different scenarios is 57%. Methane therefore contributes significantly less to global warming in 2050 in these scenarios than it contributes today.

If global methane emissions were reduced only as much as necessary to avoid *additional* warming above current levels from those emissions, this would drastically reduce the carbon budget compatible with 1.5°C. in that case, global carbon dioxide emissions would have to reach net zero more than 20 years earlier, i.e. before 2030, for the world to remain within the 1.5°C limit.

The balance between reductions of methane and carbon dioxide in the different scenarios reflects the mitigation costs for the different gases assumed in different global economic models along with the different impacts of these gases on global temperature. If a model assumes relatively low mitigation costs for methane, it will reduce those emissions more and allow a longer time to bring carbon dioxide emissions to zero. Vice versa, if a model assumes a high cost of reducing methane emissions, it will reduce those emissions less but in turn will have to reduce carbon dioxide emissions to zero earlier. Economic models balance those emissions reductions such that the total global cost across all sectors is minimised for a given temperature outcome.

4.4 Applicability of global emission reduction ranges to New Zealand

The New Zealand Zero Carbon Bill proposes a 2050 reduction target range for biogenic methane (agriculture and waste) of 24-47% below 2017 levels. This range corresponds to the interquartile range of global agricultural methane emission reductions in 1.5°C IPCC scenarios, but the IPCC range is for methane from agriculture only and reductions are relative to 2010 emissions not 2017. [4]

Apart from those differences, a key question is to what extent the global emission reduction ranges assessed by the IPCC can give guidance for national targets.

The IPCC made clear that the global scenarios do not constitute requirements at national level, i.e. emission targets for individual countries can obviously deviate from a global target. However, national targets cannot all deviate from the global target in the same direction since otherwise the

[4] Methane from waste comprises about 12% of New Zealand's total biogenic methane emissions. Methane emissions from waste declined by about 10% between 2010 and 2017, whereas methane emissions from agriculture increased by a little over 2% over the same period, with a total change of biogenic emissions of less than 1%.

global target would not be achieved. If some countries reduce their emissions by less than the global target, others will have to reduce their emissions by more if the global target is to be met.

Keeping in mind that the IPCC scenarios meet the global temperature limit at least global cost, using global scenarios as reference for New Zealand's domestic targets implies two key assumptions:

1) New Zealand's national overall emission reductions should be similar to global emissions reductions in pathways that limit warming to 1.5°C

2) The relative costs of abatement of the different gases and sectors in New Zealand are approximately the same as in the rest of the world.

Assumption 1 relies on ethical judgements whether New Zealand's overall emission reductions should mirror the necessary global average reductions, or whether New Zealand as a developed and comparatively wealthy country should undertake greater reductions than the global average. The latter would recognise that less developed countries will find it more difficult to achieve the same rate of emission reductions. This is a question of how New Zealand interprets and gives effect to the principle of "common but differentiated responsibilities" contained in the Paris Agreement.

The Zero Carbon Bill's target of reaching net-zero emissions of carbon dioxide and nitrous oxide clearly constitutes a more ambitious target than in pathways consistent with 1.5°C, as those pathways reduce only carbon dioxide emissions to net-zero by 2050 but achieve only limited reductions of nitrous oxide. By contrast, the Bill's target to reduce biogenic methane by 24-47% is slightly less ambitious than global scenarios, because reductions of methane from waste are generally assumed to be greater than reductions from agriculture due to lower abatement cost.[5]

Another important question is whether New Zealand actions should be guided by what the world as a whole *should* achieve to meet the objectives of the Paris Agreement or by the *actual* commitments and progress made by other countries. The collective mitigation commitments expressed by countries in their Nationally Determined Contributions under the Paris Agreement are currently insufficiently ambitious to limit warming to well below 2°C, let alone 1.5°C.

Answering these questions has little to do with the nature of methane as a short-lived gas but relies on ethical judgements and norms as well as geopolitical considerations.

Assumption 2 depends on whether efforts by New Zealand to reduce its biogenic methane emissions by 24-47% would have similar costs, benefits and broader social implications across New Zealand as reaching net zero emissions of carbon dioxide and nitrous oxide.

Again, answering this question is not contingent on methane being a short-lived gas but depends on economics, social impacts, and assumptions about future technologies and global markets.

Information about the actual cost of abatement remains limited given the absence of abatement incentives to date and hence limited practical experience of farmers incorporating greenhouse gas emissions into business decisions. Any emission target or target range for 2050 therefore can only be considered as an indicative starting point that must be subject to revision based on advances in mitigation technologies, possible changes in international markets and consumer demand, and actual responses of farmers to abatement incentives and the implications for rural communities.

[5] No detailed information about emissions reductions from waste are available from the publicly available IPCC database, but integrated assessment models generally assume methane emissions from waste (especially landfills) to be less costly to abate than methane emissions from agriculture (see Harmsen *et al.* (2019)). In the absence of New Zealand-specific information, we can only assume that similar relative differences in costs hold also in New Zealand.

5. Other methane reduction targets and their rationale

Some commentators and stakeholders have advocated a less stringent reduction target for agricultural methane than the 24-47% reduction range contained in the Zero Carbon Bill.

The key argument promoted is that methane should be reduced only to the point where it does not cause additional warming above today's level as this would then mirror the climate outcome of reducing emissions of long-lived gases to net-zero.

Supporters of this view argue that this would constitute an equitable and fair treatment of methane emitters compared to a net-zero target for emitters of long-lived greenhouse gases.

5.1 Scientific basis

The impacts on climate from different greenhouse gases are uncontested among climate scientists.

Emissions of carbon dioxide and nitrous oxide will continue to add further warming until their emission reach net zero, because their emissions accumulate in the atmosphere. Once net zero emissions of those gases are reached, their contribution to global warming would decline very slowly over a time scale of centuries (see Section 3.2).

Avoiding further warming from methane requires a much lesser reduction, given that methane does not accumulate in the atmosphere over centuries. A note by the Parliamentary Commissioner for the Environment last year showed that agricultural methane would need to be reduced by 10-22% by 2050, relative to 2016, to avoid any *additional* warming from New Zealand agricultural methane emissions above current levels; for technical details see Reisinger (2018).

The amount by which New Zealand's methane emissions have to be reduced to avoid additional warming is not a single fixed number but depends on actions undertaken by the rest of the world.

The reason for this is that how much the emission of one tonne of methane contributes to global warming depends on how much methane there is in the atmosphere already. The more methane is in the atmosphere already, the less additional warming an additional tonne of methane will cause.[6]

If countries globally reduce methane emissions by 2050 consistent with the goal of limiting the temperature increase to well below 2°C, the global methane concentration in 2050 could be considerably lower than today. In that case, any methane emitted by New Zealand would become more 'visible' in the atmosphere (i.e. more effective at absorbing heat radiation) and hence would cause more warming for each tonne emitted. As a result, New Zealand would have to reduce its methane emissions by 22% to avoid its emissions causing additional warming above current levels.

By contrast, if the world fails to reach the temperature goal of the Paris Agreement, global methane concentrations might not fall before 2050. In that case, New Zealand's methane emissions would have to be reduced by only about 10% to not cause additional warming.

Some scientists and stakeholders have promoted a single target of a 10% reduction for New Zealand's methane emissions as consistent with the goal of not adding to further warming. This is based on the notion that if *global* methane emissions from all sources were reduced by 10%, the contribution from methane to global warming would not increase above current levels.

However, while this is correct as a global thought experiment, New Zealand and the rest of the world are not identical. All global scenarios that limit warming to 1.5°C or even just well below 2°C reduce global methane emissions by a lot more than 10%. This is partly because a significant share of global

[6] This saturation effect is well recognized scientifically and incorporated in global models. An analogue to this saturation effect is that the voice of a single person is barely audible in a crowded room but highly audible in an empty hall.

methane emissions is tied to the extraction and use of fossil fuels, which would necessarily have to be reduced to meet the goal of the Paris Agreement (see Section 4.2).

If New Zealand as individual country wishes for its biogenic methane emissions to not cause additional warming above current levels, a 10% target by 2050 is applicable only if one assumes that the world as a whole does not reduce its methane emissions by more than 10% either. This is a significant assumption, as it would very likely mean that the temperature goal of the Paris Agreement will not be met (see Section 4.3). Whether this assumption is justified and should guide national decision-making is another matter that is not related to methane being a short-lived gas.

5.2 Equal additional warming vs equal effort: what does fairness mean?

The question of what emissions reductions are necessary to avoid additional warming from New Zealand's biogenic methane above current levels is fundamentally different to the question that is addressed by global models assessed by the IPCC.

A goal of 'not adding any additional warming from a specific gas from a specific country above the warming caused at present' is not based on any economic criteria and is not linked to a specific global temperature outcome. By design this goal ignores how much this gas contributes to global warming in absolute terms and whether future actions could reduce this contribution.

By contrast, the models assessed by the IPCC seek to achieve a given global temperature limit, relative to pre-industrial levels, at the least cost overall. By design they do not place pre-conditions on what contribution the future emissions of a given gas should make to future warming.

Given the long lifetime of carbon dioxide in the atmosphere, past emissions result in an almost constant level of warming for many centuries into the future. Future emissions of carbon dioxide will inevitably contribute additional warming on top of this historical legacy. Future emitters of carbon dioxide can at best avoid adding further warming, but they cannot undo historical warming caused by past emissions (past and future emitters are not necessarily the same entities).

Therefore, if emitters of carbon dioxide and other long-lived gases undertake maximum efforts to avoid future emissions, they can at best only achieve a goal of not creating additional warming.

By contrast, most of the warming caused by biogenic methane emitted up to 2019 will have disappeared naturally by 2050. This is a direct consequence of the relatively short lifetime of methane in the atmosphere. As a result, the contribution from biogenic methane to future global warming depends almost entirely on future emission levels and the actions taken by future emitters.

Therefore, if emitters of biogenic methane undertake maximum efforts to avoid future emissions, they could not only avoid creating additional warming but could reduce their contribution to warming well below the current contribution to global warming.

Figure 8 illustrates these differences by separating the past and future contributions to global warming that are due to past and to future emissions of fossil carbon dioxide and biogenic methane.

From a societal perspective, the question is whether we consider that the goal of 'treating sectors equally' is best served by ensuring that all sectors do not create additional warming above whatever warming they are contributing currently, or by undertaking similar efforts to reduce their emissions.

What constitutes equal efforts depends on the cost of emission reductions, current and future technologies, who actually bears such costs, and the broader societal implications of transformative change – it cannot be determined based on the atmospheric lifetime of methane.

Equal additional warming and equal effort are thus two fundamentally different things: for gases with significantly different lifetimes, causing the same additional warming above current levels almost certainly means not the same effort for emitters of those gases, and the same effort to reduce emissions almost certainly means not the same additional warming.

Future warming from a short-lived gas like biogenic methane is not an inescapable legacy of the past, it depends almost entirely on future emission choices. For biogenic methane, a target of 'not causing additional warming above current levels' therefore amounts to a grand-parenting approach, i.e. an entitlement to continue to emit methane in future at a level that is determined solely by past emissions regardless of abatement potential or cost. Like all grand-parenting approaches, this raises equity issues that cannot be resolved by climate science.

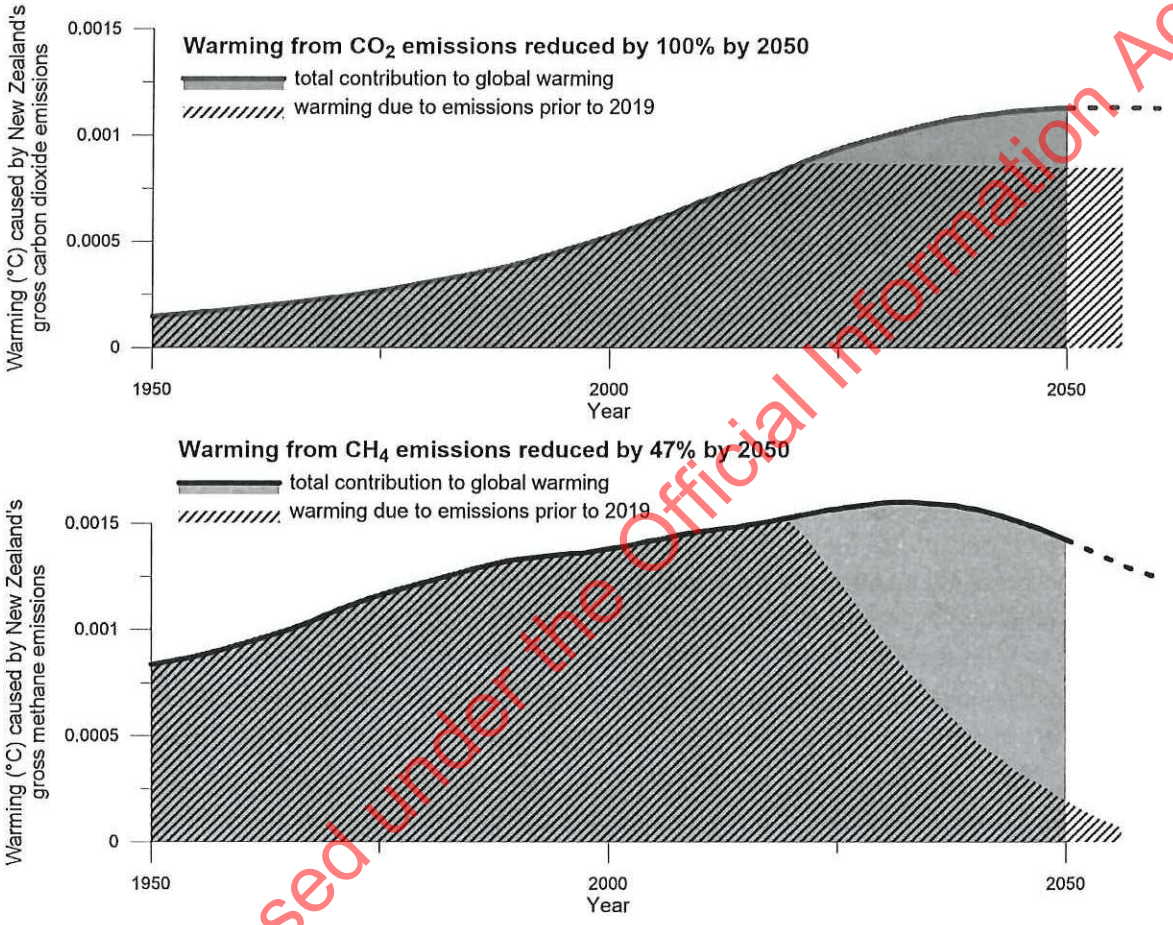

Figure 8. Total warming caused by New Zealand's gross (fossil) carbon dioxide and biogenic methane emissions, if carbon dioxide emissions reach net zero by 2050, and methane emissions are reduced by 47% by 2050 relative to 2017 levels. Hatched areas show the warming that is due to emissions that occurred prior to 2019, while solid areas show the warming that is additional to the warming caused by past emissions and that could be avoided by reducing future emissions. Dashed lines illustrate outcomes beyond 2050 if emission remain at constant levels from 2050 onwards.

Appendix I: warming from NZ under alternative global scenarios

The warming caused by emissions in New Zealand depends on how much of those gases is already present in the atmosphere. Different assumptions about global actions to reduce emissions can therefore influence how much warming would be caused by emissions in New Zealand. The warming from New Zealand's methane emissions is slightly less if the world undertakes less stringent emission reductions because this has a large impact on global methane concentrations, which in turn affects the warming efficacy of New Zealand's emissions; see Sections 3.3 and 5.1, also Reisinger (2018).

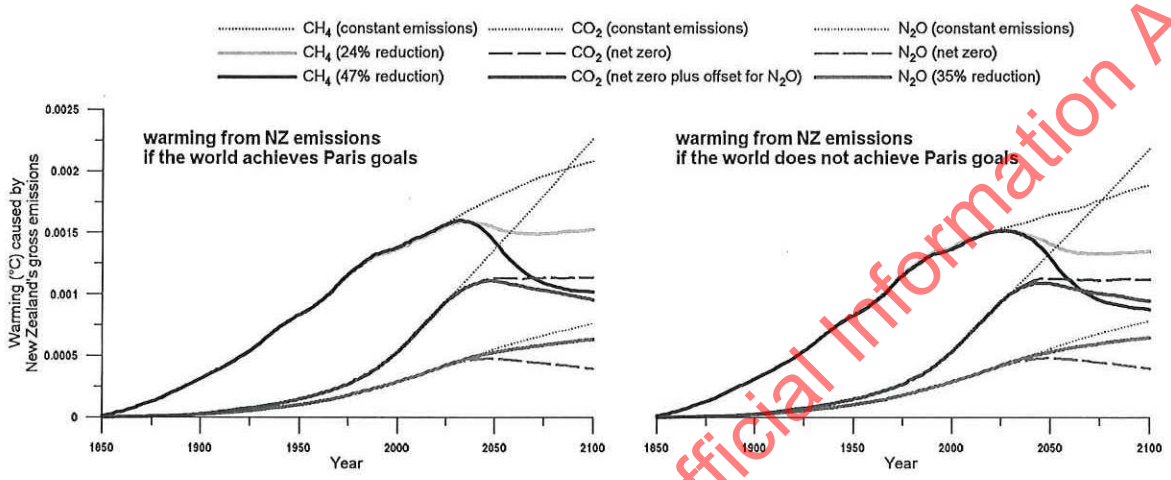

Figure 9. Contribution to global warming from individual greenhouse gases for emissions consistent with the Zero Carbon Bill. The left panel is identical to Figure 3, which assumes that the world reduces emissions by 2050 to achieve the temperature goal of the Paris Agreement. The right panel assumes that global emissions reductions are not sufficient to achieve the temperature goal of the Paris Agreement (resulting in warming of about 2.5°C above pre-industrial levels). New Zealand emissions are identical in both panels and are the same shown in the top panel of Figure 3. Technical note: for the left panel, the world follows the RCP26 pathway, for the right panel, it follows RCP45.

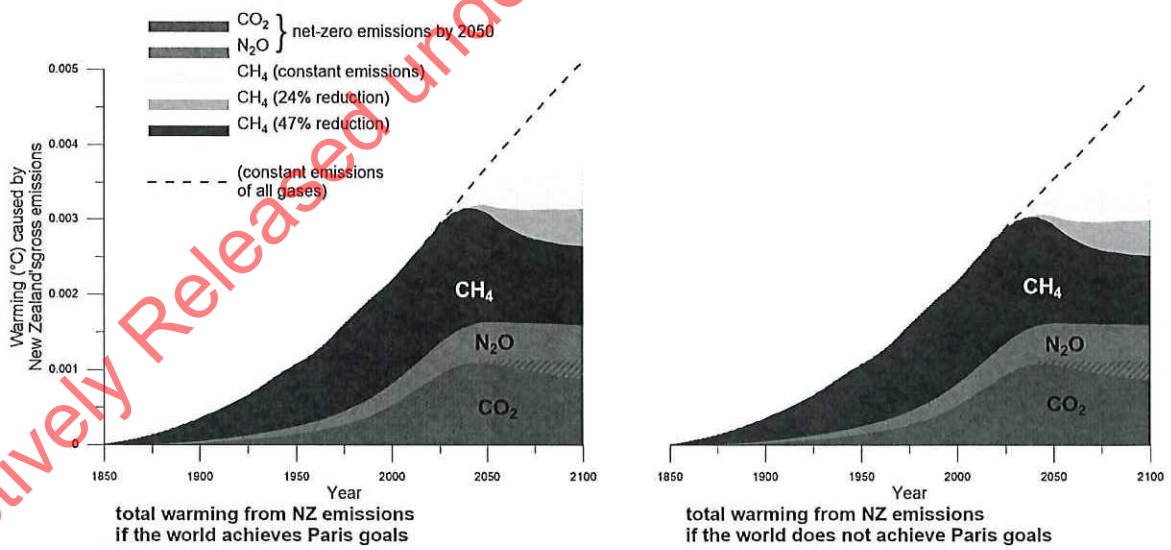

Figure 10. Combined contribution to global average temperature change from New Zealand's gross emissions of fossil carbon dioxide, nitrous oxide, and biogenic methane. The left panel is for an assumption that the world reduces emissions by 2050 to achieve the temperature goal of the Paris Agreement (identical to Figure 4). The right panel is for an assumption that the world does attempt to reduce emissions, but reductions are not sufficient to achieve the temperature goal of the Paris Agreement (resulting in warming of about 2.5°C above pre-industrial levels). New Zealand emissions are identical in both panels and are the same as in Figure 4. Technical note: for the left panel, the world follows the RCP26 pathway, for the right panel, it follows RCP45.

References

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Climate Change Response (Zero Carbon) Amendment Bill: supplementary information for the Environment Select Committee

Date Submitted:	11 July 2019	Tracking #: 2019-B-05777	
Security Level	In-Confidence	MfE Priority:	Non-Urgent

	Action sought:	Response by:
To Hon James Shaw, Minister for Climate Change	• **Approve** the proposed responses to the Environment Select Committee before Friday 12 July.	**11 July 2019**

Actions for Minister's Office Staff	**Return** the signed report to MfE.
Number of appendices and attachments # 1	1. **Appendix 1:** Climate Change Response (Zero Carbon) Amendment Bill supplementary information for the Environment Select Committee prepared by the Ministry for the Environment
Note any feedback on the quality of the report	

Ministry for the Environment contacts

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Principle Advisor	Lewis Stevens	020 4009 5469	✓
Director	Janine Smith	021 144 7617	

Climate Change Response (Zero Carbon) Amendment Bill: supplementary information for the Environment Select Committee

1. The purpose of this briefing is to provide you with the draft response to the Environment Committee's written questions, of 24 June, on the science underpinning the Climate Change Response (Zero Carbon) Amendment Bill (the **Bill**).

Draft response

2. On 24 June, the Environment Committee asked officials to provide supplementary information on the science underpinning the Bill via a series of written questions.
3. A draft response to these written questions is attached at Appendix 1, for your review.
4. The response takes into account your earlier feedback. We have also worked with the office of the Parliamentary Commissioner for the Environment (**PCE**) on the response.
5. In respect of your feedback on question three, we have added material on the economic impacts of the target choice. We recommend retaining the material around the scientific justification for the split gas target.
6. The PCE have indicated they are comfortable with the response, aside from:
    a. statements that nitrous oxide and carbon dioxide are exchangeable with respect to their impact on the climate on timescales of a few centuries. We stand by these statements.
    b. the answer to question two, which we have drafted based on the rationale for the spilt between biogenic methane and all other greenhouse gases. This rationale means the target does not set a specific reduction for nitrous oxide, and does not need to rely on the figures for nitrous oxide in the Intergovernmental Panel Climate Change report.

Next Steps

7. A written response needs to be provided to the Environment Committee by Friday 12 July.
8. Please review and approve the draft response in Appendix 1. Following your approval, we will provide the response to the Environment Committee before the end of the day on Friday 12 July.

Recommendations

9. We recommend that you:

   a. **Agree** to provide the Environment Committee with the proposed response (attached at Appendix 1) to their written questions on the science underpinning the Climate Change Response (Zero Carbon) Amendment Bill.

Yes/No

Signature

10/7/19

Lewis Stevens-Rembe
Principle Advisor
Climate Directorate

Hon James Shaw
Minister for Climate Change **Date**

Appendix 1

Climate Change Response (Zero Carbon) Amendment Bill
Supplementary Information for the Environment Select Committee

Prepared by the Ministry for the Environment

On 24 June 2019, the Environment Committee asked the following questions of officials:

	Question	Answer
1	The Explanatory Note for the Bill (page 4) states that the IPCC 1.5C report concluded that in the central range of global scenarios consistent with staying within 1.5C, with limited or no overshoot, required CO2 to reduce to zero and methane to reduce 24 – 47%, what did the IPCC report say for nitrous oxide?	The Intergovernmental Panel on Climate Change (IPCC) assessment describes scenarios consistent with limiting global warming to 1.5 degrees Celsius with limited or no overshoot. As stated in the quote from the report in your Q9, they do not indicate requirements. In these scenarios, the central range of reductions in nitrous oxide emissions is -26% to +1% relative to 2010 levels by 2050.
2	Why has the IPCC report not been used to set the target for nitrous oxide?	The global pathways assessed in the IPCC report illustrate future global scenarios that are compatible with a 1.5°C world. The report does not make recommendations for national targets for nitrous oxide or any other individual greenhouse gas. The Bill sets a joint target for all gases other than biogenic methane because these gases have a comparable temperature impact over timescales of a few centuries. Combining them also provides greater flexibility in terms of how the target can be met compared to setting separate targets for individual gases. The Climate Change Commission must consider the amount by which each greenhouse gas must be reduced as part of its advice to government on emissions budgets.
3	Why have we split short and long lived gases in setting a target?	New Zealand's current emissions reduction targets include all gases in a single basket, but short and long-lived gases behave differently in the atmosphere and have different contributions to warming. Splitting the gases into two groups allows us quantify the temperature outcomes of the targets. The

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		long-lived gases are exchangeable with regard to their effect on temperature over timescales of a few centuries. Economic modelling indicated that a net-zero all-gases targets would require greater land use change and have greater impacts on the agricultural sector. This was a consideration in opting for a split-gas target over a net-zero all-gases target. In coming to a decision on the target, the Government also considered the broader potential economic impacts and the international context alongside the scientific evidence.
4	In calculating the pathways for different gases, does the IPCC use a split gas approach for short and long-lived gases?	No, the scenarios assessed by the IPCC investigate how mitigation of different gases in different sectors can be combined to reach a given global temperature outcome at least cost. The assumptions used include various possible scenarios for technological progress, as well as social and economic trends. The results are then aggregated and reported by gas.
5	Has the belief that short-lived gases do not need to reduce to zero been based on the IPCC 1.5C report, if so, what page number?	The understanding that, to limit warming to 1.5°C, short-lived gases do not need to reduce to zero pre-dates the IPCC 1.5°C report. But it is also clearly stated in Cross-Chapter Box 2: "Measuring Progress to Net Zero Emissions Combining Long-Lived and Short-Lived Climate Forcers [SLCFs]", on page 66. An extract from this box says: "Natural processes that remove CO_2 permanently from the climate system are so slow that reducing the rate of CO_2-induced warming to zero requires net zero global anthropogenic CO_2 emissions, meaning almost all remaining anthropogenic CO_2 emissions must be compensated for by an equal rate of anthropogenic carbon dioxide removal (CDR). In contrast, sustained constant emissions of a SLCF such as methane, would (after a few decades) be consistent with constant methane concentrations and hence very little additional methane-induced warming."

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		(extract simplified by removing references)
6	Does the IPCC report state that nitrous oxide emissions need to reduce to zero to avoid 1.5C of warming, if so, what page number?	The report does not make that statement.
7	If the assumptions in the IPCC models were changed to assume nitrous oxide could be mitigated at a lower cost, would that impact the calculated pathway for methane? (i.e. are reduction interchangeable)	There are a number of pathways outlined in the report, all with different inputs and assumptions, and all producing different trajectories for each gas. The biogenic methane target in the Zero Carbon Amendment Bill is based on the ensemble of model pathways in the IPCC report limiting warming to 1.5 C with no or limited overshoot, that takes into account a range of assumptions. There is a trade-off between the emissions reductions of different greenhouse gases, with respect to achieving a warming goal. Different long-lived gases are directly exchangeable: for example, a reduction target could be achieved by reducing only CO_2 emissions, or only N_2O, or a combination of the two. All three options have essentially the same temperature benefit. If the assumptions in the models were changed, so that the abatement costs of nitrous oxide became lower than the abatement costs of methane, the resulting cost-effective pathways would be likely to feature greater reductions in global nitrous oxide emissions and lesser reductions in global emissions of methane, everything else being equal. But the trade-off between methane and nitrous oxide is not a straightforward exchange: the temperature contribution from long-lived gases depends on the total cumulative emissions, while the temperature contribution from short-lived gases depends primarily on current and recent annual emission rates. The complexity of this comparison between cumulative emissions, on the one hand, and

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		recent rates, on the other, is an important reason for the adoption of the split target.
8	Why have we on one hand made a decision to take a split gas approach, but on the [other] hand based the level of our targets (for some gases) on models that allow different reductions in different gases to be interchanged?	The models assessed in the IPCC report enable all greenhouse gas emissions and removals to be interchanged, in the sense that they identify global least-cost combinations of mitigation activities that are compatible with a given temperature objective. The IPCC report made clear that there are many ways to reduce emissions. This is why the Government has taken an approach that will allow flexibility to pursue cost-effective emissions reductions. As identified in the answers to Q3 and Q7 above, we have adopted a split gas approach in order to make the temperature outcomes of our target clearer, and considering the likely impacts of the target.
9	In regards to all of the pathways presented in the IPCC report, why did the IPCC state, "These pathways illustrate relative global differences in mitigation strategies, but do not represent central estimates, national strategies, and do not indicate requirements"?	That statement in the IPCC 1.5 C report refers to the four Illustrative Pathways in Figure SPM.3b. It is also generally true of any individual pathway. The emissions pathways, and IPCC products in general, are "policy-relevant but not policy-prescriptive" The IPCC states of its reports: "*They may present projections of future climate change based on different scenarios and the risks that climate change poses and discuss the implications of response options, but they do not tell policymakers what actions to take*"
10	What level of reduction in each of the three main gases would be required to have no further warming from 2050?	There is no single answer to that question, but the extract from the IPCC 1.5 C report provided in the answer to Q5 is a good explanation.
11	The IPCC report presents representative pathways for four different global scenarios, including one scenario described as a "Middle of the road scenario". Some scenarios have 'overshoot' of a 1.5C and require negative emissions in the second half of the century. Why have we used only those scenarios that have "limited or no overshoot"?	The "middle of the road" scenario refers to the underlying assumptions of this pathway, drawn from the so-called "Shared Socio-economic Pathways" (SSPs). See Table 2.3 of the IPCC 1.5 C report (page 110) for more information about the different pathways. The choice of referring to pathways with no or limited overshoot is not a question of science.

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		The range for 1.5 C scenarios with "no or limited overshoot" is cited in the Figure SPM.3b of the IPCC 1.5 C report. This reflects the Government's ambition for limiting global warming, as stated in Part 1 of the Bill. The central range of emissions reductions in 2050 for methane from agriculture in all 1.5 C scenarios including those with high overshoot is 11 to 41 percent below 2010 levels.
12	Does the Paris Agreement address the issue of if temperature limits are to be achieved with limited or no overshoot?	No, there are no time constraints associated with the temperature goals in the Paris Agreement.
13	The IPCC 1.5 report states that available pathways that achieve a 1.5C limit with limited or no overshoot keep global CO2e emissions to 25 – 30 Gt by 2030, this contrasts to median estimates for Paris targets (NDCs) of 52-58 Gt by 2030 (page 95) – in other words, in order to be on a pathway with limited or no overshoot global emissions would need to be near half those countries have pledged. We understand that countries will resubmit targets by 2020 following the Talanoa Dialogue, but is it reasonable to base New Zealand policy on a pathway that is so far off where countries have thus far indicated they are willing to go?	Signatories to the Paris Agreement committed to pursue efforts to stay within 1.5°C of pre-industrial levels. The target in the Zero Carbon Amendment Bill aims to set New Zealand on a path to reduce emissions consistent with this global goal.
14	Were pathways with overshoot considered and, if so, why were they rejected?	The use of scenarios that limited global warming to 1.5°C with limited or no overshoot reflects the Government's ambition for limiting global warming, as set out in Part 1 of the Bill.