

## Chapter 9

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# Te Whāinga – Te Whakaheke Tukunga Hauwaro ki te 1.5°C Contributing to limiting warming to 1.5°C

### Summary

Limiting warming requires a global effort with each country playing its part by meeting its international climate change commitments to reduce emissions. Global ambition is increasing with many of the world's largest emitters committing to strengthened climate targets.

The domestic emissions reduction targets for Aotearoa are set at a level the Government has judged to be in line with contributing to global efforts to limit warming to 1.5°C. This is a requirement under the Climate Change Response Act (the Act). To make sure the Climate Change Commission's (the Commission's) budgets are compatible with this, we have carried out a detailed assessment.

#### **Our assessment of how the recommended budgets contribute to the global 1.5°C effort:**

We have considered two components when assessing whether our emissions budgets are compatible with the global 1.5°C effort.

1. We looked at whether the emissions budgets are compatible with the 2050 emissions reduction targets. The country's carbon dioxide and methane targets were set by the government as our domestic contribution to the 1.5°C global effort.
2. We looked at how the emissions reductions for the different greenhouse gases in our work compare to the Intergovernmental Panel on Climate Change (IPCC) 1.5 °C pathways. We looked at the relative reductions and global trajectories for the different greenhouse gases in the IPCC's work, drew out the key features, and then applied these in the Aotearoa context.

The Commission's analysis shows our recommended emissions budgets put Aotearoa on track to reach net-zero carbon dioxide emissions by 2038. This is ahead of the range in the IPCC pathways of 2045-2055. The recommended budgets also put us on track to reach net zero for all long-lived greenhouse gases before 2050.

The reductions in agricultural methane for our emissions budgets put Aotearoa just outside the IPCC's interquartile range for 2030. However, by 2050 we consider it is likely Aotearoa will be within the interquartile range.

The Act sets targets for reductions in total biogenic methane, this includes biogenic methane emissions from waste as well as agriculture. Our analysis shows Aotearoa has an opportunity to significantly reduce emissions from waste. This would lead to a reduction of total biogenic methane between 2010 and 2030 of 12%, which is within the IPCC range.

Our recommended budgets see reductions in nitrous oxide between 2010 and 2030 of 3%, which is inside the IPCC's interquartile range. This path also puts nitrous oxide reductions on track to reach the lower emissions end of the IPCC interquartile range by 2050.

### Changes in our final advice

This is a new chapter in our final advice. It answers questions that were raised during consultation about the contribution of Aotearoa to the global 1.5°C effort.

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## Introduction

- 1 When the Government passed the Climate Change Response (Zero Carbon) Amendment Act (the Act) in 2019, one of the purposes of the new Act was to:

*Provide a framework by which New Zealand can ... contribute to the global effort under the Paris Agreement to limit the global average temperature increase to 1.5° Celsius above pre-industrial levels.*
- 2 The Act sets out the domestic 2050 emissions reduction targets (2050 targets). The 2050 targets in the legislation were set at a level that the Government viewed to be in line with limiting the global average temperature increase to 1.5°C above pre-industrial levels (global 1.5°C effort).
- 3 In setting these 2050 targets, the Government drew on the Intergovernmental Panel on Climate Change (IPCC) *Special Report on Global Warming of 1.5°C* released in 2018. Through the 2050 targets set in the Act, Parliament has set the direction for what domestic contribution Aotearoa will make to the global 1.5°C effort.
- 4 This chapter outlines the science of the different greenhouse gases, the global emissions reductions modelled as compatible with the global 1.5°C effort, and our assessment of how our recommended emissions budgets are compatible with contributing to that effort.

## Box 9.1: Emissions budgets and the Nationally Determined Contribution

During consultation, we received feedback from submitters asking how we could conclude that our draft emissions budgets aligned with contributing to the global 1.5°C effort while concluding that the Nationally Determined Contribution (NDC) under the Paris Agreement did not. The 2050 targets in the Act were drawn from the work of the IPCC and were set by the Government as our domestic contribution to the global 1.5°C effort. Emissions budgets must set Aotearoa on a path to meet the 2050 targets, must be achievable and focus on domestic actions. There are a broad range of factors outlined in the Act that we must consider in recommending emissions budgets – factors that do not always pull in the same direction.

The NDC is different from emissions budgets in that it can involve both domestic action and contributing to action overseas (offshore mitigation). Emissions budgets represent only part of the total contribution Aotearoa makes to limiting warming. As offshore mitigation can be included in the NDC, the difficulty of reducing emissions within Aotearoa is less relevant to assessing the NDC, but remains a mandatory consideration for emissions budgets under the Act.

The NDC is also a successor to previous international emissions commitments the government has made and so the assessment of budgets and the NDC start from different points. *Chapter 22: Factors relevant to the Government's decision on the level of the Nationally Determined Contribution* describes these differences further.

## 9.1 The science of the different greenhouse gases

- 5 The impact a particular greenhouse gas has on the climate depends on two key factors – its ability to absorb heat energy on a molecule-by-molecule basis, and how much of it there is in the atmosphere. This impact can be expressed as the ‘radiative forcing’ of that greenhouse gas. Radiative forcing is a measure of how much a gas is driving the changes in the global climate.
- 6 Carbon dioxide is responsible for the majority of human-driven warming to date.
- 7 Carbon dioxide is the most important greenhouse gas produced by human activities. It has the ability to absorb a wide range of radiated energy. It is also very long lived, meaning that carbon dioxide released today will still be causing warming centuries or millennia into the future. It is the greenhouse gas the world is emitting the most of, and which has the highest concentration in the atmosphere.
- 8 Methane is the second most important greenhouse gas and is responsible for around a sixth of human-caused warming that has occurred to date.
- 9 Molecule for molecule, methane emissions have a much greater warming effect in the atmosphere than carbon dioxide. However, methane is a short-lived greenhouse gas. It has an intense warming effect for the first few decades after it is emitted, but this effect dissipates as methane breaks down in the atmosphere.
- 10 Methane’s properties mean it has a different effect on warming, which is an important factor when considering global and domestic pathways for reducing emissions.
- 11 In our analysis of how Aotearoa could achieve our recommended emissions budgets, we have applied a split-gas framework that takes into account methane’s different properties. This is consistent with the approach taken by the Act. This avoids the use of metrics to compare methane with other greenhouse gases or trade off effort across the different greenhouse gases.

## Box 9.2: The carbon and nitrogen cycles

**Carbon dioxide**, methane and nitrous oxide are produced as part of global chemical cycles. These gases can be produced naturally or as a result of human activities that are driving climate change and are the focus of mitigation efforts.

Carbon exists in many different forms and is found in vast amounts in soils and rocks, and in plants and animals. Physical processes like the weathering of rocks and volcanos, and the biological processes of photosynthesis and respiration lead to this carbon cycling in and out of the atmosphere as carbon dioxide. The burning of fossil fuels and forests also releases carbon dioxide into the atmosphere. Human activities are releasing carbon dioxide into the atmosphere more than 100 times faster than from natural processes, and it is the resulting increased concentration of carbon dioxide in the atmosphere since the industrial revolution that is the primary driver of climate change.

**Methane** is also part of the carbon cycle. It can come from fossil fuel sources, such as leaking from coal mines or fossil gas fields. It can also come from biogenic processes like the rotting of vegetation and as a by-product of digestion in animals – particularly ruminants such as cattle, sheep and goats. This biogenic methane can be thought of as a loop in the carbon cycle that begins and ends with carbon dioxide in the atmosphere.

The natural process of grass growth uses photosynthesis to take up carbon dioxide from the atmosphere and converts it into plant tissues. Some of the grass will be eaten by animals and ultimately returned to the atmosphere either rapidly (through respiration and urine or dung) or over a few years (as products and carcasses eventually decay).

However, when the grass is eaten by ruminants some of the carbon is converted to methane by microbes in the rumen and expelled to the atmosphere. This methane eventually decays back to carbon dioxide after 12-20 years. Whether it is produced through the breakdown of plant material or from ruminant livestock, methane production is an intrinsic part of food production. The increase in biogenic methane concentration in the atmosphere is closely linked to increased food production to feed a growing human population.

**Nitrous oxide** is formed as part of the nitrogen cycle. Nitrogen is one of the most common elements on Earth. Most of it is locked up in the atmosphere as nitrogen gas, which plants and animals can't use. To become available, nitrogen needs to be converted into different forms like ammonium, a process known as nitrogen fixation. The two most common ways this happens are lightning and conversion by soil bacteria.

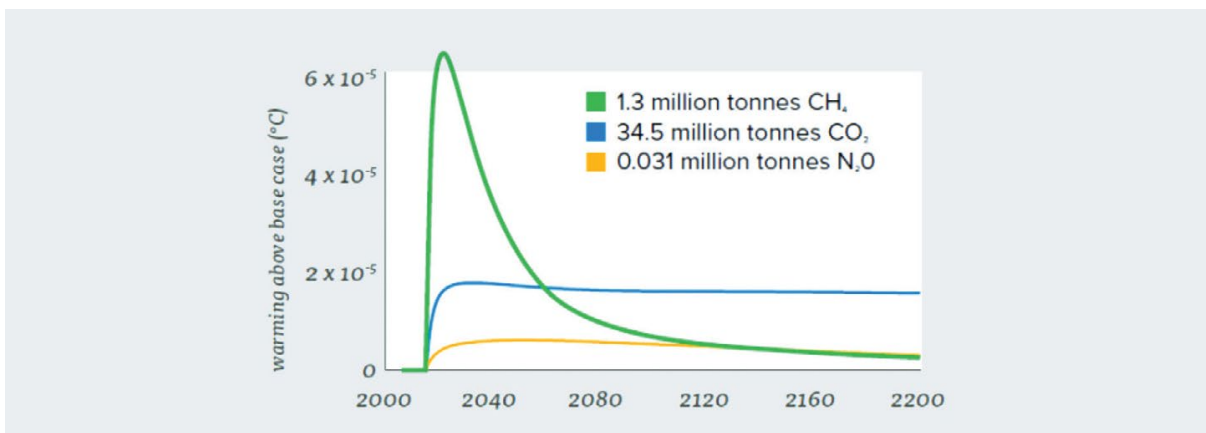
Animals get nitrogen by feeding on plants, and use it to build proteins and tissues and grow. Any excess nitrogen is excreted in urine and dung in the form of urea. This urea is then broken down by soil bacteria and can follow one of three paths:

- Some of the nitrogen is taken up again by plants
- Some of the nitrogen is converted to highly soluble nitrate, which can be washed off into waterways or leach down through soil into groundwater
- A small amount of the nitrogen is converted into nitrous oxide and emitted into the atmosphere

As with biogenic methane, the increase in nitrous oxide concentration in the atmosphere is closely linked to increased food production to feed a growing human population.

For more details, see *Chapter 7: Reducing emissions from agriculture* of the *2021 Supporting Evidence*.

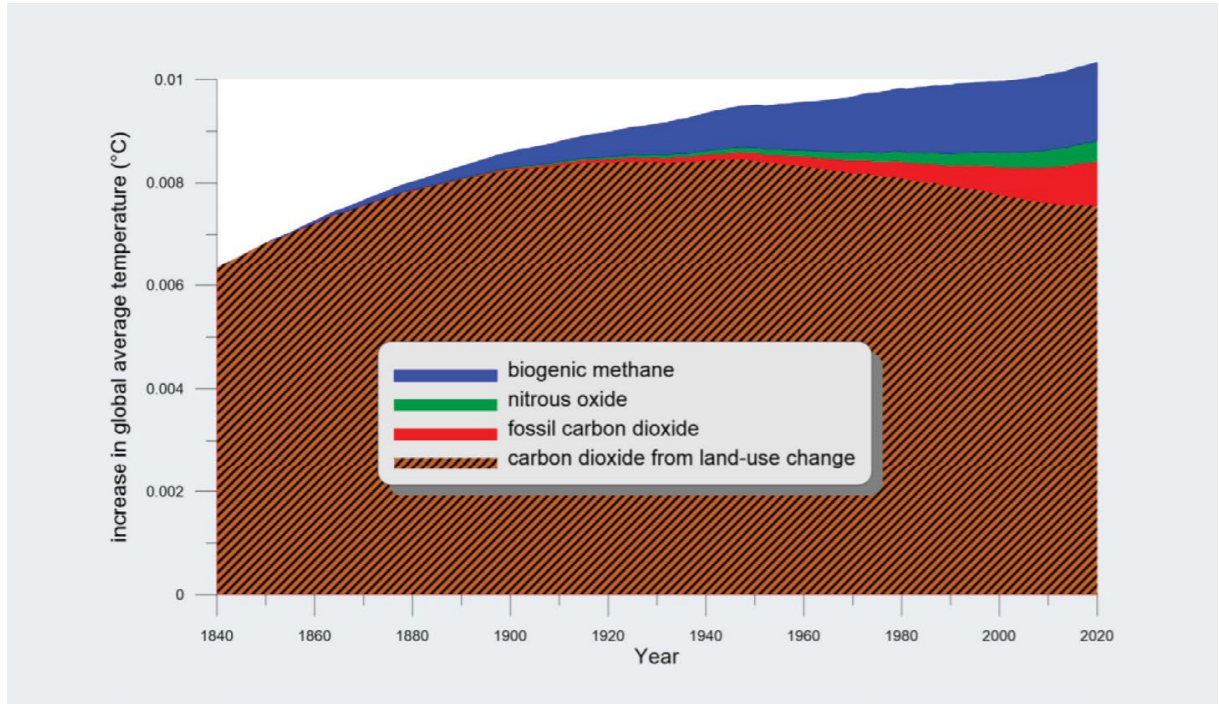
- 12 Nitrous oxide is a much more powerful greenhouse gas in the atmosphere than carbon dioxide on a molecule-by-molecule basis and is also relatively long-lived in the atmosphere. However, nitrous oxide is emitted at a rate that is much lower than carbon dioxide or methane. As a result, it contributes less to human-driven warming – around 6% of the warming to date.
- 13 Other greenhouse gases include small levels of synthetic gases such as hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride. Some of these synthetic gases have very powerful warming effects.
- 14 Continuing to emit long-lived gases, like carbon dioxide and nitrous oxide, results in these gases accumulating in the atmosphere. They are effectively being added faster than they are being removed. Therefore, a constant rate of carbon dioxide and nitrous oxide emissions, year to year, leads to growing concentrations and more warming. Emissions of long-lived gases need to drop to zero to stop adding to warming.
- 15 Methane breaks down at a faster rate, and a constant rate of emissions will stabilise within about 50 years. Because methane does not accumulate to the same extent as long-lived gases, its emissions do not need to reduce all the way to zero for them to stop adding to global warming.
- 16 Figure 9.1 shows how the current rates of emissions of carbon dioxide, methane and nitrous oxide from Aotearoa each year would contribute to warming over two hundred years. Given current annual emissions, methane emissions cause the most warming over the first few decades. However, because methane breaks down more quickly, the longer lasting warming from carbon dioxide dominates beyond that. See *Chapter 1: The science of climate change of the 2021 Supporting Evidence* for more details.



**Figure 9.1: The effect of the country's yearly emissions of carbon dioxide, methane and nitrous oxide on warming. Note: This figure is based on 2016 emissions in Aotearoa**

Source: Interim Climate Change Committee.

17 The total warming impact of each greenhouse gas over time depends on current emissions rates as well as past emissions of that gas and how much is still in the atmosphere. The New Zealand Agricultural Greenhouse Gas Research Centre has estimated that Aotearoa has contributed close to 0.3% of the 1°C warming that has occurred since pre-industrial times. This historic contribution Aotearoa made to warming came from a mix of carbon dioxide released when native forests were first cleared and ongoing emissions of carbon dioxide from fossil fuel use, methane and nitrous oxide (Figure 9.2).



**Figure 9.2: The contribution Aotearoa made to warming since 1840**

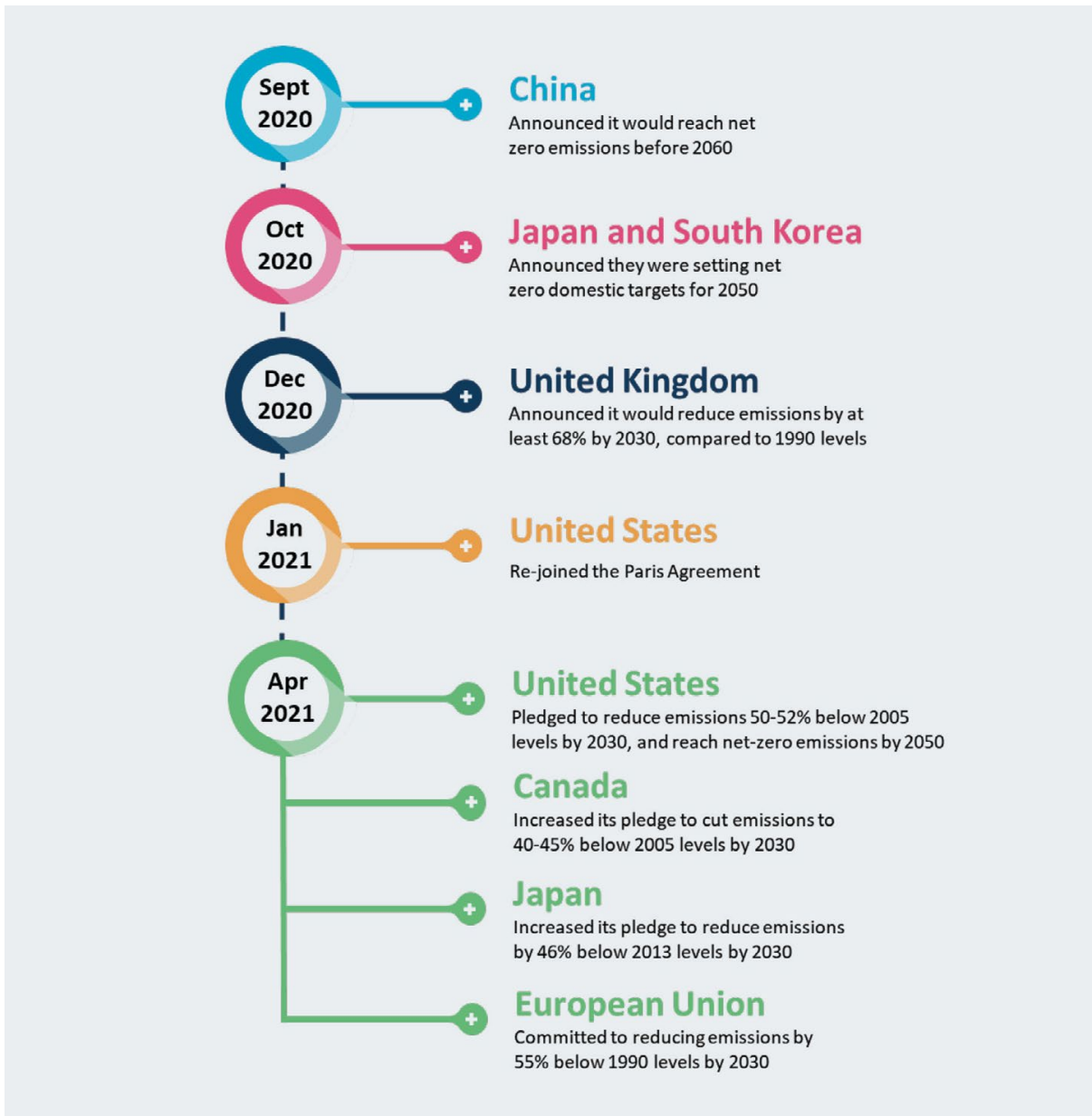
Source: New Zealand Agricultural Greenhouse Gas Research Centre.

## 9.2 Global efforts to limit warming to 1.5°C

18 One of the central objectives of the Paris Agreement is for countries to contribute to “holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels.”

19 Assessments of the current global effort show that the world is not on track to meet the Paris Agreement’s temperature goals. The 2020 United Nations Environment Programme Emissions Gap report warns that warming will increase to around 3°C this century based on current pledges.

20 Reducing emissions requires a global effort - each country needs to do its part under the Paris Agreement. More and more countries are strengthening their international climate change commitments, particularly in the lead up to the next international climate change conference in November 2021. In the last 18 months, many of the world’s largest emitters have already stated they would move to more ambitious emissions targets (Figure 9.3).



**Figure 9.3: Increased climate change commitments since late 2020**

- <sup>21</sup> The Climate Change Commission (the Commission) takes a systems view of Aotearoa and its place internationally. The world needs to minimise climate change and its impacts, but the Commission also collectively needs to consider broader wellbeing factors like eradicating poverty, safeguarding food security and addressing other environmental outcomes. These considerations are important in the context of reducing emissions, but also in considering the need to adapt to more severe and costly impacts of climate change if the world does not act to reduce emissions.
- <sup>22</sup> When making judgements about trade-offs, careful consideration needs to be given to where to concentrate efforts, and how the impacts and consequences are spread across countries, people, place, and time. These judgements must be made from an Aotearoa perspective, taking a te ao Māori view, and must consider environment, economy, society, and the broader wellbeing of Aotearoa.

## 9.3 Global 1.5°C compatible pathways

- <sup>23</sup> The IPCC has outlined a number of different global pathways that have a likely (50-66%) chance of limiting warming to within 1.5°C above pre-industrial levels. These pathways are drawn from peer-reviewed modelling studies. They are not based solely on atmospheric science, but also on the ease and costs of reducing emissions of different greenhouse gases across sectors, and consider a range of socio-economic scenarios.
- <sup>24</sup> Under these global pathways, different greenhouse gases reduce at different rates. They also rely on emissions removal technologies, such as bioenergy with carbon capture and storage or afforestation, to varying degrees. Within all these pathways, limiting warming to 1.5°C requires the world to rapidly reduce emissions of all greenhouse gases between now and 2030. Slower reductions are then needed out to the end of the century.
- <sup>25</sup> All these 1.5°C compatible pathways show:
- Net emissions of carbon dioxide and other greenhouse gases peaking in the 2020s, then rapidly reducing through the 2030s and 2040s.
  - Emissions of methane reducing substantially through the next 20 years, but not reaching zero by 2050 or 2100, due to the short-lived nature of the gas and the difficulty of eliminating methane emissions from food production.
  - Emissions of nitrous oxide peaking in the 2020s and then reducing, but not reducing to zero due to the difficulty of eliminating nitrous oxide emissions from food production.
  - Gross emissions of long-lived greenhouse gases reducing to near zero by 2050.
- <sup>26</sup> Most of these 1.5°C compatible pathways show:
- Some remaining emissions in 2050 from hard-to-abate sectors. This includes things like carbon dioxide from cement manufacturing. As a result, emissions removals are required to ensure emissions reach, and remain at, net zero.
  - Carbon dioxide being removed from the atmosphere on an ongoing basis, beyond what is needed to keep emissions at net zero, to bring temperatures back below 1.5°C above pre-industrial levels after a temporarily overshoot.
- <sup>27</sup> It is often said that global emissions must halve by 2030 from 2010 levels to limit warming to within 1.5°C above pre-industrial levels. This is a useful rule of thumb, but is a simplification of the actual emissions reductions assessed by the IPCC. In the global 1.5°C pathways, net carbon dioxide emissions are modelled to reduce by around 50% by 2030. Emissions of other gases are modelled to reduce more slowly.
- <sup>28</sup> The global IPCC pathways provide useful insights for considering how our recommended emissions budgets contribute to the global 1.5°C effort. However, the pathways represent global averages and do not set out prescriptive pathways for individual nations. There is no 'right way' to reduce emissions. Care needs to be taken when applying the IPCC pathways to Aotearoa for three key reasons:
- Many of the emissions reduction opportunities that will be most important for the world will not be as important in Aotearoa given our major sources of emissions. For example, globally, coal power generation accounts for a much larger share of emissions and it is here that the sharpest early reductions in the IPCC pathways occur. Most electricity generation in Aotearoa however is already renewable, so this large reduction opportunity does not exist for Aotearoa.
  - The IPCC pathways group the emissions of the individual gases in different ways to those in the Act. For example, the IPCC assessed reductions in methane from agriculture, while emissions budgets are set for biogenic methane.

- The IPCC pathways are set relative to a 2010 base year, while the targets in the Act are set relative to 2017.

<sup>29</sup> There are questions about whether it is still possible for the world to limit warming to 1.5°C. The longer countries wait to act, the harder it gets, with greater reliance placed on emissions removal technologies that are not currently available. Towards the end of 2021 the IPCC will release its sixth assessment report which will provide the most up-to-date science on this question.

## 9.4 Assessing how our emissions budgets contribute to the global 1.5°C effort

<sup>30</sup> We have considered two components when assessing whether our emissions budgets are compatible with contributing to the global 1.5°C effort.

<sup>31</sup> The first and most relevant is whether the emissions budgets are compatible with the 2050 targets in the Act. This is because the 2050 targets were drawn from the work of the IPCC and were set by the government as our domestic contribution to the global 1.5°C effort.

<sup>32</sup> Our modelling shows that the emissions budgets set us on a track to meet the 2050 targets, both for long-lived gases and biogenic methane.

<sup>33</sup> As an additional consideration, we have also looked at how the emissions reductions for the different gases in the demonstration path compare to those in the IPCC’s pathways. These are not directly comparable so we look at the relative reductions and global trajectories for the different gases in the IPCC pathways, draw out the key features, and then apply these in the Aotearoa context.

<sup>34</sup> Table 9.1 shows the percentage reductions in net carbon dioxide, agricultural methane and nitrous oxide between 2010 and 2030 from the IPCC’s pathways. The table also shows the reductions in these gases over the same period that the demonstration path would achieve. For a detailed explanation of the IPCC range used here see *Chapter 22: Factors relevant to setting the level of the Nationally Determined Contribution* and Chapter 1 of the *2021 Supporting Evidence*.

**Table 9.1: Reductions in emissions between 2010 and 2030, by gas, in IPCC pathways and in our demonstration path. The reductions for net carbon dioxide are calculated using a gross-net approach. See Chapter 3: How to measure progress of the 2021 Supporting Evidence for more detail on this approach and the basis for its use. We have used the ‘interquartile range’ of the IPCC’s pathways. The interquartile range represents the middle 50% of modelled reductions. This gives a more conservative, but also more likely, range for the emissions reductions that are needed.**

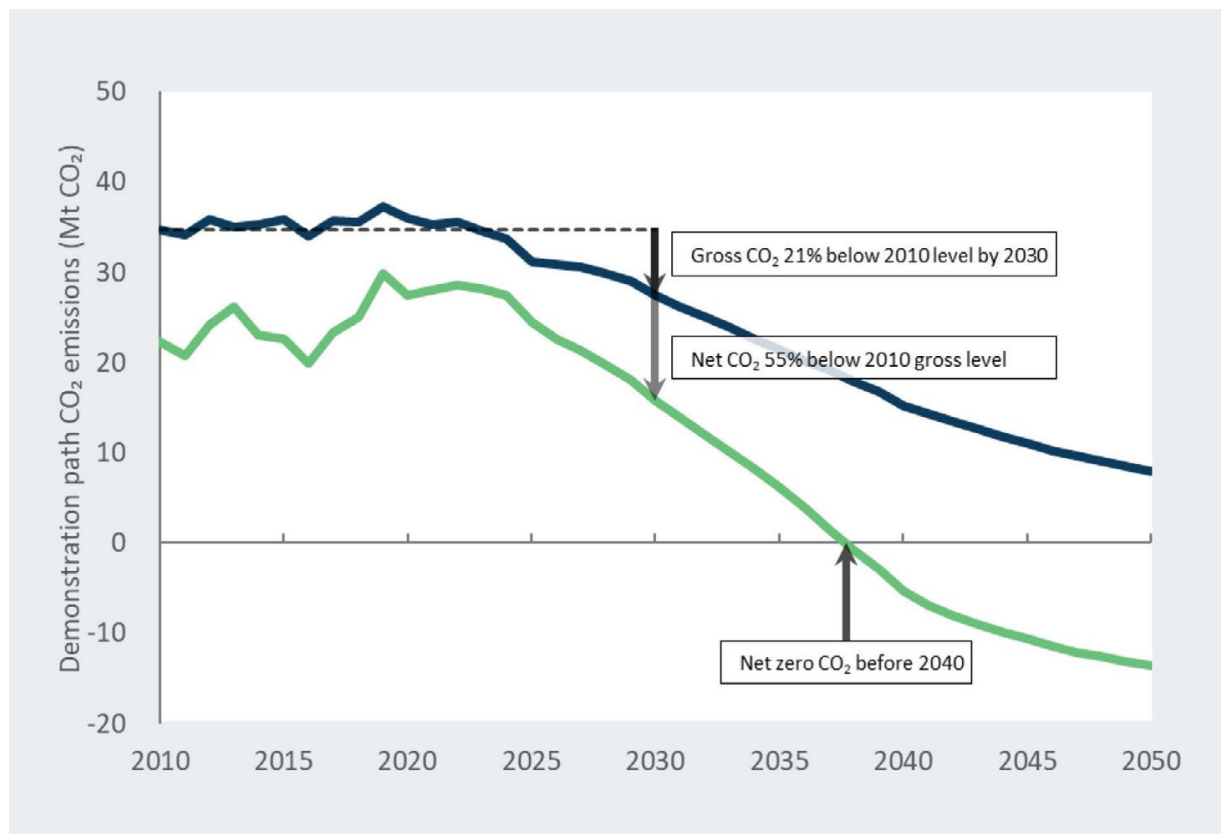
	Percentage change between 2010 and 2030	
	IPCC	Demonstration path
Net carbon dioxide emissions	-40 to -58 %	-55 %
Agricultural methane emissions	-11 to -30 %	-8 %
Total biogenic methane	-	-12 %
Agricultural nitrous oxide emissions	+3 to -21 %	-3 %

Source: IPCC – Special Report on 1.5°C, Summary for Policymakers, Table SPM.3b. Integrated Assessment Modelling Consortium data, hosted by IIASA.

### 9.4.1 Net carbon dioxide

<sup>35</sup> Carbon removals by forests are a major opportunity to reduce net emissions in Aotearoa. Figure 9.4 shows the scale of carbon removals by forests in comparison to gross emissions of carbon dioxide in the demonstration path. Under the internationally agreed accounting rules, all emissions from deforestation are included, as are carbon removals from forest planted after 1989. This is different to the 2010 base year used in the IPCC pathways. However, by 2030 almost all of the forest removals are from forest planted after 2010, so the effect of the different base year is negligible.

<sup>36</sup> Figure 9.4 shows that Aotearoa reaches net-zero carbon dioxide emissions by 2038, ahead of the range in the IPCC pathways of 2045-2055.



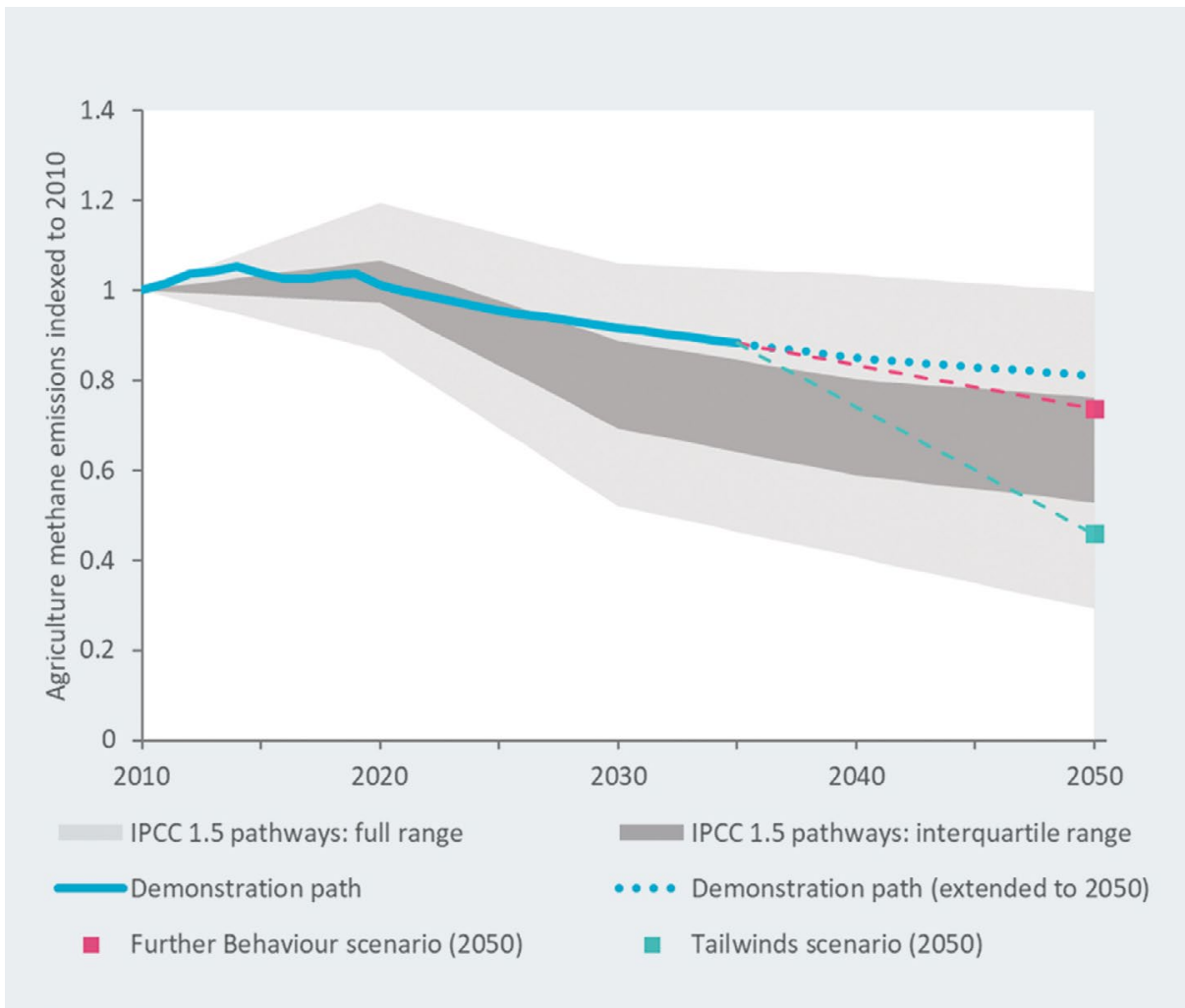
**Figure 9.4: Gross and net carbon dioxide emissions under the demonstration path between 2010 and 2050**

Source: Commission Analysis

### 9.4.2 Biogenic methane

<sup>37</sup> Figure 9.5 shows that the reductions in agricultural methane in the demonstration path for our emissions budgets put us just outside the IPCC's interquartile range at 2030. Figure 9.5 also shows that our most conservative scenario puts us on track to be within the IPCC interquartile range by 2050. Our most ambitious scenario puts us on track outperform the IPCC range.

<sup>38</sup> The Act sets targets for reductions in biogenic methane, rather than just agricultural methane. Our analysis has shown Aotearoa can make large reductions in biogenic methane emissions from waste. If reductions from waste are included, our demonstration path would lead to reductions in total biogenic methane between 2010 and 2030 of 12%.



**Figure 9.5: Reductions in agricultural methane in the demonstration path for the first three emissions budgets. Also shown are the modelled reductions in agricultural methane in 2050 under our Further Behaviour and Tailwinds scenarios.**

Source: Commission Analysis

### 9.4.3 Nitrous oxide

<sup>39</sup> The demonstration path sees reductions in nitrous oxide between 2010 and 2030 of 3%, which is inside the IPCC’s interquartile range. This path also puts nitrous oxide reductions on track to reach the lower emissions end of the IPCC interquartile range by 2050.

## 9.5 Overall domestic contribution to the global 1.5°C effort

<sup>40</sup> Overall, our assessment is that our recommended emissions budgets are compatible with the 2050 targets and the requirements of the Act, and with contributing to the global effort to limit warming to 1.5°C above preindustrial levels.

<sup>41</sup> The Commission will have an ongoing role reviewing the 2050 targets in the future to make sure that the targets remain compatible with contributing to the global 1.5°C effort in light of changing global circumstances and new knowledge.