He Pou a Rangi
Climate Change Commission

Advice
on Aotearoa New Zealand's **fourth emissions budget**

November 2024

Haere mai – Welcome

This report is required under sections 5J, 5ZA and 5ZE of the Climate Change Response Act 2002.

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Disclosure statement: As anticipated by the appointment criteria, the Climate Change Commissioners come from varying fields such as adaptation, agriculture, economics, te ao Māori and the Māori–Crown relationship. While a number of board members continue to hold roles within these fields, our advice is independent and evidence based. The Commission operates under its Interests Policy, which is derived from the Crown Entities Act 2004. You can read more about our board members on the Climate Change Commission website. The Commission regularly updates and publishes on its website a register of relevant board interests.

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Te karere a te Tumu

Ko ngā tahua tukuwaro o Aotearoa he panoni i tā te whenua nei ahunga pae tawhiti ki te whakaheke tukuwaro rangona noa kia ngāwari mai tōna rangona, tōna tātaia, otiia, tōna tutukinga. Ko tēnei tonu te tūtohu ake i ngā tau 10-15 e haere mai nei, ā, ko te ahumahi me ngā pakihi, te kāwanatanga me ngā hapori hoki, ka pakari tauroa mai nei ki te whakamahere, te penapena me te mahi.

He tika atu tā te Kāwanatanga manawanui hei whakatutuki i tōna whenua ahunga whakaheke tukuwaro 2050. Hei tā te Kāwanatanga whakatau ki te reanga o te tahua tukuwaro tuawhā o te wā he hirahira ki te tutuki, nātemea ka noho whakatau ake i te aroaro o Aotearoa ki te 2050. I ā mātou tātainga he whakaatu atu ka āhei tēnei whenua ki te whakaheke i ngā tukuwaro tāngata e hua tonu mai ai ngā painga – nā whai anō, ka pai ki te ōhanga, ki te taiao, otirā hei mahinga mā tātou katoa.

Ko te ranunga o ngā mahinga me ngā tukanga ki te whakaheke tukuwaro, arā o te tūtohu ake e hia hoki te hauwaro me tango i te kōhauhau mā te ahungahere rā anō, he tino whakataunga hoki. I pēnei hoki nā te nui o te utu ki te tango rehukino i te kōhauhau, me ngā hangarau tukuwaro iti hou e whanake nei, ā, kua whanake kē, he whai pānga ki te tūpono o tā te whenua tutuki i tōna tahua tukuwaro. Ko tētahi atu hiranga ko tā te Kāwanatanga kōwhiringa (ko ēnā o te pakihi, o te takitahi, o te hapori hoki) ki te tutuki i te tahua, he rerekē tonu ngā tūpainga, ngā tūraru me ngā tūpānga, ā, ka nunui te momo pānga ki tēnā rāngai, ki tēnā hapori hoki.

Me whai waahi atu te Kāwanatanga ki te tātai ake i ngā tūwhiringa me ngā piringa tūpainga, tūraru, tūpānga hoki.

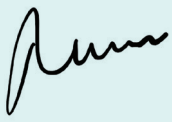
Kei ngā taunakitanga te whakaatu i ngā kōwhiringa ki te whakaheke tukuwaro tāngata me tōna hāngai ki te ahunga 2050 o te wā, i konā mai ngā āheinga me ngā painga ki tō te whenua ōhanga, pāpori, taiao me ngā whakareanga hou. Ko te pānga kē ko ngā whiwhinga ōhanga, pāpori hoki. E pēnei ana nā runga hoki i ngā āheinga ōhanga, he nui atu anō ngā painga hirahira ka puta i te whakaheke tukuwaro. E matapaetia ana, hei te wā tahua tukuwaro tuawhā tonu, ka kitea pea ngā pikinga ki te hauora e tatauhia ana ki te $2.1 piriona o ia tau ki te oranga mai o te hau nā te hekenga o ngā hinuwaro e tahua ana e te ahuwaka. Inā rā hoki ngā hua, he tino wāhanga ā ngā whakapeto ngoi ki te anamata ora mō Aotearoa tonu. Heoi anō, hei aronga matua mā tātou, ko ētahi ahumahi, hapori, kāinga hoki ka kino ake i ētahi atu tōna rangona o ngā whiunga. He haepapa tā te Kāwanatanga ki te whakapūmau i te whakawhitianga tautika, me ngā rauemi hoki ki tēnā tutukinga. Hei āpiti atu, ko ngā whare ka whakamahia atu i ōna hinuwaro hei hana me te whakatere waka, ā, ki te whakawhiti ki te hiko ka penapena i te manomano taara i ia tau.

Kua rerekē ngā āhuatanga mai i ngā tahua tuatahi e toru i whakatauhia, nā reira kei te whakahauhia kia aromatawaia ngā tahua tuatahi, tuatoru, tuatoru hoki. Inā pērā ana, ka koke tonu ngā tahua ki te ārahi i ngā mahi ki te whakaheke tukuwaro e taea ai te tutukinga o te tahua tukuwaro tuawhā, ā, he tuku i te whenua nei ki tētahi ara whakatutuki i te ahunga 2050.

Mā te arotake i ngā tahua tukuwaro ka noho hei taikaha matua ki te punaha i whakaurua e Pāremata i 2019. E tōmua ana te tokanga o ngā tahua mā te 10 tau – koinei te whakakitenga ki te anamata, engari ko ngā ārai tukanga, ngā waiaro me ngā hangarau ka rerekē hoki i te tere hohoro. Karekau tētahi i te mōhio hoki he aha ngā hangarau ka wātea, ā, ki ngā utu ka kitea ki te 10-15 tau te haramai nei, he aha rānei ngā tūāhuatanga o te tuawhenua, o tāwāhi rānei ka whakarerekētia. Mā te whakahou i ngā tahua hei urupare ki aua whakarerekētanga ka taea e tēnei whenua te noho ki te ara me te mea anō ka pakari ake ki ngā panonitanga ka tukia.

Ahakoa karekau he tangata e taea te matakite ake i te anamata, ko tā mātou e mōhio nei, ko ā mātou hoariri i tāwāhi me ngā kaihokohoko kei te nuku kē ki ngā hua, ngā kaupapa me ngā pāpori iti nei te tukuwaro nātemea he tika ki te ōhanga. Ko ēnei ngā tohu e matapaetia ana ka eke, ā, ka tere hoki.

I Aotearoa nei ko te ara pai ko te whāinga iho i ngā āheinga o te whakawhitianga, inā hoki te whakahaere i te rahinga me te terenga o te panoni, hei kaupare noa i ngā whiunga a te āhuarangi ki ō mātou hapori me ngā nohoanga.



Tākuta Rod Carr, Te Tumu

Chair's message

Aotearoa New Zealand's emissions budgets turn the country's long-term emissions reduction target into tangible, measurable and achievable steps. These steps signal the path ahead for the next 10–15 years, meaning industry and businesses, government and communities all have confidence to do long-term planning, investment and action.

The Government has made clear its commitment to achieving the country's current 2050 emissions reduction target. The Government's decision on the level of the fourth emissions budget is important to achieve this because it will set Aotearoa New Zealand's trajectory out to 2050. Our analysis shows that the country can reduce gross emissions in ways that bring substantial accompanying benefits – and that overall, it is better for the economy, the environment and for all of us to do this.

The mix of actions and policies to reduce emissions, and to determine how much carbon dioxide to remove from the atmosphere through forestry or other means, is also an important decision. This is because how much we rely on removing greenhouse gases from the atmosphere, and on new low emissions technology being developed and taken up, affects how likely it is that the country will achieve its emissions budgets. Another important aspect is that the Government's choices (and those of businesses, individuals and communities) on how to achieve the budget have different benefits, risks and impacts that will affect different sectors and communities in different ways. The Government will need to weigh up these options and the associated benefits, risks and impacts.

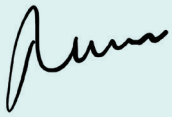
The evidence shows there are options to reduce gross emissions in line with the current 2050 target, which also bring opportunities and benefits for the country's economy, society, environment and future generations. Overall, the effect would be economic and social gains. This is because as well as economic opportunities, there are other substantial benefits that can come from reducing emissions. We estimate, in the fourth emissions budget period alone, there could be improvements in health valued at $2.1 billion a year due to cleaner air from less fossil fuels being burned for transport. Such additional benefits are a critical part of what will contribute to a thriving future for Aotearoa New Zealand. However, it is important to note that some sectors, communities and households will feel the impacts more than others. The Government has a role in ensuring an equitable transition, and the tools to make it happen. In addition, households that swap out fossil fuels used for heating and transportation in favour of electricity stand to save thousands of dollars a year in energy costs.

Circumstances have changed since the first three budgets were set, so we are recommending that the first, second and third emissions budgets are revised. Doing so means the budgets will continue to guide action to reduce emissions that make the recommended fourth emissions budget achievable, and put the country on a path to meeting the 2050 target.

Being able to revise emissions budgets is a critical strength of the system that Parliament endorsed in 2019. Budgets are set 10 years in advance – this is the foreseeable future, but measurement methodologies, behaviours and technologies can change with unforeseen speed. No one knows exactly what technologies will be available and at what cost over the next 10–15 years, or how the domestic and global situations will change. Being able to update budgets in response to such changes means the country can stay on track and is more resilient to any future changes.

Although no one can predict the future exactly, what we do know is that our international competitors and customers are already moving to low emissions products, services and societies because it makes economic sense. These trends are expected to continue and accelerate.

It's in Aotearoa New Zealand's best interest to choose a path that realises the opportunities of the transition, whilst driving the scale and pace of change needed to avoid the worst impacts of climate change on our communities and livelihoods.



Dr Rod Carr, Chair

Te kupu a te Pou

Ko te kupu akiaki motuhake, whai mana nei he whakaatu atu ki te Kāwanatanga i tōna whakataunga ki te tahua tukuwaro tuawhā he pēhea tōna takotoranga (ki te wāhanga 2036-2040). Ko tēnei whakatau ka whai pānga ki ngā mahi, ki ngā mahere me ngā whakatau rawa mō te 10-15 tau neke atu, nātemea ko ngā tahua tukuwaro he 'tohu hirahira' ki te ahunga whakaheke tukuwaro 2050 o te wā mā Aotearoa.

Kua arotake kētia e matou (mō tōna wā tuatahi) ngā tahua tukuwaro e tau tonu nei, me ngā ture e hāngai ana ki aua mea na. Ko tēnei arotake he tino herenga ki te pūnaha hei hāpai ake ki te whakahāngai i ngā tahua tukuwaro – ki a rātou anō me te whakatutukinga o te ahunga 2050. Ko ā mātou whakahau hukihuki he hāpai ake i te ūnga o ngā tahua tahi, rua me te toru e mahi tonu ai i āna anō mahi.

E whanake mai ai tēnei kupu akiaki i tirohia te taha pūtaiao, i kōrero ki ngā iwi, me te whakapau kaha ki te whai māramatanga ki ngā whēakotanga me ngā whiunga. Ko ā mātou whakaritenga ki ngā tauira me te aromatawai he whakawhanake ake i tōna tūāpapa, me ngā whakahounga, te whakaritenga i whakamahia ki ō mātou kupu akiaki ō mua ki ngā tahua tahi, rua me te toru, nā whai anō tōna whakapakaritanga me tōna i whakamanahia e ngā mātanga ā-ao.

Ko tēnei aromatawai he kōrero nā te hiahia ki ngā taunakitanga, ā, kua whakahoungia ki ngā raraunga o te wā, āpitihia ko ngā taunakitanga me ngā akoranga o ngā uiuinga tūmatanui ki tō mātou kupu hukihuki. Tuia ki tēnei ko te kōrero hou ki te wātea mai o ngā hauwaro, ngā raraunga hou ki te ahurākau, te kōkirihanga o ngā whakamahinga kikowaro, te painga o te whakamahinga hiko ki te ahi ki ngā hanganga mētera, me te painga o ngā taunga ngāwhā whakaputa hiko.

Ko ngā akoranga me ngā taunakitanga i kohua ake i ngā uiuinga he whakatauira me te whakakaha ake I te mōhioranga o ngā āheinga o te wā, āpiti atu ko ngā tūraru me ngā whiunga o te tini āheinga ki ngā whakahenga tukuwaro. Ko ngā tahua tukuwaro he tino herenga ki te punaha whakaheke i tā Aotearoa tukuwaro. Ka ārahina te ahunga o ngā tukanga kāwanatanga ki ngā mahinga o te āhuarangi ki tēnei whenua. Kei te Kāwanatanga ngā kōwhiringa kia pēhea tōna tukunga i ngā tahua tukuwaro. Ko ēnei kōwhiringa me whai waahi ki te tuku I te ahunga Paeroa, arā kia tutuki i te ahunga whakaheke tukuwaro ki 2050 rā anō.

Ko ā mātou arotake he whakaatu i te huhua o ngā āheinga ki te tutuki i ngā tahua tukuwari me te whakatau i te ara ki tēnā whāinga. Ko te ara ka whāia te tūtohu i ngā momo painga me ngā āheinga ki ngā kāinga, ngā pakihi me ngā hapori. Ka whai pānga hoki ki tō Aotearoa whakahaere i ōna tūraru me ngā pōhehe ka kitea ā ngā tau te haere mai nei.

Kāore tonu e mōhio ana i te anamata, ā, ka rerekē hoki ngā āhuatanga – koinei tonu te take ka whakamahia te arotake tairongo me ngā horopaki ‘Inā hoki…ka’, hei tūtohu ake i te ara hei whāinga ki te whakawhitianga, māna ko te hoatu I tētahi mahere māro me ia kokenga e whakawhirinakihia ana e te matapae he aha oti ngā āhuatanga ka puta.

Ko ā mātou aromatawai he whakaatu mena rā ka pēnei te tutukinga a tēnei whenua i ngā whakahau e tika ana ki te tukuwaro mō te wāhanga 2036-2040, ko te katoa o te whiunga ka whai hua ki te ōhanga me te pāpori.Heoi anō, kei te āhua o ngā kōwhiringa e whakaheke mai ana i ngā tukuwaro tāngata me te hua mai o ngā painga irarua. Ko te nunui o ngā rawa i hua ake i ngā hanga tukuwaro iti kei tō mātou ake ara ka eke atu tōna utu i a ia anō i te pae tawhiti, mā roto mai i te penapena penehīni me te whakaheke i te utu ki ngā whakahaerenga. E matapae hoki ana mātou te tika mai o ngā penapena pūtea a ngā whakamahinga ki te whakaheke tukuwaro tāngata me te whakatupu ki te $1 piriona i ia tau hei te 2040 (te mutunga tēnei ki te wāhanga tahua tukuwaru tuawhā).

Ko ā mātou whakahau he aro ki ngā whakataunga o ā mātou kokenga hou ki te ara o te anamata tukuwaro iti, me te aha, kātahi te whakahīhī, kātahi hoki tōna porotutuki, kātahi rā hoki tōna pīngore ki te anamata, tōna toiroa ki te ōhanga, ki te pāpori, ki te taiao hoki.

Jo Hendy, Te Pou

Chief Executive's message

This independent, evidence-based advice will inform the Government's decision on what the fourth emissions budget (for the period 2036–2040) should be. This decision will affect the country's actions, planning and investment decisions for the next 10–15 years and beyond, because emissions budgets are 'stepping stones' to Aotearoa New Zealand's current 2050 emissions reduction target.

We have also reviewed (for the first time) the emission budgets that are already in place, and the rules that apply to them. This review is a vital part of the process to help keep emissions budgets aligned – with each other and with achieving the 2050 target. Our recommended revisions will help maintain the integrity of the first, second and third emissions budgets so they do the job they're supposed to.

To develop this advice we looked at the science, talked to people, and worked to understand real life opportunities and impacts. Our modelling and analysis approach builds on, and updates, the approach we used for our previous advice on the first, second and third emissions budgets, which was robustly tested and validated by international experts.

This analysis was informed by a call for evidence, and has been updated with the latest data, as well as evidence and insights from our public consultation on our draft advice. This includes new or updated information on the availability of gas supply, forestry data, planned biomass use, the feasibility of using an electric arc furnace for steel manufacture, and the feasibility of new geothermal power generation.

The insights and evidence provided through consultation tested and strengthened our understanding of the options available, as well as the potential issues and impacts of various opportunities for emission reductions.

Emissions budgets are a critical part of the system for reducing Aotearoa New Zealand's emissions. They help guide government policy on domestic climate action. The Government has choices about how it delivers on emissions budgets. These choices need to add up to deliver the long-term goal, which is meeting the emissions reduction target by 2050 and beyond.

Our analysis shows there are multiple ways to meet emissions budgets and set the path to the target. The path taken affects what kinds of benefits and opportunities are available to households, businesses and communities. It also affects how Aotearoa New Zealand is able to manage risks and uncertainties in the years ahead.

The future is uncertain, and circumstances change – this is why we use sensitivity analysis and 'what if' scenarios, and present a path to guide the transition, rather than providing a detailed step-by-step plan that relies on forecasts speculating on exactly what will happen.

Our analysis shows that if the country acted to achieve the recommended level of emissions for the 2036–2040 period, the overall effect would be economic and social gains. However, this depends on making choices that reduce gross emissions *and* unlock co-benefits. Many of the investments made in low emissions technologies included in our recommended path would more than pay for themselves in the long term, through fuel savings and lower maintenance costs. We also estimate direct financial savings from actions to reduce gross emissions would grow to $1 billion per year by 2040 (the end of the fourth emissions budget period).

Our recommendations reflect our judgements of what should be the next step on the path to a low emissions future that is ambitious and achievable, provides flexibility for the future, and offers lasting economic, societal and environmental benefits.

Jo Hendy, Chief Executive

Mō He Pou a Rangi
Climate Change Commission

He hinonga Karauna motuhake te Komihana nei a He Pou a Rangi i whakatūria e Te Ture Urupare Āhuarangi 2002 (te Ture) hei:

- whakarite i te kupu-akiaki motuhake, whai taunakitanga hoki mā ngā kāwanatanga hou, mō te whakamauru i te huringa āhuarangi (tae ana ki te whakaheke i te tuku haurehu kati mahana) me te urutau ki ngā whiunga o te āhuarangi
- aromatawai, hei arotake hoki i te anga whakamua o te whakaheke tukuwaro me te whakawhiti ki te rehu tika.

Kua ū ngā kāwanatanga hou ki te whakaheke i ngā haurehu whakapoke-āhuarangi o Aotearoa me te urutau ki ngā pānga o te huringa āhuarangi. Tukua ai e te Kōmihana ngā pārongo tapatahi e pā ana ki ngā kōwhiringa me urupare rā e te kāwanatanga o te rā. Mā tō mātou motuhaketanga e mōhio ai a Aotearoa – me te ao – ki te motuhenga o ngā mahi huringa āhuarangi o Aotearoa.

Ko te hōkaitanga me ngā angawā kua whakaritea mō ngā aroturukitanga me ngā kupu āwhina a te Komihana, kei roto tonu i te Ture. Kei te Minita Āhuarangi te tikanga rā kia tono motuhake ki te Kōmihana mō tētahi kupu akiaki motuhake.

Kei te Ture te mana ki te Komihana kia tō māi i te taunakitanga tika o te wā, te tātaritanga me ngā whiunga a te āhuarangi, ka mutu, ko te pānga ki a Aotearoa ā-tairoa nei, āpiti tonu ki ngā tūhonohono me ngā uiuinga tūmatanui.

Kei te Ture hoki te tohutohu i a mātou kia whai whakaaro ki te hononga a te Karauna ki te Māori, ki te ao Māori me ōna tino pānga ki te iwi Māori, i ā mātou mahi. Tuia rā ko te whakawhanake i ētahi hononga pono ki te iwi Māori, te mahi kia mātau ki ngā whakaaro whānui, ki ngā hiahia me ngā awhero o te iwi Māori, te mōhio ki te mana me ngā tikanga o te iwi Māori, ka mutu, kia tika te rapa o te hononga e tika ai te urunga ki o mātou mahi.

Kāore mātou e whakatakoto kaupapahere, ehara hoki i te mea me whai te Kāwanatanga i ā mātou kōrero āwhina. Heoi anō, e ai ki te ture, me tāpae te Kāwanatanga i ā mātou kupu akiaki ki te Pāremata, me te urupare tūmatanui mai mā te tuhi – āpiti tonu ko te whai whakaaro noa ki te wehenga atu i ā mātou whakahau. Ka āwhina ēnei haepapa ki te whakaū i te āta arohia o ngā kōrero āwhina motuhake e pā ana ki te urupare huringa āhuarangi o te motu e ngā Kāwanatanga hou.

E aro ana te kupu akiaki a te Kōmihana ki ngā hua ka taea mā ngā mahi, ngā kaupapahere hoki a te kāwanatanga, me ngā kōwhiringa e wātea ana ki te hunga whakatau – tae ana ki ngā ara me ngā tūraru ka tāpaetia e ēnā kōwhiringa. Ko te whāinga ko te tautoko i te Kāwanatanga ki te whakatutuki i tana tūranga i raro i te Ture, tae ana ki te whakatutuki i ngā tahua tukuwaro me te whāinga o 2050, me te tuku i a ngā iwi o Aotearoa ki te whakarite, ki te urutau anō hoki ki ngā pānga o te huringa o te āhuarangi.

Ko tēnei te tūāpapa o tā mātou mahere mahi, e tuku ana i te kupu akiaki motuhake, whai taunakitanga anō hoki, ki te Kāwanatanga mō tā Aotearoa whakamauru me te urutau ki ngā whiunga o te āhuarangi me te whakawhiti atu ki tētahi anamata tōnui, āhuarangi-pakari me te tukuwaro iti.

Kei tā mātou pae tukutuku ētahi pārongo anō e pā ana ki te hōtaka mahi a te Kōmihana, kei www.climatecommission.govt.nz

About He Pou a Rangi
Climate Change Commission

He Pou a Rangi Climate Change Commission (the Commission) is an independent Crown entity established by the Climate Change Response Act 2002 (the Act) to:

a. provide independent, evidence-based advice to successive governments on mitigating climate change (including through reducing emissions of greenhouse gases) and adapting to the effects of climate change
b. monitor and review progress towards emissions reduction and adaptation.

Successive governments have committed to reducing Aotearoa New Zealand's emissions of greenhouse gases and adapting to the impacts of climate change. The Commission provides impartial information about the choices the government of the day has to respond to climate change. Our independence provides assurance to New Zealanders – and internationally – about the credibility of Aotearoa New Zealand's action on climate change.

The scope and timeframes for the Commission's advice and monitoring reports are set out in the Act. In addition, the Minister of Climate Change may also make a specific request to the Commission for advice on any topic.

The Act requires the Commission to draw from the best available evidence and analysis, and to consider the impacts of climate change and the implications for Aotearoa New Zealand over time, including through engagement and public consultation.

The Act also directs us to consider the Crown–Māori relationship, te ao Māori, and specific effects on iwi/Māori in our work. This involves building meaningful and respectful relationships with iwi/Māori, working to understand the diverse perspectives, needs and aspirations of iwi/Māori, recognising Māori rights and interests, and enabling active partnership and participation in our work.

We do not set policy, and the Government does not have to take our advice. However, the Act does require the Government to present our advice to Parliament, and to respond publicly in writing – including providing any reasons for departing from our recommendations. These obligations help ensure independent advice on the country's climate change response is given due consideration by successive governments.

The Commission's advice focuses on the outcomes that can result from government action and policy, and the choices that decision-makers have – including the opportunities and risks presented by those different options. The aim is to support the Government to fulfil its role under the Act, including achieving emissions budgets and the 2050 target, and allowing the people of Aotearoa New Zealand to prepare for, and adapt to, the effects of climate change.

This is the foundation of our programme of work providing the Government with independent, evidence-based advice on how Aotearoa New Zealand can mitigate and adapt to the effects of climate change and transition to a thriving, climate-resilient, and low emissions future.

More information on the Commission's work programme can be found on our website, www.climatecommission.govt.nz.

Te whakarākei matua
Executive summary

Under the Climate Change Response Act 2002, He Pou a Rangi Climate Change Commission must provide the Government with advice on setting Aotearoa New Zealand's fourth emissions budget by the end of 2024.

As part of this work, we also advise whether revisions are needed to the first, second and third emissions budgets, and on the rules that apply to emissions budgets.

This advice sets out our recommendations for the fourth emissions budget (covering the period 2036–2040), following consultation on draft advice in April and May 2024.

It shows how Aotearoa New Zealand can best take advantage of the benefits and opportunities presented by the transition to a thriving, low emissions economy.

This final advice is updated with new information and the latest available data, and informed by consultation feedback. The insights and evidence provided through consultation have tested and strengthened our understanding of the options available, as well as the potential issues and impacts of emission reductions.

Key points for decision-makers

Emissions budgets turn a long-term target into achievable steps, and provide predictability and stability for Government, business and community action.

This advice recommends a level for the fourth emissions budget (for the period 2036–2040) as the next step on the country's path to the 2050 target – based on the latest evidence and data, including insights received through our call for evidence and consultation.

Our recommendation is both ambitious and achievable. It provides flexibility for the future, and offers lasting economic, societal and environmental benefits that will likely exceed overall costs.

Continued on next page.

Key points for decision-makers (continued)

We have also provided advice on updates to the previous emissions budgets, and the rules that govern how greenhouse gases are measured and monitored in Aotearoa New Zealand. This is part of the system that allows for response to changed conditions, supporting the country to stay on course for achieving its long-term climate goals.

What matters when considering the fourth emissions budget

- The recommended level for the emissions budget for 2036–2040 is a feasible and effective next step in the country's emissions reduction efforts.
- Our recommendations are based on a close review of the emissions reduction action already happening, and opportunities for further reductions – this is what forms the base of the 'EB4 demonstration path' that underlies the advice.
- The recommendations take into account benefits, challenges and risks that require careful consideration to ensure success. We did this through exploring alternative ways the budgets could be met, and through sensitivity analysis.

Key facts and figures

- We are recommending a fourth emissions budget of 160 $MtCO_2e$:[i] the annual average emissions in the budget period would be 56% lower than they were in 2022.
- A comparison of actual emissions in 2022 to expected emissions in 2040 (the last year of the budget period) shows gross emissions of all greenhouse gases would reduce by 37% from 79 $MtCO_2e$ to 50 $MtCO_2e$, while carbon dioxide removals by forests would increase from 5 $MtCO_2e$ to 22 $MtCO_2e$.
- By sector, the largest reductions in gross emissions come from energy (21 $MtCO_2e$), transport (18 $MtCO_2e$) and agriculture (17 $MtCO_2e$) – this is a comparison between the recommended fourth emissions budget and the third emissions budget as set by the Government in 2022.
- We estimate there will be no noticeable impact on the level of GDP in the budget period from following the EB4 demonstration path.
- There are substantial co-benefits of action to reduce emissions. We anticipate improvements in health valued at $2.1 billion a year in the fourth emissions budget period, from cleaner air when less fossil fuels are burned for transport.
- For many of the actions in the EB4 demonstration path, investments made in low emissions technologies will more than pay for themselves from 2036 onwards through fuel savings and lower maintenance costs. Since some technologies, for example those related to biogenic methane, are expected to emerge during the fourth emissions budget period, the impacts and benefits of that technology will be realised over following budget periods.
- We estimate direct financial savings from actions that reduce gross emissions would grow to NZ$1 billion per year by the end of the fourth budget period.

Next steps: It is the Commission's role to advise on emissions budgets, and the Government's role to set these budgets and create the emissions reduction plans and policy to meet them. The Minister of Climate Change is required under the Act to set the fourth emissions budget by 31 December 2025.

i All carbon dioxide equivalents presented in this report are on the AR5 GWP_{100} basis. See **Box 3.1** in *Chapter 3: Recommended level for the fourth emissions budget* for further information on greenhouse gas metrics.

What we are recommending

Recommended level for the fourth emissions budget

Our recommended level for the fourth emissions budget is 160 $MtCO_2e$. This means the net average annual emissions in the budget period (2036–2040) would be 56% lower than they were in 2022. We have revised this recommended level based on tested methods of analysis of the latest available information and evidence, including feedback on our draft advice.

We recommend a limit of zero for offshore mitigation to meet the fourth emissions budget.

Recommended revisions to the set emissions budgets

We recommend adjustments to the first, second and third emissions budgets, to reflect changes in the country's official calculation of greenhouse gas emissions (New Zealand's Greenhouse Gas Inventory, or the GHG Inventory), and the impact of higher rates of forestry planting than were projected at the time those budgets were set.

Rules for measuring progress towards meeting emissions budgets and the 2050 target

We have recommended matters the Government should consider in developing accounting methodologies for additional emissions sources and sinks. We do not, however, recommend any changes to the rules that govern current greenhouse gas measurement and calculation.

A full set of recommendations is on pages 25–28.
The approach taken, and the final analysis underlying these recommendations, are summarised in this executive summary, along with an overview of how we have responded to feedback on the draft advice.

What this advice on the fourth emissions budget provides

The next step in Aotearoa New Zealand's transition to low emissions

Emissions budgets limit the amount of greenhouse gases Aotearoa New Zealand can emit in a five-year period. They act as stepping stones, guiding the country's path to meeting the 2050 target in an ambitious, achievable, and measurable way.

In 2022, the Government, with cross-party support, set Aotearoa New Zealand's first emissions budget (2022–2025), second emissions budget (2026–2030), and third emissions budget (2031–2035).

In 2025, the Government will need to set the fourth emissions budget (2036–2040), as the next step in the country's transition to low emissions.

The Government has made its commitment to achieving the 2050 target clear. Our final advice provides the Government with independent, expert advice on the choices it has in setting the level of the fourth emissions budget, and on the path to follow to achieve those outcomes. The decisions the Government makes will affect what kinds of benefits and opportunities are available to households, businesses and communities, and how Aotearoa New Zealand is able to manage risks and uncertainties in the years ahead.

Introduction

Emissions budgets lay the path towards a thriving, low emissions future

In the face of the sharpening climate change challenge, the world is intensifying efforts to limit global warming by reducing greenhouse gas emissions in ways that will sustain and keep their communities safe. Aotearoa New Zealand has committed to this global response and is building its own transition to a thriving, low emissions economy.

This transition can support people, businesses and communities in Aotearoa New Zealand to respond to the opportunities opening up in a global low emissions economy, while building the resilience the country needs to adapt to the climate impacts already felt across the motu. It presents a range of benefits – including new market openings, cleaner air, lower overall energy costs, and healthier oceans – and it also presents challenges and risks that require careful consideration to ensure success.

The 2050 target represents Aotearoa New Zealand's long-term commitment to reducing its emissions to contribute to global efforts to limit warming to 1.5°C above pre-industrial levels, which evidence shows will help avoid the worst impacts of climate change. The target is set under the Climate Change Response Act 2002 (the Act), the purpose of which is to provide a framework for clear and stable climate change policies.

Emissions budgets help turn this long-term commitment into tangible, measurable and achievable steps.

At all times, there are at least three emissions budgets in place, giving households, businesses and communities a view of Aotearoa New Zealand's emissions reduction path at least 10 years into the future. When people are clear on the way forward, they can make informed planning decisions and invest confidently in low emissions alternatives, such as heat pumps and electric vehicles.

Separate but connected advice: Our review of the 2050 target and international shipping and aviation emissions

In late 2024 the Commission also provided advice to the Government following reviews of the 2050 target and international shipping and aviation emissions (see https://www.climatecommission.govt.nz/our-work/advice-to-government-topic/review-of-the-2050-emissions-target/2024-review-of-the-2050-emissions-target/final-report). These related reviews have looked at whether the target as created in 2019 is fit-for-purpose in the current circumstances, and whether international shipping and aviation emissions should be included in the target.

The two reports we provided to Government at the end of 2024 are connected but necessarily separate. This advice, on the fourth emissions budget, is aligned to the *current* 2050 target. It does not take into account any recommendations we make to Government about potential changes to the target.

While each piece of advice has a specific focus, they both deal with Aotearoa New Zealand's journey to becoming and maintaining a thriving, low emissions economy by and beyond 2050. Together they provide decision-makers and citizens with a clear view of options for Government decision-making that will affect the country's actions, planning and investment for the next 20–30 years.

Because emissions budgets are set as a net volume of greenhouse gas emissions, they can be met through a combination of actions, including:

- reducing gross emissions (reducing emissions at their source)
- removing carbon dioxide from the atmosphere (for example through growing trees)[ii]
- in limited circumstances, using offshore mitigation (when Aotearoa New Zealand pays for emissions reductions or removals that occur overseas).

Our approach to developing this advice

The Commission's approach to developing this advice is based on tested methodology, building on the approach and process developed when the Commission advised on the first three emissions budgets in 2021 (*Ināia tonu nei: a low emissions future for Aotearoa*).[1]

Our approach, as an independent Crown entity, is founded on research, evidence and modelling, and draws on the expertise of our Board of Commissioners, He Pou Herenga (a Māori advisory body to the Board), and staff. In preparing this advice on the fourth emissions budget, we have examined the latest publicly available data on the country's emissions profile and the scientific evidence about options for reducing emissions, and feedback from consultation.

We gained invaluable insight by engaging with people on the ground. This included our consultation on the draft advice in April and May 2024, our earlier call for evidence, and the information gathered from engagement with iwi/Māori and stakeholders over the course of the Commission's existence. This engagement informed our modelling and helped shape our final advice. It has allowed us to test our assumptions and strengthen our understanding of the future actions Aotearoa New Zealand can take to reduce its emissions – see 'What we heard and how we responded' following.

In forming our key judgements and final recommendations, we have carefully considered a wide range of factors as required by the Climate Change Response Act 2002 (the Act). This includes the latest science and technological developments, opportunities for reducing or removing emissions, and the limits of what is achievable. We have taken into account the Crown–Māori relationship, te ao Māori and specific effects on iwi/Māori, and the likely impacts of actions taken to meet emissions budgets (see **Figure 1.4** in *Chapter 1: Introduction*).

How we reached our recommendations on the level of the fourth emissions budget

Our analysis shows there are multiple ways Aotearoa New Zealand could achieve the 2050 target. The Government has choices about what level it will set for the fourth emissions budget, and the path taken to achieve those outcomes.

ii Currently, planting and growing trees is the only method of removing and storing carbon dioxide from the atmosphere in Aotearoa New Zealand.

To develop our final advice on the fourth emissions budget we looked at what has changed since the first three emissions budgets were set by the Government, including the options available for Aotearoa New Zealand to reduce its emissions. Those changes include updated information and trends, assumptions (reflecting new evidence), the New Zealand Greenhouse Gas Inventory (GHG Inventory) and updated projections from government agencies.

Using this updated information about possible emissions reductions and removals, we modelled different scenarios to help us understand what mix of actions and levels could achieve the 2050 target. As part of this work, we created a 'reference scenario' as a baseline; this allows comparison of proposed action to current policies and measures. This is explained further in *Chapter 4: Developing the path to the fourth emissions budget*.

To illustrate how budgets could realistically be met we developed an 'EB4 demonstration path', which is a set of measures and actions that would achieve the proposed budget.[iii] We updated this EB4 demonstration path for our final advice, to arrive at the recommended level of the fourth emissions budget, and recommended breakdown of greenhouse gases.

As part of this we tested alternative ways in which the budgets could be met, to ensure the recommended budget could be met through a range of ways. We also looked at how changes in some assumptions would affect the level of emissions through 'sensitivity analysis'. This checked what would happen if important factors were different from the assumptions made, and was a critical step in demonstrating that the recommended budget could be met.

Our final advice on the fourth emissions budget reflects our judgements of what would be ambitious and achievable, provide flexibility for the future, and offer lasting economic, societal and environmental benefits that will likely exceed overall costs.

How we reached our recommendations on revising the first, second and third emissions budgets

Part of our task in advising on emissions budgets is to look back at the budgets that have already been set, and consider whether any revisions are needed. This is our first review of set emissions budgets, and we developed a new process for this work, based on the requirements in the Act.

The Commission can only advise a change to emissions budgets if we find evidence that specific circumstances have changed since the budgets were originally set. It is the Minister of Climate Change's decision whether to revise an emissions budget. For the current budget period (2022–2025), the threshold for change is higher – there need to be 'exceptional circumstances' for the Minister to revise a budget after the budget period has begun.

These requirements set a high bar for change, helping to ensure stability for households, businesses, and communities while still allowing flexibility for the country to respond to significant changes in circumstance.

iii The EB4 demonstration path is a tested set of measures and actions within each sector that would deliver the recommended fourth emissions budget. It is not the only option, it is not a forecast of what will happen, and it is not a strict plan that Government must follow.

For set emissions budgets, the two kinds of change we checked for were:

- **methodological changes** to the way the GHG Inventory calculates and reports greenhouse gas emissions and removals
- **significant changes** in circumstances (such as economic circumstances, scientific advice and technological developments) since the emissions budgets were set.

Our recommendations on revising the first, second and third emissions budgets reflect the impacts of the methodological and significant changes we found. Our final analysis shows our recommended revisions would bring the first, second and third emissions budgets back in line with the original intent when they were set.

How we reached our recommendations on rules used to measure progress

We are also required under the Act to assess if changes are needed to rules for measuring progress towards meeting emissions budgets and the 2050 target.

We looked at whether the Government has updated its approach to emissions accounting (since our previous advice in 2021 when the first three emissions budgets were set) to understand whether changes are needed to the rules to measure progress towards meeting emissions budget and the 2050 target. We did not recommend changes to the current accounting rules, but we do make a recommendation about matters to consider when Government is developing accounting methodologies for additional emissions sources and sinks.

What we heard and how we responded

Our engagement included an initial call for evidence in 2023, and consultation on our draft advice in April and May 2024.

This final advice incorporates the contribution of over a thousand people from across the motu who participated in our consultation process. This included representatives of over 300 organisations and community groups. These discussions and written submissions tested and strengthened our approach and conclusions.

Themes that emerged from feedback

We invited people to share their priorities for the country's climate change response. The feedback we receive about values and priorities informs Commission advice, and is reflected to Government decision-makers, and to people in the community who act in response.

The Government has choices about how to reduce Aotearoa New Zealand's greenhouse gas emissions. Our advice provides a thorough and robust package of information and analysis that can help the Government understand the implications of its choices about emissions reduction and where value judgements need to be made.

We heard four different themes in the feedback received:

- values and priorities in decisions about climate change response
- areas to consider while reducing greenhouse gas emissions
- the role of government in reducing emissions
- practical options the country has to reduce greenhouse gas emissions.

We carefully considered the points, priorities and values that emerged under these themes – see *Chapter 2: What we heard*.

Specific feedback on our draft advice on the fourth emissions budget

Consultation on our draft advice for the fourth emissions budget allowed us to test our draft recommendations, approach, assumptions and evidence base.

Feedback on the proposed level and demonstration path

Most submitters agreed with our approach to developing the demonstration path and our assessment of the considerations for the fourth emissions budget level, including our key judgements. Submitters provided a range of evidence on the feasibility, cost and implications of options for reducing emissions. We assessed the evidence and updated some of our modelling assumptions. Updated assumptions reflect new information on expected forestry planting rates, availability of gas supply, biomass use at the Huntly power station, electric arc furnace use for steel production, and feasibility of new geothermal power generation.

Feedback on assessment of impacts

There was support from most submitters for our assessment of the impacts of action to reduce emissions to the proposed level for the fourth emissions budget.

We received a range of feedback on other impacts that should be considered, or given more prominence. This informed our assessment of how actions to achieve the recommended fourth emissions budget could affect people and communities across Aotearoa New Zealand.

Overall, we assess the level of impacts to be similar to that in our draft advice. In many places we have revised our description of impacts to reflect insights provided in feedback. This includes changing how we describe effects specific to iwi/Māori to better reflect the whakaaro heard in feedback.

Feedback on proposed revision of set budgets

There was support from most submitters for our approach to assessing whether changes were needed to the first three emissions budgets. Most agreed with our proposal to revise those budgets for changes in the methodology for emissions accounting, and with our assessment of significant changes that justified revision of a set budget.

We updated our assessment of the effects of changes in methodology for emissions accounting and confirmed our assessment that the recent higher rates of exotic afforestation, from the available data, are the only significant change to information that has occurred since budgets were previously set.

Feedback on measuring progress towards emissions budgets and the 2050 target

Most submitters agreed with our assessment that the Government should continue with the existing approach to measuring and calculating emissions, and also with our draft recommendation on what the Government should consider when developing accounting methodologies for additional emissions sources or sinks.

Our recommendations for the fourth emissions budget

Our recommended level for the fourth emissions budget is 160 $MtCO_2e$. The recommended level means the net average annual emissions in the budget period (2036–2040) would be 56% lower than they were in 2022.

The choices that Government has in how it meets the fourth emissions budget involve decisions around the mix of actions and policies to reduce emissions, and how much forestry will play a role to remove carbon dioxide from the atmosphere. These choices matter, as each decision will have benefits and consequences.

The Act requires that our advice on the fourth emissions budget includes how we expect the budget, and the 2050 target, could be realistically met – and must show the corresponding levels of gross emissions reductions and removals, and the contribution of each greenhouse gas. To do so we have looked at what we think is the best course of action for Aotearoa New Zealand, with consideration to a range of matters under the Act.

Our recommendations for the breakdowns in reductions and removals, and volumes of different greenhouse gases, are shown on pages 25–26, along with our recommendation on the contribution of offshore mitigation to the budgets as required in the Act.

Advice to inform Government decisions for future emissions reduction

Our final advice provides the Government with the basis to decide on a fourth emissions budget level, which will help determine the trajectory of Aotearoa New Zealand's emissions reduction out to 2050. It also sets a path for decisions needed on how the emissions budget is achieved through specific policies and actions – which Government will set out in the emissions reduction plan for that fourth budget period.

Our analysis shows that there are opportunities to reduce gross emissions on the path towards the fourth emissions budget that would bring a wide range of benefits for Aotearoa New Zealand. There remains an important role for greenhouse gas removals through forestry to meet and maintain the net zero component of the 2050 target. We have found that – due to the opportunities for gross emissions reductions and recent high levels of planting – less afforestation would be needed in the future than anticipated when we advised on the first three emissions budgets in *Ināia tonu nei*. This also means that investing in carbon capture and storage technologies may not need to play a large role to achieve the 2050 target.

Achieving the fourth emissions budget this way would allow the country to reduce emissions in line with meeting the 2050 target, while accessing a range of opportunities and benefits for the economy, society, the environment and future generations. It would give Aotearoa New Zealand flexibility to respond to new information about the viability of different emissions reduction technologies and opportunities.

What the recommended fourth emissions budget might mean for New Zealanders

The role of the Commission in advising the Government requires us to consider the implications of decisions about emissions reduction for the country as a whole. This is fundamental for informing the judgements we need to make in advice on the fourth emissions budget, and will be important for the Government to consider in its final decisions.

Setting the level of an emissions budget does not on its own have direct impacts on people. It is the choices made to achieve the budget that determine the impacts that the budget creates. Some of these choices are made by government, others by individuals, businesses, industries or even the international community.

Consideration of impacts means taking into account all the changes that can be expected, both positive and negative, from the actions required to meet an emissions budget. Understanding the likely opportunities and challenges enables us to understand how New Zealanders will be affected by the fourth emissions budget, and if the impacts on the economy, businesses, households and whānau, regions and communities, iwi/Māori, and the environment can be managed in an equitable way.

Assessing the consequences of choices for a future period is challenging, even as an idea. We have built on the process used for our earlier work on the first three emissions budgets, as set out in *Ināia tonu nei*.

To assess impacts we look at the differences between our reference scenario and the EB4 demonstration path (see 'How we reached our recommendations on the level of fourth emissions budget'). For example, when we look at the savings from electric vehicles, we estimate this based on the difference in the number of electric vehicles in the reference scenario, and the number of electric vehicles in the EB4 demonstration path.

Our assessment of how changes to achieve the recommended fourth emissions budget could affect people and communities across the motu and over time was updated to reflect feedback from consultation and new information and data.

We assessed the potential economic impacts of the recommended fourth emissions budget

Our assessment of the potential economic impacts used a range of models and approaches, which provide different perspectives and insights. This is important because focusing on a single perspective alone would provide an incomplete picture of the overall outcomes from the EB4 demonstration path and potentially be misleading.

Our analysis shows that if the country acted to achieve the recommended level of emissions reductions for the 2036–2040 period, the overall effect would be economic and social gains. This depends on making changes that reduce gross emissions and can unlock co-benefits. Significantly, our work shows that cleaner air from less fossil fuels burned for transport (from a faster transition to electric vehicles and reducing private vehicle use) would lead to improvements in health valued at around NZ$2.1 billion a year over the fourth emissions budget period.

We looked at the changes in direct financial costs and savings under the EB4 demonstration path, compared to the reference scenario. Analysis using the Energy and Emissions in New Zealand (ENZ) model showed that, for many of the actions in the EB4 demonstration path, investments made in low emissions technologies will more than pay for themselves in the long term through fuel savings and lower maintenance costs.

We estimate direct financial savings from actions that reduce gross emissions would grow to NZ$1 billion per year by the end of the fourth emissions budget period.

We also considered the impacts of following the EB4 demonstration path on the whole of Aotearoa New Zealand's economy. This perspective helps us to see the big-picture effect of our proposals on the economy as well as how things shift between sectors.

For the fourth emissions budget period we anticipate that following the EB4 demonstration path would not lead to a noticeable change in the level of GDP compared with the reference scenario. In 2050 we estimate a GDP level around 1% lower than if the country made no change from the current trajectory as shown in the reference scenario.[iv]

Our economic analysis provides no evidence that the recommended level for the fourth emissions budget is unattainable, or would provide significant or material economic impacts for the country as a whole. We expect it to result in a different pattern of economic activity than the reference scenario – with the output of some sectors increasing and others decreasing. The distribution of these changes will also depend on the policies chosen to achieve the budget.

The Crown–Māori relationship, te ao Māori, and specific effects on iwi/Māori

We have considered specific effects for iwi/Māori, as well as wider matters relating to te ao Māori and the Crown–Māori relationship. Our assessment recognises the potential benefits presented by the transition to a lower emissions economy as well as the accompanying need to increase resilience to the impacts of climate change. This is based on what we have heard through our recent consultation, as well as earlier engagement and consultations, and from research.

We heard that the Māori economy's level of investment in land-based activity increases iwi/Māori exposure to climate change, while the higher proportion of lower income households that include Māori may expose iwi/Māori to greater costs or make the transition harder.

We also heard that many iwi/Māori are already helping lead the response to climate change, as tangata whenua, rangatira and kaitiaki. Almost all Māori submitters noted their communities' existing climate strategies or initiatives to reduce emissions and manage the effects of climate change. There was a call for local and central government to resource these plans and initiatives to support faster emissions reduction, to the benefit of the community, and ultimately all of Aotearoa New Zealand.

Choices made about actions to meet the fourth emissions budget also present opportunities and risks for the Crown–Māori relationship. An effective relationship between iwi/Māori and the Crown and private entities is more likely to lead to effective and durable emissions reductions, avoiding unnecessary delays and costs.

iv The estimated change in GDP should be considered in the context of the great uncertainty inherent in predicting the level of GDP over 25 years.

The Government has a role in ensuring the transition to low emissions supports New Zealanders

While many actions to meet the fourth emissions budget will have positive impacts, some actions or changes may be harder to navigate – particularly for certain sectors, communities, some iwi/Māori, and households.

While household electricity bills are unlikely to significantly change, there may be some upward pressure on prices. There are also expected increases in the cost of fossil gas for households using it for heating and cooking, and in petrol and diesel prices.

People on lower incomes may be more in need of energy efficiency and cost saving measures but also less able to afford them. Government support targeted to those people facing cost or other barriers during the low emissions transition will be important to manage impacts.

For fossil fuel sectors such as coal, mining and gas, the transition to a low emissions economy is expected to result in reduced revenue and reduced opportunities for employment. For agriculture, reducing emissions in line with meeting our recommended fourth emissions budget is not expected to significantly diminish profit levels; there is, however, expected to be an effect on the growth of revenue. Managing impacts in specific subsectors will likely require changes in operating practices, informed by education and training, as well as support from the Government.

By clearly signalling its transition plans, the Government can help to provide certainty and time for sectors and communities to plan and change. Targeting policies, investment and support to those who will face the greatest relative costs will be important for managing impacts.

We recommend revisions to keep the first three emissions budgets ambitious and achievable

Part of our work providing advice on setting a new emissions budget includes looking back at the emissions budgets that have already been set, and considering whether any revisions are needed. These reviews help ensure that previously set budgets remain ambitious, and technically and economically achievable over time, and that Aotearoa New Zealand stays on track to meet the 2050 target.

Achieving the fourth emissions budget will depend on actions taken during the first three emissions budgets to reduce emissions, including building renewable energy infrastructure, transitioning to electric vehicles, and improving the productivity of agriculture.

We can, however, only recommend revisions to emissions budgets that are already in place, if there have been changes to the way the country's emissions are calculated and reported, or if significant changes in circumstances have occurred since the budgets were originally set.

Our analysis shows that methodological changes have occurred since the budgets were originally set and we recommend that methodological changes are incorporated into revisions for all emissions budgets as a matter of course. Methodological changes in 2024 impacted the first and second budget periods, but not the third.

We have also assessed that the impacts of higher rates of recent forestry planting are a significant change in the second and third emissions budget.

These recommended revisions are set out in detail on page 27.

Rules for measuring progress

Our role advising on emissions budgets includes reviewing the rules that govern how greenhouse gas emissions are measured and calculated in Aotearoa New Zealand. These are used for measuring progress towards meeting emissions budgets and the 2050 target, and identifying whether changes are needed to stay on track.

We first advised on these accounting rules in *Ināia tonu nei*. When the Government set the first three emissions budgets, it put in place rules that were largely in line with our advice. Under these rules, all emissions produced within Aotearoa New Zealand count towards emissions budgets. The current rules also have a specific way of calculating emissions related to planting and clearing forests.

Our final advice has no recommendation about changes to the current accounting rules. We do, however, make a recommendation about matters the Government should consider in developing accounting methodologies for additional emissions sources and sinks. We also strongly encourage reporting of the options considered and rationale for choices made.

What matters when changing methods for emissions measurement and reporting

The Government has indicated it plans to make two changes in its approach to measuring and reporting emissions, which may impact emissions budgets:

- The Government has said it intends to make changes that will allow emissions and removals from pre-1990 forest management activities to be included when calculating Aotearoa New Zealand's emissions.[v]
- It has started work to include additional sources of emissions and removals, outside those counted under current accounting rules.

Without careful consideration, these changes could make it possible to achieve set emissions budgets without meaningfully reducing gross emissions. This would impact how effectively these budgets can help Aotearoa New Zealand step down its emissions in line with achieving the 2050 target, so contributing to global efforts to limit warming to 1.5°C above pre-industrial levels.

By applying principles of additionality (where removals are only counted if they are 'additional' to the status quo) and permanence (which considers how long removed emissions can be stored) to accounting rules, the Government can help ensure Aotearoa New Zealand's efforts to reduce emissions are not unintentionally undermined by any changes to how emissions are measured and reported.

We are recommending the Government adopt these two principles and include them as criteria when calculating removals. We are also recommending the Government develop and implement long-term plans for measuring and monitoring the new sources of emissions and removals, and managing related risks and uncertainties.

v We understand this is now scheduled to be published as part of the country's first Biennial Transparency Report before the end of 2024.

Our recommendations

Under the Act, we are required to provide the Government with advice on specific matters related to the fourth emissions budget. These are our recommendations to Government.

Recommendation 1 – Proposed budget level

We recommend that the Government set the fourth emissions budget (2036–2040) at:	160 $MtCO_2e$ (total, AR5 GWP_{100})

Recommendation 2 – Breakdown of the fourth emissions budget

We recommend that, to meet the fourth emissions budget (2036–2040), the Government implement policies that result in a balance of emissions and removals as outlined in this table*:

Total net emissions Annual average	160 $MtCO_2e$ 32.1 $MtCO_2e$
Total carbon dioxide removals Annual average	102 $MtCO_2e$ 20.5 $MtCO_2e$
Emissions – all greenhouse gases, other than biogenic methane Gross greenhouse gases • Carbon dioxide • Nitrous oxide • F-gases • Non-biogenic methane	 81 $MtCO_2e$ 29 $MtCO_2e$ 4 $MtCO_2e$ 1 $MtCO_2e$
Emissions – biogenic methane Gross biogenic methane	5.23 $MtCH_4$

*All values listed in $MtCO_2e$ are calculated using the IPCC AR5 GWP_{100} values; components may not sum to total due to rounding.

Recommendation 3 – Reductions by greenhouse gas to meet the emission budget

We recommend that, to meet the fourth emissions budget, the Government implement policies that deliver reductions of each greenhouse gas as outlined in this table*:

	2022	Fourth emissions budget (2036–2040)
Total net emissions ($MtCO_2e$/yr) Annual average Reduction from 2022	73.6 $MtCO_2e$	 32.1 $MtCO_2e$ 41.5 $MtCO_2e$
Total gross emissions ($MtCO_2e$/yr) Annual average Reduction from 2022	78.9 $MtCO_2e$	 52.5 $MtCO_2e$ 26.3 $MtCO_2e$
Gross emissions broken down by:		
Carbon dioxide ($MtCO_2e$/yr) Annual average Reduction from 2022	31.9 $MtCO_2e$	 16.3 $MtCO_2e$ 15.6 $MtCO_2e$
Nitrous oxide ($MtCO_2e$/yr) Annual average Reduction from 2022	6.9 $MtCO_2e$	 5.9 $MtCO_2e$ 1.0 $MtCO_2e$
F-gases ($MtCO_2e$/yr) Annual average Reduction from 2022	1.6 $MtCO_2e$	 0.9$MtCO_2e$ 0.7 $MtCO_2e$
Non-biogenic methane ($MtCO_2e$/yr) Annual average Reduction from 2022	0.8 $MtCO_2e$	 0.3 $MtCO_2e$ 0.6 $MtCO_2e$
Biogenic methane ($MtCH_4$/yr) Annual average Reduction from 2022	1.35 $MtCH_4$	 1.05 $MtCH_4$ 0.30 $MtCH_4$

*All values listed in $MtCO_2e$ are calculated using the IPCC AR5 GWP_{100} values; components may not sum to total due to rounding.

Recommendation 4 – Limit on offshore mitigation for the fourth emissions budget and circumstances justifying its use

We recommend that, to meet the fourth emissions budget (2036–2040), the Government:

a. limit offshore mitigation for the fourth emissions budget to 0.0 $MtCO_2e$
b. only use offshore mitigation as a last resort in exceptional circumstances beyond the Government's control, such as force majeure events, where domestic measures cannot compensate for emissions impacts.

Recommendation 5 – Revisions to the set emissions budgets

We recommend that the Government revise the first, second and third emissions budgets as outlined in the table* below:

	First emissions budget (2022–2025)	Second emissions budget (2026–2030)	Third emissions budget (2031–2035)
Set budgets (total net emissions)	290 $MtCO_2e$	305 $MtCO_2e$	240 $MtCO_2e$
Difference due to methodological changes	-7 $MtCO_2e$	-1 $MtCO_2e$	0 $MtCO_2e$
Difference due to significant changes	0 $MtCO_2e$	-14 $MtCO_2e$	-18 $MtCO_2e$
Recommended budgets (total net emissions)	283 $MtCO_2e$	290 $MtCO_2e$	222 $MtCO_2e$
Annual average	70.8 $MtCO_2e$/yr	58.0 $MtCO_2e$/yr	44.4 $MtCO_2e$/yr

*All values listed in $MtCO_2e$ are calculated using the IPCC AR5 GWP_{100} values.

Recommendation 6 – Rules to measure progress

We recommend that, as the Government considers whether to include any new sources of emissions or carbon dioxide removals in its accounting for emissions budgets, it:

a. adopts the principles of additionality and permanence (durability) and includes them as criteria for any recognised carbon removal activities, along with other key characteristics including removal capacity, measurability, cost, and acceptability
b. develops and implements a long-term plan for measuring and monitoring additional sources, sinks, and changes in management activities, including how the plan will be funded
c. develops and implements a plan for how the Government will manage accuracy and uncertainty risks, limiting the risk that over- or under-estimation will impact long-term emissions trajectories and associated emissions reduction efforts.

Wāhanga 1 | Chapter 1

He whakatakinga
Introduction

This chapter introduces emissions budgets, and the approach we have taken to prepare advice on the fourth emissions budget.

In the face of the sharpening climate change challenge, the world is intensifying efforts to limit global warming by reducing greenhouse gas emissions in ways that will sustain and keep their communities safe. Aotearoa New Zealand has committed to this global response and is building its own transition to a thriving, low emissions economy.

This transition can support people, businesses and communities in Aotearoa New Zealand to respond to the opportunities opening up in a global low emissions economy, while building the resilience the country needs to adapt to the climate impacts already felt across the motu. It presents a range of benefits – including new market openings, cleaner air, lower overall energy costs, and healthier oceans – and it also presents challenges and risks that require careful consideration to ensure success.

Our advice here focuses on the next step the country needs to take in navigating that transition – setting the fourth emissions budget for 2036 to 2040, on the country's path towards the 2050 emissions reduction target. It is our final advice, following consultation on draft advice in April–May 2024.

It is provided to the Minister of Climate Change alongside our final advice on related reviews, required under the Climate Change Response Act 2002 (the Act), of the 2050 target and international shipping and aviation emissions.

Advice for the next step on the path to reducing the country's emissions

Emissions budgets are important tools used to set limits on the amount of greenhouse gases that can be emitted over a specific time period. They act as stepping stones, guiding Aotearoa New Zealand's emissions reduction path in an ambitious, achievable and measurable way.

In 2022, the Government published Aotearoa New Zealand's first emissions budget (2022–2025), the second emissions budget (2026–2030), and the third emissions budget (2031–2035).

Under the Act, He Pou a Rangi Climate Change Commission (the Commission) must provide the Government with advice on setting Aotearoa New Zealand's fourth emissions budget (2036–2040) by the end of 2024. As part of this work, we may also advise on whether the first, second and third emissions budgets should be revised.

This final advice reflects feedback received in consultation on the draft and the latest information and data available. It details our approach, the evidence, and our recommendations.

This chapter sets out how emissions budgets work, how we have approached our work to advise on the country's fourth emissions budget, and updates we made since consulting on the draft. It also describes how this advice relates to the reviews of the 2050 target and international shipping and aviation emissions.

About emissions budgets

Emissions budgets represent the total allowable net emissions of greenhouse gases across a five-year period, known as a budget period.[vi] Each budget is smaller than the one before so that emissions decline over time.

Because emissions budgets are set as a net volume of emissions, they can be met through a combination of actions, including:

- reducing gross emissions (reducing emissions at their source)
- removing carbon dioxide from the atmosphere (through growing trees)
- in limited circumstances, using offshore mitigation (when Aotearoa New Zealand pays for emissions reductions or removals that occur overseas).

The Act requires three emissions budgets to be in place at all times – one for the current period, and two further budgets covering the following two consecutive budget periods. This gives households, businesses, and communities a view of Aotearoa New Zealand's emissions reduction path at least 10 years into the future, providing them with information they need to make important planning and investment decisions.

Emissions budgets are part of Aotearoa New Zealand's contribution to the global effort to limit warming to below 1.5°C

The Act provides a framework by which Aotearoa 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°C above pre-industrial levels, and
- prepare for and adapt to, the effects of climate change.

As set by Parliament, the 2050 emissions reduction target (**Figure 1.1**) represents Aotearoa New Zealand's domestic contribution to the global effort to limit warming to 1.5°C above pre-industrial levels.

The Act provides that emissions budgets are to be set with a view to meeting the 2050 target and contributing to the global effort under the Paris Agreement to limit the global average temperature increase to 1.5°C above pre-industrial levels. Emissions budgets must be set in line with meeting the current 2050 target.

Aotearoa New Zealand's 2050 target

Aotearoa New Zealand has a 'split gas' target for domestic emissions, which considers biogenic methane separately from all other greenhouse gases. This reflects the different impact that methane (short-lived) has compared with other (long-lived) greenhouse gases, such as carbon dioxide.

vi The first budget covered a four-year period from 2022–2025.

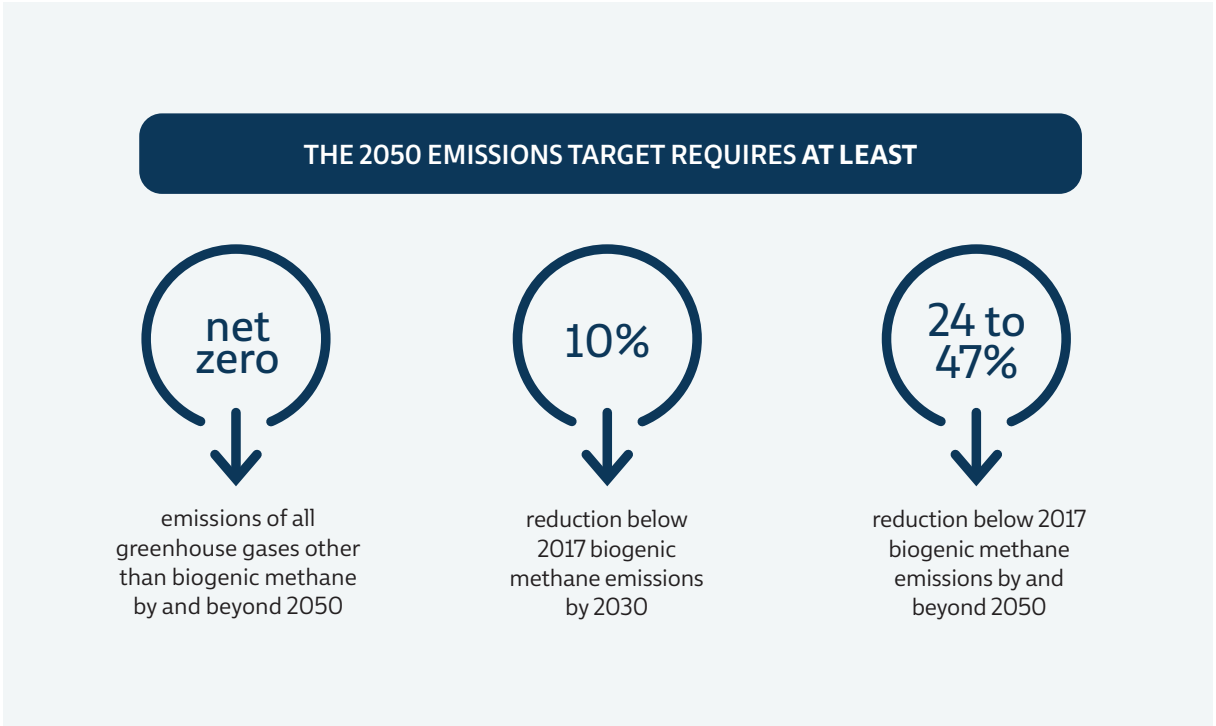
The target has three components. The first is to reduce emissions of greenhouse gases (other than biogenic methane) to **net zero** or lower by 2050 and beyond. 'Net zero' means that the Government can decide how to get to the target via a combination of *gross reductions* (fewer greenhouse gas emissions) and *removals* (such as absorption of carbon dioxide as trees in forests grow).

The other two components are focused on lowering biogenic **methane emissions** by:

- at least 10% below 2017 levels by 2030
- 24–47% below 2017 levels by 2050 and beyond.

These two components are both gross targets rather than net targets. This means efforts need to be focused on reducing the amount of biogenic methane added to the atmosphere.

Figure 1.1: 2050 emissions reduction target



The Government is responsible for setting emissions budgets and ensuring they are met

While the Commission is responsible for providing the Government with advice on the level of each emissions budget, the Government is ultimately responsible for setting budgets and ensuring they are met.

Under the Act, the Government must produce emissions reduction plans that set out the strategies and policies for meeting each budget period.

The Government released its first emissions reduction plan in 2022, covering the first budget period (2022–2025). A draft of the second emissions reduction plan covering the second budget period (2026–2030) was consulted on by the Government in July and August 2024; it is due to be published in final form before the end of 2024.

The Act also sets out processes to monitor and report progress on meeting emissions budgets, to ensure Aotearoa New Zealand is on track to meeting the 2050 target. The Commission published the first annual progress report on emissions reduction in July 2024. The next progress report is due mid-2025, and the first end-of-budget report before the end of 2027. These reports will be important for determining the Commission's advice on how future emissions budgets could be met.

New Zealand's Greenhouse Gas Inventory is a key source of data used for informing our advice on emissions budgets

New Zealand's Greenhouse Gas Inventory (GHG Inventory) is produced annually and is the key source of evidence on Aotearoa New Zealand's emissions. This data source is used for international reporting as part of Aotearoa New Zealand's obligations under the United Nations Framework Convention on Climate Change (UNFCCC). The GHG Inventory is also used domestically to inform policy development and to measure progress against emissions budgets and the 2050 target.[2]

International reporting guidelines govern what the GHG Inventory covers and when it is submitted. This is why the GHG Inventory is 15 months behind the current calendar year. The latest GHG Inventory data was published in April 2024 and contains data from 1990–2022.

Each year when the GHG Inventory is produced, it may include improvements to reflect latest scientific knowledge or improvements to how emissions data is assessed. When the methodology or underlying data changes, the whole inventory time series from the base year to the latest year is recalculated.

This final advice incorporates the latest data published in the 2024 edition of the GHG Inventory.

Emissions budgets support meeting Aotearoa New Zealand's international emissions reduction commitments

Under the Paris Agreement, every five years participating countries submit an updated nationally determined contribution (NDC) to the UNFCCC. NDCs represent the part each country is committing to play to reduce emissions and adapt to the impacts of climate change and must reflect the country's highest possible ambition.

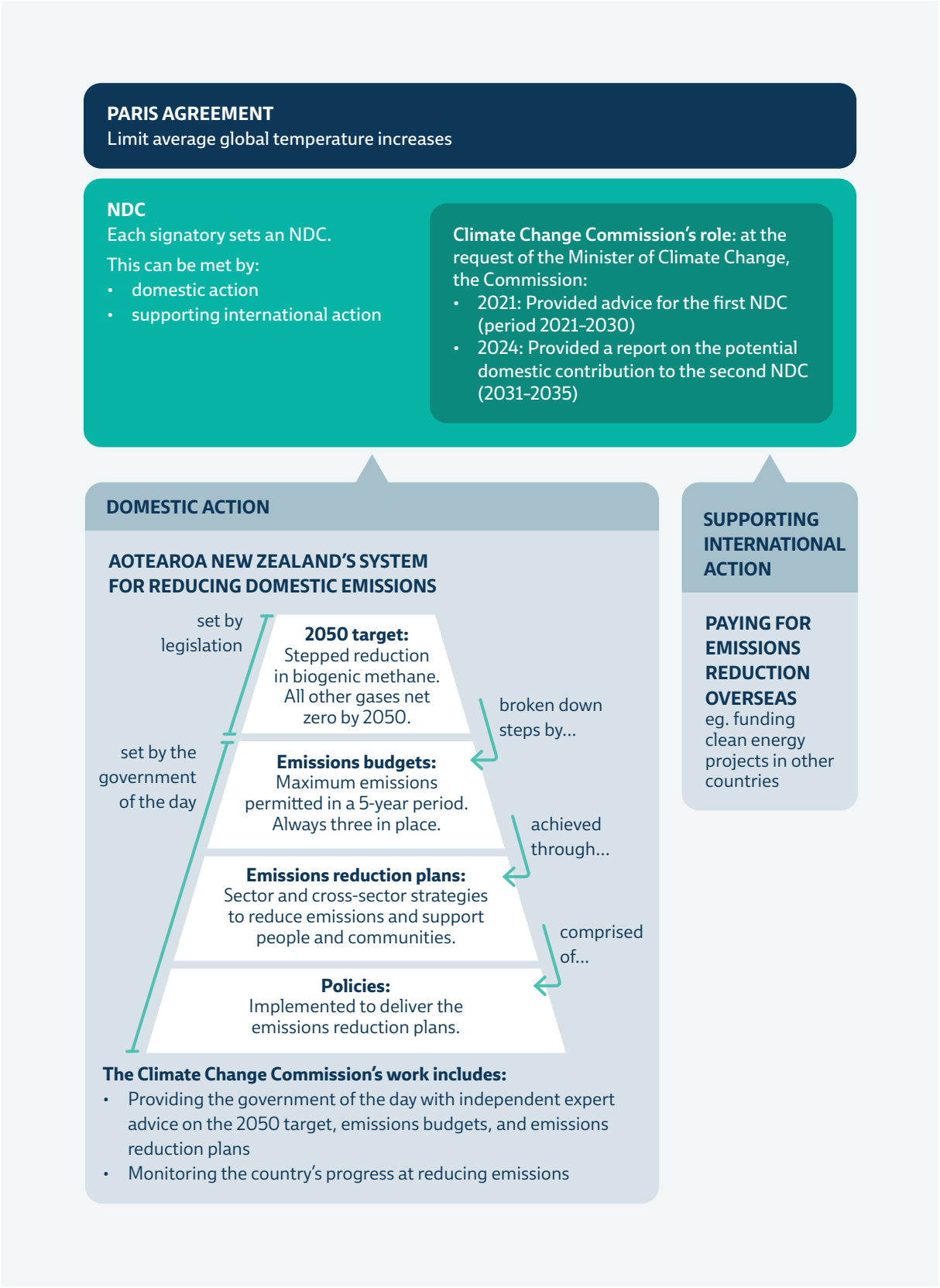
In 2021, the Government updated Aotearoa New Zealand's NDC, which is now to reduce net emissions by 50% below gross 2005 levels by 2030. The NDC can be met through a combination of domestic actions to reduce emissions and carbon removals by forests, and there is also an option to use offshore mitigation, which is when Aotearoa New Zealand pays for emissions reductions or removals that occur offshore.

The more Aotearoa New Zealand does to reduce emissions domestically through its emissions budgets, the less it will need to pay for offshore mitigation.

The 2050 target and emissions budgets (together with emissions reduction plans) are part of Aotearoa New Zealand's system for reducing domestic emissions (**Figure 1.2**).

The Government requested advice from the Commission on the potential domestic contribution to the second NDC (2031–2035). That advice was provided to the Minister in October 2024 (see https://www.climatecommission.govt.nz/our-work/advice-to-government-topic/nationally-determined-contributions/ndc2-report/).

Figure 1.2: Emissions reduction commitments and the system for meeting them



Box 1.1: How this advice relates to other Commission advice in 2024

Review of the target and international shipping and aviation emissions

The Commission is also providing advice to the Government in 2024 on its review of the 2050 emissions reduction target. This is the first five-year review of the target required under the Act.

That advice – delivered in parallel to the Minister – includes the results of a one-off review under the Act of whether international shipping and aviation emissions should be included in the 2050 target and, if so, how (https://www.climatecommission.govt.nz/our-work/advice-to-government-topic/review-of-the-2050-emissions-target/2024-review-of-the-2050-emissions-target/final-report).

In April we published three consultation documents for feedback. Our final advice is provided as two documents: this advice, and a combined report on our review of the 2050 target and inclusion of international shipping and aviation emissions.

The relationship between the three pieces of advice we are providing in December is set out in **Figure 1.3**.

This advice on the fourth emissions budget is aligned to the current 2050 target – our advice for that budget does not take into account any recommendations we make to Government about potential changes to the target.

How a target change could affect future advice, including on the fourth emissions budget

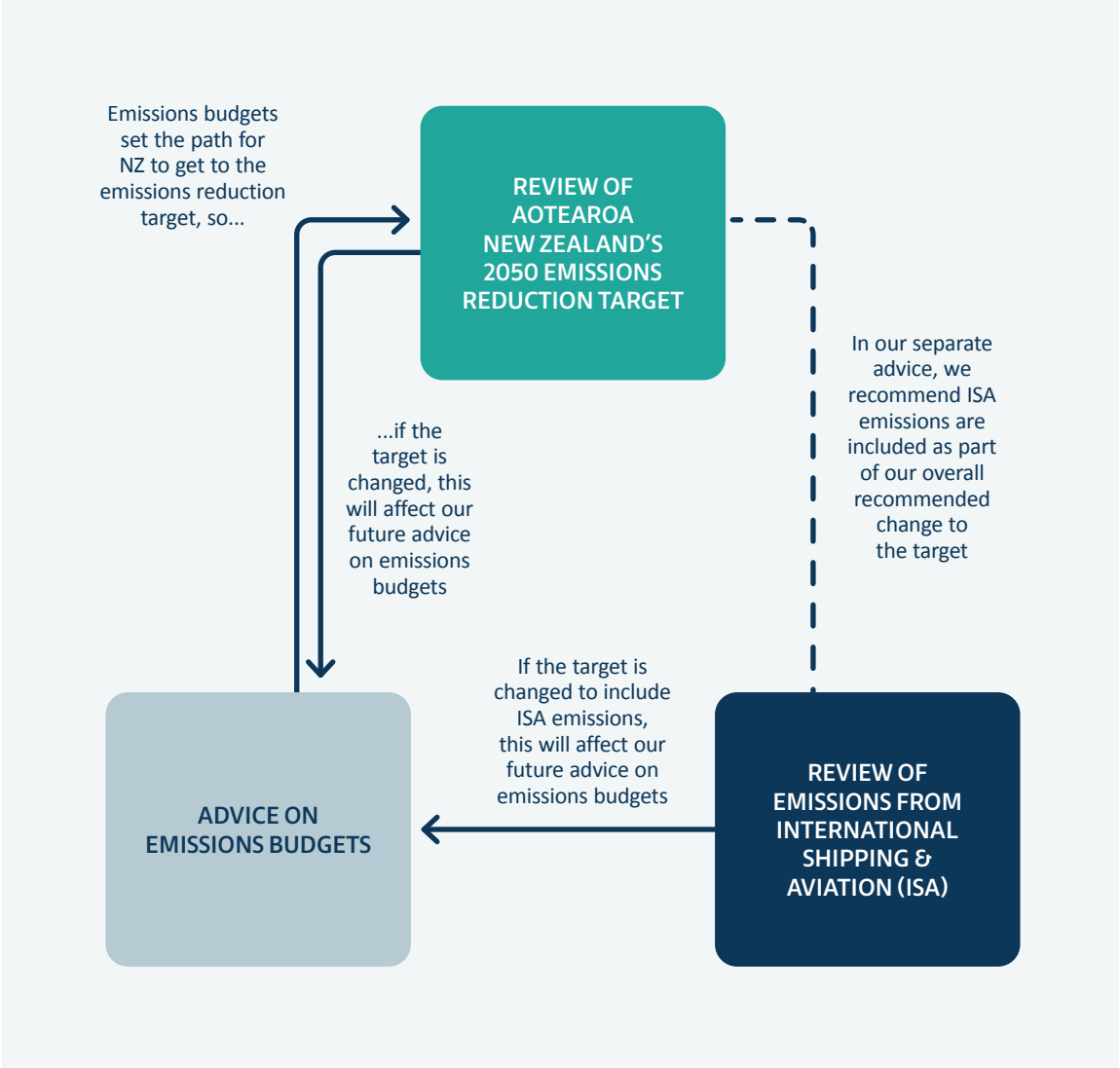
The Act sets a deadline for the Government to set the fourth emissions budget by 31 December 2025.

If the Government decided to change the 2050 target, this would affect our future advice on budgets. In the event of a change to the target, the Commission may then look at whether any relevant emissions budgets – including the fourth emissions budget – should be revised.

Continued on next page.

Box 1.1: How this advice relates to other Commission advice in 2024 (continued)

Figure 1.3: How the fourth emissions budget advice is connected to reviews of the 2050 target and international shipping and aviation emissions



Advice on the second nationally determined contribution (NDC)

The Commission has also, in late 2024, provided the Government with advice on the potential domestic contribution to the country's second nationally determined contribution (NDC), for the period 2031–2035.

Our approach to developing this advice

The Commission's approach to developing this advice is based on tested methodology, building on the approach and process developed when the Commission advised on the first three emissions budgets in our 2021 (*Ināia tonu nei*: *a low emissions future for Aotearoa*).[3]

Our approach, as an independent Crown entity, is founded on research, evidence and modelling, and draws on the expertise of our Board of Commissioners, He Pou Herenga (a Māori advisory body to the Board), and staff.

In preparing this advice on the fourth emissions budget, we have examined the latest publicly available data on the country's emissions profile and the scientific evidence about options for reducing emissions. This final advice is updated to reflect new data and information available since we published the draft advice, and feedback from consultation.

We are informed by evidence and insights gathered by engaging with people on the ground, including through consultation on the draft advice, and the earlier call for evidence. This is built into our modelling approach and informs the shaping of our advice.

Our advice on emissions budgets

The Act sets out specific requirements for what should be contained in our advice on emissions budgets. These requirements help to ensure the Government has all the information it needs to make a decision on an emissions budget so that the emissions budgets it sets are consistent with meeting the 2050 target.

This report contains our final advice on these matters, including recommendations for:

- the quantity of emissions that will be permitted in each emissions budget period (in this case, the first, second, third and fourth emissions budgets)
- the rules that will apply for measuring progress towards meeting emissions budgets and the 2050 target
- how the emissions budgets, and ultimately the 2050 target, may realistically be met, including through pricing and policy methods
- the proportions of an emissions budget that will be met by domestic action to reduce emissions compared to the amount of carbon dioxide removals by forests
- the amount by which emissions of each greenhouse gas should be reduced to meet the emissions budgets and the 2050 target
- the appropriate limit on offshore mitigation that may be used to meet an emissions budget and an explanation of the circumstances that justify its use.

This report also contains our recommended adjustments to the first, second and third emissions budgets. The Act says that we may also give advice on recommended revisions to the emissions budgets that are already in place if there have been changes to the way emissions are calculated and reported in the GHG Inventory, or if significant changes in circumstances have occurred since the budgets were originally set.

Matters we considered in developing this advice

The Act sets out a range of matters the Commission must consider when we develop advice on emissions budgets. Consideration of these matters is fundamental for informing key judgements we need to make in our advice.

What the Act requires of us, the outcomes we are seeking, and the key judgements we make were set out in *Ināia tonu nei* and are shown below in **Figure 1.4**.

Figure 1.4: What the Act requires of us, the outcomes we are seeking and our judgements in emissions budgets

Source: Commission analysis – this appears as Figure 5.1 in *Ināia tonu nei* (p.63)[4]

Our analytical approach

Our work uses the latest scientific evidence and insights gained through engagement

In preparing this final advice, we have used the latest available information from the GHG Inventory and government projections to ensure our advice accurately reflects Aotearoa New Zealand's emissions profile and latest methodologies used to report and calculate emissions (see **Box 4.1** in *Chapter 4: Developing the path to the fourth emissions budget*).

We have undertaken research to understand the latest scientific evidence on opportunities and costs of different actions that could support Aotearoa New Zealand's transition, such as agricultural mitigation technologies and impacts on air quality. This includes new evidence provided through feedback on our draft advice.

The consultation process has strengthened our evidence base, building on our earlier engagement with iwi/Māori and a variety of stakeholders, including through our call for evidence in 2023. The wide range of feedback informs our understanding of the broader context around some of the actions that we are assessing, helps us gain insights into latest trends, and tests our assumptions (see *Chapter 2: What we heard* for a summary of feedback and how we have reflected that in our final advice).

Our models are tested and improved over time

Our emissions budgets advice is informed by modelling (**Box 1.2**). These models have been developed by highly regarded experts and were reviewed by experts from Aotearoa New Zealand and around the world when we gave advice on the first three emissions budgets in 2021.[vii]

Since *Ināia tonu nei* and through engagement and feedback on the draft advice, we have had opportunity to further refine our approach to modelling for this advice. This has included:

- updating our assumptions to include new evidence and data
- updating and improving our models to include new features to support integrating new evidence
- making our models more robust by improving the way our models interact across different assumptions (for example, in the aviation sector we now have more integrated and detailed information)
- having these updates reviewed by the experts who developed these models.

The changes to our modelling from consultation feedback are summarised in *Chapter 2: What we heard* and made clear in related chapters. More detail on our models and underlying assumptions can be found in the *Technical Annex: Modelling and analysis to support final advice on Aotearoa New Zealand's fourth emissions budget and the review of the 2050 emissions target including whether emissions from international shipping and aviation should be included* and related assumptions logs. These are available on the Commission website: https://www.climatecommission.govt.nz/our-work/advice-to-government-topic/preparing-advice-on-emissions-budgets/advice-on-the-fourth-emissions-budget/modelling-and-data-final-report

vii More information on the expert reviews of our models can be found here: https://www.climatecommission.govt.nz/our-work/advice-to-government-topic/inaia-tonu-nei-a-low-emissions-future-for-aotearoa/modelling/

Box 1.2: Our advice is informed by modelling

Using models is helpful to ensure consistent assumptions are applied across sectors and that the interactions between actions are captured. The primary models we have used are:

- **ENZ (Energy and Emissions in New Zealand)**: a bottom-up technology-rich model that covers all the main emitting sectors in Aotearoa New Zealand – energy, industry, transport, agriculture, forestry, product use and waste. ENZ captures the major interactions within the energy system and between different sectors.
- **C-PLAN (Climate Policy Analysis)**: a Computable General Equilibrium (CGE) model that combines economic theory with data to estimate how the economy might respond to a limit on emissions.

ENZ gives the scale of emissions reductions that are achievable in each sector by factoring in specific technologies and options to reduce emissions. The C-PLAN model allows us to understand the overall impact of our recommended emissions budgets on GDP, including how different sectors could expand and contract.

In *Ināia tonu nei* our impact analysis drew on the DIM-E model to understand effects on employment across sectors, regions, demographic groups, and socioeconomic groups. We have not repeated this analysis for the fourth emissions budget as we expect changes in patterns of employment to be similar to what was estimated in our 2021 advice. Instead, we have focused our analysis on areas that have changed.

Further details on these models and results can be found in *Ināia tonu nei* and the *Technical annex* that supports this advice (see links in the text above this box).

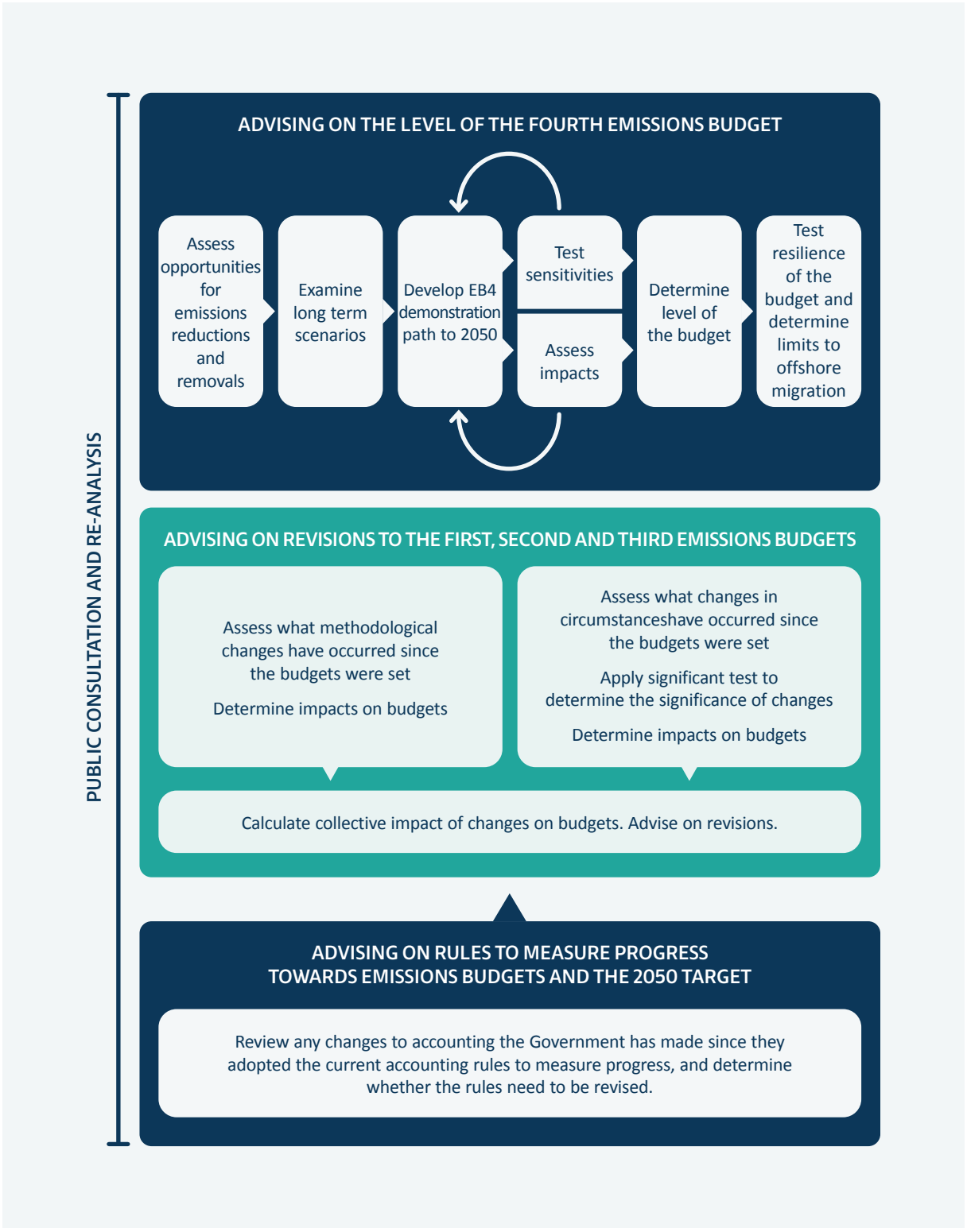
Our process for developing this advice

Ināia tonu nei set strong foundations for a robust process to determine emissions budgets, including through public consultation on a draft version of the advice. Our advice on the fourth emissions budget builds on this process, including a new stage of work on assessing revisions to existing budgets. This is shown at a high level in **Figure 1.5** and explained further below.

Advising on the level of the fourth emissions budget

We carried out detailed assessments of the opportunities to reduce and remove emissions in each sector, using the latest scientific evidence and insights learned through engagement, including feedback from consultation. These opportunities for emissions reductions and removals included systems changes (behaviour or practice changes) and existing and anticipated technologies. For example, a systems change could be using public transport or walking or cycling rather than driving. The assessment included analysing the options considered in *Ināia tonu nei* as well as new options based on information or evidence that has come to light since *Ināia tonu nei*, including new evidence submitted in feedback on our draft advice (see *Chapter 5: Sector contributions to meeting the fourth emissions budget*).

Figure 1.5: High level illustration of the process for developing our advice



Source: Commission analysis

We used scenario modelling to understand what types of actions and what budget levels could get Aotearoa New Zealand to the 2050 target and contribute to the global effort to limit the average temperature increase to 1.5°C above pre-industrial levels. We did this because there are several pathways that Aotearoa New Zealand could take. Scenarios and pathways are different from forecasts and predictions. While forecasts and predictions might be useful in the short term, they cannot reflect changes over time that will affect our ability to reduce emissions or adapt to the impacts.

We used evidence gained through our assessment of emissions reductions and removals and insights from our scenario analysis to develop a projected path (EB4 demonstration path) to 2050, which would put Aotearoa New Zealand on track to meeting the 2050 target and contribute to the global effort to limit the global average temperature increase to 1.5°C above pre-industrial levels. This involved applying our expert judgement, with consideration to all the matters specified under the Act, to determine a set of actions that would be ambitious and achievable, provide flexibility for the future, and offer lasting economic, societal and environmental benefits that will likely exceed overall costs. This was an iterative process through which we considered the principal uncertainties of different actions through sensitivity analysis and the impacts as required by the Act as we developed the path (see *Chapter 6: The impacts on New Zealanders of meeting the fourth emissions budget*).

We repeated that process after updating some of our assumptions in our modelling from feedback received on our draft advice and updated the EB4 demonstration path accordingly. This is set out in *Chapter 4: Developing the path to the fourth emissions budget*.

From the finalised EB4 demonstration path, we were able to determine our recommended budget level for the fourth emissions budget (see *Chapter 3: Recommended level for the fourth emissions budget*). As for our draft advice, we again tested that this budget was resilient to future uncertainties by developing alternative paths that explored scenarios where technology and system change did not happen at the same speed or scale as in the EB4 demonstration path.

Advising on revisions to the first three emissions budgets

We developed a process for assessing the impacts of methodological changes and significant changes.

This was to understand what changes have occurred since the budgets were originally set to ensure integrity of the ambition of those budgets. Developing a robust approach to assessing these changes is important to ensure this can be consistently applied in the future. More detail on this process can be found in *Chapter 7: Recommended changes to the first, second, and third emissions budgets*.

Advising on the rules to measure progress towards emissions budgets and the 2050 target

We looked at whether the Government has updated their approach to accounting since our previous advice in *Ināia tonu nei* to understand whether changes are needed to the rules to measure progress towards emissions budget and the 2050 target. More detail on this process can be found in *Chapter 8: Measuring progress towards emissions budgets and the 2050 target*.

How this document is structured

This advice is structured by chapters; these chapters reflect the analysis undertaken to fulfil our statutory obligations under the Act.

Context setting	
Chapter 1: Introduction	This chapter provides context, explaining what emissions budgets are and our task for this advice. It sets out our analytical approach and describes at a high level the process for developing and finalising our advice.
Advising on the level of the fourth emissions budget	
Chapter 2: What we heard	This chapter sets out the key themes and insights we heard from consultation, highlighting where our thinking has shifted as a result. The first section covers who we heard from and met with, and outlines our process for incorporating the feedback we received into our work. The second section shares what we heard and then steps through how consultation feedback has influenced specific parts of this advice.
Chapter 3: Recommended level for the fourth emissions budget	This chapter sets out our recommended budget level for the fourth emissions budget (2036–2040) and the analysis that supports this recommendation. This includes matters we have considered in determining the budget including updates from consultation feedback, how we have tested the resiliency of the budget, limits to offshore mitigation, and information on likely actions needed to meet the fourth emissions budget.
Chapter 4: Developing the path to the fourth emissions budget	This chapter provides an overview of how we developed the path to the fourth emissions budget, including key insights from our analysis and updates from feedback. It covers the current trajectory for emissions in Aotearoa New Zealand, our assessment of opportunities to reduce and remove emissions, our long-term scenarios out to 2050 and beyond, and our final EB4 demonstration path.

Advising on the level of the fourth emissions budget (continued)	
Chapter 5: Sector contributions to meeting the fourth emissions budget	This chapter describes what changes happen across sectors in the EB4 demonstration path. It explains what evidence or key judgements were made in determining the assumptions that underpin these changes and how these were updated from feedback.
Chapter 6: The impacts on New Zealanders of meeting the fourth emissions budget	This chapter shows the potential opportunities and challenges for Aotearoa New Zealand under the EB4 demonstration path.
Advising on revisions to the first three emissions budgets	
Chapter 7: Recommended changes to the first, second and third emissions budgets	This chapter contains our analysis and recommendations for revising emissions budgets that have been set. It lays out the rationale for these changes based on the requirements under the Act.
Advising on rules to measure progress	
Chapter 8: Measuring progress towards emissions budgets and the 2050 target	This chapter looks at the accounting rules the Government has adopted to measure progress against meeting emissions budgets and the 2050 target.

Wāhanga 2 | Chapter 2

Tā mātou i rangona
What we heard

For Aotearoa New Zealand to achieve a thriving, low emissions future, the country needs stepping stones to the 2050 target that support ambitious and achievable action on climate change.

That is why it is essential that our advice and recommendations about the fourth emissions budget for 2036–2040 are informed by people on the ground, who know which actions are practical and what impacts will be felt.

In April and May 2024, we asked the people of Aotearoa New Zealand to provide their feedback on our draft advice on the country's fourth emissions budget. At the same time, we consulted with the country about our initial review of the 2050 target and our initial review of whether international shipping and aviation emissions should be included in the target.

This final advice incorporates the contribution of over a thousand people from across the motu who participated in our consultation process, testing and strengthening our approach through discussion and written submissions. This included representatives of over 300 organisations and community groups.

This chapter sets out the key themes and insights we heard from consultation, highlighting where our thinking has shifted as a result. The first section covers who we heard from and met with, and outlines our process for incorporating the feedback we received into our work. The second section shares what we heard and then steps through how feedback has influenced specific parts of this advice.

While we have made every endeavour to reflect the range and nature of the feedback we received, it is not possible for this report to represent the full diversity of the views shared with us. Readers can also view the consultation submissions directly via our website: https://www.climatecommission.govt.nz/consultation/submissions

Pre-consultation engagement

To inform our draft advice on the fourth emissions budget, we drew from the large body of evidence and insights gathered from engagements with iwi/Māori and stakeholders held over the course of the Commission's existence.

In addition, we ran a call for evidence from 31 March to 31 July 2023. A mix of individuals and organisations answered. There were 14 responses specific to the fourth emissions budget and potential revision of the three earlier budgets.

Between July and December 2023, we met with some of the organisations who submitted as part of our call for evidence, as well as a range of other stakeholders.

This early engagement provided us with a range of evidence and perspectives on the potential for biogas integration, and diverse options for emissions reduction for industry and energy, as well as for decarbonising rail.

These pre-consultation engagements helped us understand more about the opportunities and impacts stakeholders viewed as being important for the Commission to consider in our advice. This informed our preparation of draft advice, and continued to provide us with valuable evidence and insights as we finalised our advice and recommendations.

Consultation

On 8 April 2024, we released three separate but connected documents for consultation:

- a discussion document on our Review of the 2050 emissions reduction target
- a discussion document on our Review of whether emissions from international shipping and aviation should be included in the 2050 target, and if so how
- a draft version of our Advice on Aotearoa New Zealand's fourth emissions budget.

While each consultation document had a specific focus, they all dealt with Aotearoa New Zealand's journey to becoming and maintaining a thriving, low emissions economy by and beyond 2050. Consulting on this work together gave us the opportunity to engage with Aotearoa New Zealand on both *where* we are heading as a country, and *how* we will get there.

Over the following eight weeks, we engaged (in person and online) with approximately 1,200 people including representatives of more than 300 different organisations and community groups in 129 events and meetings engagements. We shared our thinking and listened as people told us about the issues, impacts and evidence they wanted the Commission, and eventually the Government, to consider and prioritise.

We sought feedback across multiple channels, including through virtual events, in-person engagements, and an online submission process.

During consultation we:

- held in-person engagements all across the country, including in Northland, Auckland, Waikato, Taranaki, Manawatū-Whanganui, Wairarapa, Wellington, Nelson, Tasman, Canterbury, Otago (including Queenstown Lakes), and Southland, and we also met virtually with representatives from Bay of Plenty, Hawke's Bay, Rotorua and Christchurch
- hosted two public webinars with approximately 120 total attendees
- held sector-focused meetings for shipping and aviation (both online), and for agriculture/rural communities in Masterton, Whanganui, Inglewood, Taupō, Te Awamutu, Wellsford, Gore, Oamaru and Nelson (a mix of in-person and online)
- hosted a youth workshop in Wellington, with a hybrid option for those who could not attend in person
- held events in partnership with, or were hosted by, entities like the Sustainable Business Council, Future Farmers, Are Ake, Forest Owners Association, BARNZ, Cool-Safe
- engaged with iwi/Māori in dedicated events, both ā-tinana and online
- held briefings for the media, stakeholders, and government agencies.

Incorporating the results of consultation

Consultation closed on 31 May 2024. We received a total of 526 submissions from a mix of individuals (265 submissions) and groups (261 submissions), including submissions from iwi/Māori, businesses, industry organisations, local government, non-governmental organisations, membership organisations and advocacy groups.

Of these, 176 submissions were focused on our draft advice on Aotearoa New Zealand's fourth emissions budget, while 192 submissions were focused on our initial review of Aotearoa New Zealand's 2050 target, and 158 were on our review of emissions from international shipping and aviation.

Commission staff considered each piece of consultation feedback we received, whether it was shared in an online submission, at a consultation event, or by email. In line with the Commission's commitment to upholding Māori data sovereignty, all kaupapa Māori submissions, including those related to mātauranga Māori, tikanga, kawa, whakapapa, and/or relationships to whenua, were analysed in accordance with the *Principles of Māori Data Sovereignty* by Te Mana Raraunga.[5]

Where we were presented with new evidence, we investigated it carefully and considered its potential impact on our work, re-evaluating our approach and analysis as appropriate.

What we heard through consultation also shaped the next stages of our analysis and helped lead us to the recommendations in this report. Before confirming these recommendations, our Board of Commissioners tested whether the recommendations appropriately reflected the feedback and evidence shared with us.

Themes that emerged from feedback

This section summarises the themes we heard throughout consultation and outlines how these contributions have shaped our final advice. The themes that emerged are set out under four headings:

- values and priorities in decisions about climate change response
- areas to consider while reducing greenhouse gas emissions
- the role of government in reducing emissions
- practical options for reducing greenhouse gas emissions.

Our consultation included invitations for submitters to share their priorities for the country's climate change response. The feedback we receive about values and priorities informs Commission advice, and is reflected to Government decision-makers, and to people in the community who act in response.

The Government has choices about how to reduce Aotearoa New Zealand's greenhouse gas emissions. Our advice provides a thorough and robust package of information and analysis that can help the Government understand the implications of its choices about emissions reduction and where value judgements need to be made.

As an independent, expert advisor to the Government, the Commission is not driven by commercial interests or by politics. This independence is essential to ensuring the government of the day gets the impartial, evidence-based advice it needs to make informed decisions. In shaping our advice in response to consultation feedback, we have given weight to new evidence and insights.

Values and priorities in decisions about climate change response

The increasing cost of climate change impacts: The growing intensity and scale of the effects of climate change was a thread in many submissions, underlining calls for more urgent and ambitious action. Some submitters pointed out that impacts were felt more keenly in communities and households with fewer resources to adapt.

Submitters highlighted the unique and also disproportionate impacts of climate change on hapori Māori, including effects on traditions and knowledge systems, and vulnerability of taonga and wāhi to severe weather events and sea level rise (for example whenua, marae, urupā). The Māori economy's level of investment in land-based activity also increased iwi/Māori exposure to climate change.

Interconnections with adaptation response: Some submissions, including those with a kaupapa Māori focus, noted the interconnectedness between the health of the economy, people and environment, and the importance of enabling adaptation action for an effective and durable transition. We also heard that many iwi/Māori are already helping lead the response to climate change, as tangata whenua, rangatira and kaitiaki, and about the role places like marae play in community-led responses to severe weather events.

Opportunities available: Respondents also highlighted that the transition to a low emissions economy presented opportunities, across multiple sectors.

Paris Agreement goals: Many submissions gave priority to supporting Aotearoa New Zealand's commitment to limit the temperature increase to 1.5°C, as specified in legislation, within the wider framing of the Paris Agreement.[viii]

International alignment and contribution: We also heard that if Aotearoa New Zealand makes changes to the 2050 target, it will be important to align with international action and ensure the country is contributing fairly to global efforts to address climate change. Some submitters were concerned that if Aotearoa New Zealand does not take steps to reduce its emissions, there could be negative impacts to the country's reputation and ability to operate in international markets.

Global responsibility: We heard the view that, as a developed nation, Aotearoa New Zealand could do more to contribute to limiting global warming. Some submitters urged the Commission to more explicitly consider the implications for Aotearoa New Zealand's neighbours in the Pacific, which are more immediately vulnerable to changes in the climate. This argument was based on Aotearoa New Zealand's historic contribution to global temperature rises and its close ties to those countries.

Social justice: We heard about the importance of recognising the opportunities for greater social justice in the transition to a low emissions country, including the need to directly consider people struggling to meet basic needs such as food and shelter.

Areas to consider while reducing greenhouse gas emissions

Consideration of the impacts of action to reduce emissions was a key focus in the consultation feedback. Some submitters agreed with the Commission's assessment of the impacts of emissions reduction action, or highlighted particular aspects as important to take into account, while others questioned our assumptions. This section sets out themes that showed through in feedback about impacts, calling for particular aspects to be considered in the advice we provide, and the Government's decision-making.

Relative cost of action and inaction: Submitters emphasised the importance of greater understanding of the economic impacts of climate action, alongside increasing understanding of the costs of inaction.

Effects of land-use change: We heard a lot of concern about the effects of changes in land use from livestock farming to exotic forests – for carbon dioxide removal, and also as potential feedstocks for biofuels. This included impacts on rural communities and regional and local economies, and impacts on natural systems including from forestry operations and large-scale monoculture.

viii The Paris Agreement goals formally are "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". The Paris Agreement is an international treaty aimed at post-2020 climate change action that was adopted in 2015 by 196 parties to the United Nations Framework Convention on Climate Change.

Equity: Many submitters commented on the importance of achieving equitable outcomes for future generations, rural communities, and businesses in this country. Supporting future generations was the basis for some of the calls we heard for amending the 2050 target to increase the contribution Aotearoa New Zealand is making to global efforts to limit warming to 1.5°C.

Some Māori respondents emphasised that a 'just and equitable' transition means engaging locally – with whānau, people on the whenua, and through marae – before engaging with hapū and iwi. We heard about the importance of working on local solutions to local problems with local support and guidance throughout the entire process from planning and strategy to policy.

Crown–Māori relationship: We heard about the need for better, meaningful collaboration and engagement with Māori as Treaty partners.

Some submitters said an effective and equitable relationship between the Crown and iwi/Māori can only be achieved through communication and consultation, and ensuring the principles of Te Tiriti o Waitangi/The Treaty of Waitangi are upheld and honoured in partnership. We heard about the importance of early engagement with mana whenua and the potential for using local mātauranga Māori approaches in the response to climate change.

Emissions leakage: We heard that any increase in ambition of national climate action should consider the risk of emissions leakage and ensure that Aotearoa New Zealand's businesses and industries are not put at a comparative disadvantage in the international marketplace.

The role of government in reducing emissions

Policy to drive transition: We heard support for government use of policy to enable the transition to a low emissions country, including regulation, mandates, tax incentives, incentivising the domestic production of alternative fuels, incentivising the transition to low and zero emissions technologies, and emissions pricing.

This included submissions that called for continued use of complementary policies alongside the New Zealand Emissions Trading Scheme (NZ ETS), to support the required pace and scale of transition at sector level while reducing the social and economic impact of high carbon prices.

Investment: We heard calls for increased government investment in a range of areas to support the transition to a lower emissions economy. This included investment in facilities, infrastructure and workforce training. Māori submitters emphasised the need to invest in better education at all levels (including for whānau, hapū, iwi, tamariki, rangatahi and pakeke) around climate change, emissions reduction, and adaptation – to better equip Māori for the effects of climate change.

Resourcing for iwi/Māori initiatives: Almost all Māori submitters noted their communities' existing climate strategies or initiatives to reduce emissions and manage the effects of climate change. The intergenerational taiao strategies, grounded in tikanga and mātauranga Māori, reflected the localised nature of climate change impacts, as well as community priorities. There was a call for local and central government to resource these plans and initiatives to support faster emissions reduction, to the benefit of the community, and ultimately all of Aotearoa New Zealand.

Manage negative impacts of emissions reduction action: Some submissions argued it is part of the role of government to monitor and reduce potential negative impacts from the transition to low emissions, including the potential environmental impacts of switching to alternative energy sources.

Practical options for reducing emissions

Agriculture and methane: We received many submissions that saw agriculture as having a vital role to play in Aotearoa New Zealand's economy. We heard that action in this area will impact rural communities but also that methane emissions can be an opportunity for immediate reductions. Some submitters believe methane-reducing technologies will have a significant role in Aotearoa New Zealand's future and others said they are not feasible and should not be relied upon.

Alternative fuels: We heard a range of views on the role of alternative fuels in Aotearoa New Zealand. Some suggested the Commission has been overly optimistic about the role alternative fuels will play, due to where they are in the development cycle and the scale they can be employed at, while other submitters saw alternative fuels as a domestic production and investment opportunity.

Gross emissions reduction: We heard from a variety of respondents that more emphasis should be given to reduction of emissions at source, rather than relying on removal of greenhouse gases – which in Aotearoa New Zealand is currently achieved through forests. We heard from submitters on the international shipping and aviation review that emissions reductions should occur at source in the international transport sectors, and this should be prioritised over removals to support effective action to meet domestic and global targets. Submitters on the review of the 2050 target raised concerns over the permanence and durability of removals; there was support for amending the target to include a gross reductions component. Other submitters said that higher levels of carbon removal are required than current settings and also that using offshore mitigation (when Aotearoa New Zealand pays for emissions reductions or removals that occur overseas) was questionable.

Wider range of strategies: We also heard submissions to include a wider range of emission reduction and removal strategies. This included options focused on increasing energy efficiency and optimising resource use to support a circular economy, and consideration of diverse carbon capture and storage (CCS) technologies.

How we responded

This section is focused on our response to themes that emerged in feedback across the three documents we published for consultation. The following sections report the detail of our response to specific areas of feedback on our draft advice on the fourth emissions budget.

We carefully considered these themes, and the insights provided about priorities and values that people expressed through the consultation process. The new evidence and information highlighted here was investigated, at the same time as we processed updated data and information from other sources.

Our final advice presents the results of our review of judgements, conclusions and recommendations in this light.

Relevant changes to our advice, reflecting the themes that emerged in consultation, include:

- We considered the views of submitters on the need for more urgent and ambitious action as part of our decision-making about the 2050 target. The consideration we gave to what was feasible for the country to achieve was informed by other areas that emerged as themes in feedback, including emphasis on greater understanding of the economic impacts of climate action, as well as the costs of inaction.
- In our review of the 2050 target, we re-evaluated our initial view of significant changes that would justify a change in the target. We revised our judgement in three areas, finding that there is significant change in scientific understanding and global action that will place a greater burden on future generations; that there has not been significant change in technological developments including methane inhibitors; and there has not been significant change in the social impacts of extensive land-use change to forestry.
- In our review of whether international shipping and aviation emissions should be included in the 2050 target, we recommend that the Government should develop measures for meeting the target that ensure there is a specific focus on gross emissions reduction for international shipping and aviation.
- We analysed international approaches to counting international shipping and aviation emissions and noted the Government may need to revise the measure over time for this.
- We adjusted key assumptions for our modelling, to lower the level of afforestation in the demonstration path for the fourth emissions budget, which means a lower level of land-use change from livestock farming to new forestry between 2025 and 2050. This informs the recommended level of the fourth emissions budget, and is reflected in our assessment of the impacts of achieving that budget, and of our separate recommendations for changes to the 2050 target.
- We have updated how we describe our understanding of specific effects for iwi/Māori, including potential negative impacts for hapori as well as opportunities presented in the transition to a low emissions economy.

Responses to our draft advice on the fourth emissions budget

Our draft advice set out our initial thinking about the fourth emissions budget (for 2036–2040), in line with the tasks set in the Act. The draft advice covered:

- a proposed level for the fourth emissions budget
- a path that can achieve that level of emissions reduction (the 'EB4 demonstration path')
- the sector contributions involved in those reductions
- how we considered potential impacts of actions to reduce emissions to that level
- whether the first, second and third emissions budgets should be revised at the same time
- advice on the rules that apply to emissions budgets.

Through consultation we tested our approach, our assumptions underlying the modelling, and the evidence base for our analysis. We sought New Zealanders' feedback on our overall approach, and whether our proposed recommendations to the Government were on the right track. We also wanted to hear if we had missed important information or evidence, to strengthen our understanding of the issues, impacts and evidence to inform our final advice and recommendations.

Respondents generally agreed with our approach, and our assessment of the evidence and potential impacts of action to reduce emissions to the proposed level for the fourth emissions budget. This included strong support for our approach to developing the 'EB4 demonstration path'.

The 176 submissions on our draft advice provided information ranging from new evidence on feasibility, cost and implications of options for reducing emissions, to insights on the proposed changes to the first three emissions budgets.

We summarise this feedback, and how we responded, in three sections as shown in **Table 2.1**.

Table 2.1: Feedback summary and how it relates to the structure of our advice

Consultation responses	Section of our advice
Feedback on our approach and key proposals	• Level for the fourth emissions budget • Developing the path to the fourth emissions budget • Sector contributions to the fourth emissions budget • The impacts on New Zealanders of meeting the fourth emissions budget
Feedback on proposed changes to set emissions budgets	• Changes to the first, second and third emissions budgets
Feedback on rules for measuring progress	• Measuring progress towards emissions budgets and the 2050 target

Feedback on our approach and key proposals

We heard general agreement about our assessment of the considerations that informed our proposed fourth emissions budget level, including our key judgements. There was also general agreement with the approach we have taken to developing our demonstration path for the fourth emissions budget.

Submitters provided a range of evidence on the feasibility, cost and implications of potential options for reducing emissions in the fourth emissions budget period – this is set out in detail below under the heading 'Feedback on sector contributions to the budget'.

There was general support for our assessment of the impacts of action to reduce emissions to the proposed level for the fourth emissions budget.

Submitters provided a range of feedback on other impacts that should be considered, or given more prominence, including matters relating to the Crown–Māori relationship, te ao Māori and specific effects on iwi/Māori – see 'Themes that emerged from feedback' earlier in this chapter, and *Chapter 6: The impacts on New Zealanders of meeting the fourth emissions budget*.

We heard feedback that our assumptions and assessments do not sufficiently consider the impacts of not acting, particularly for communities and households with fewer resources to adapt to climate change effects. There were concerns expressed that the costs of transmission and distribution of electricity and of gas were not considered in our assessment of impacts on households. We heard concerns about the risk low income households would not be able to afford electric vehicles.

Submitters questioned our assumptions about continued economic growth, on the grounds of the limits set by planetary boundaries and the economic models we use. Submitters also called for closer examination of economic, social and cultural impacts of climate policies, and asked how much consideration was given to limited availability of skilled labour.

Some of the feedback on impacts related to issues outside the scope of the advice, or were not substantiated with evidence that could inform the analysis.

How we responded

We maintained the approach set out in our draft advice to determine the recommended level for the fourth emissions budget, the final EB4 demonstration path, and the potential impacts of the fourth emissions budget.

We assessed the evidence provided and changed some of the assumptions in our modelling and analysis (in the scenarios and the EB4 demonstration path), which underpin the recommended level of the fourth emissions budget.

Our refreshed analysis also incorporated new evidence and data available from other sources.

Level for the fourth emissions budget

As a result of our re-assessment, we have changed our recommended level for the fourth emissions budget. The recommended level, reflecting these adjustments, is 160 $MtCO_2e$.[ix] In our draft advice the proposed level was 134 $MtCO_2e$.

The recommended level for the fourth emissions budget is 26 $MtCO_2e$ higher than proposed in our draft advice.

This difference is mainly due to methodological changes in New Zealand's Greenhouse Gas Inventory (GHG Inventory) and lower carbon dioxide removals as a result of less afforestation.

Offshore mitigation

We have not changed our draft recommendation to set at zero the limit on offshore mitigation contributing to emissions budgets. There was no new evidence provided through consultation that suggested we should change this advice.

The impacts on New Zealanders of meeting the fourth emissions budget

New evidence and insights from feedback were part of our reassessment of the potential effects of action to reduce emissions. Our overall assessment of how changes could affect people, businesses and communities over time and across Aotearoa New Zealand were consistent with our draft advice. In many places we revised our description of impacts to reflect insights provided in feedback. This includes revision of our reporting of effects specific to iwi/Māori to better articulate the whakaaro heard in feedback.

ix All carbon dioxide equivalents presented in this report are on the AR5 GWP_{100} basis. See **Box 3.1** in *Chapter 3: Recommended level for the fourth emissions budget* for further information on greenhouse gas metrics.

Feedback on sector contributions to the budget

This section provides a summary of feedback on emissions reduction contributions from individual sectors of the economy.

Agriculture:

- Feedback noted that the draft EB4 demonstration path hit net zero earlier than 2050. This meant there could be room to lower the amount of forest area added (afforestation) and still hit targets.
- Submitters suggested the high afforestation rates used would cause significant reduction in stock numbers as land use changed from livestock farming to forestry, and would have flow-on economic impacts on rural communities.
- We heard that the methane-reducing technology included in our assumptions would not come to pass in the way we predicted (it could be later, or more expensive, or less effective).
- Submitters said that dairy productivity improvements would hit a ceiling, meaning that declining stock numbers would mean less milk production, rather than about the same amount, as was modelled in the draft.
- We heard that not increasing dairy production was at odds with the Government's goal of doubling exports and this could mean all gains in efficiency would be offset by increasing numbers of animals, resulting in more milk and the same or even greater total emissions.

Forests:

- We heard that the rates of exotic afforestation used in the EB4 demonstration path were at historically high levels that were unlikely to be sustained, while the rates for native afforestation were set higher than had occurred in practice.

Waste:

- There was feedback that methane emissions measurements at landfills were likely to be wrong.
- We heard that the ambition for reductions in emissions from waste was very ambitious and would require extensive systems change – particularly to divert organic waste.
- Submitters said that the focus for emissions reductions at landfills should be on non-municipal landfills, not Class 1 landfills, which were already efficient.

Transport:

- Submitters presented a range of views on the projected level of electric vehicle (EV) uptake in the light vehicle fleet. We also received submissions supportive of the role of hybrid vehicles in reducing emissions from the light vehicle fleet, highlighting that improvements in vehicle fuel efficiency had a significant impact on transport emissions.
- There was feedback questioning the level of change assumed for the shift towards active and public transport. This assumption was considered too high by some and too low by others.
- Submitters highlighted the importance of, and barriers to, the uptake of biofuels as a means of decarbonising transport.
- We heard about the potential of hydrogen for moving heavy freight, and evidence on the willingness of heavy vehicle owners to adopt new technology, despite barriers to change.

Energy:

- We heard that gas supply was already constrained and was likely to be significantly more constrained into the future than our draft EB4 demonstration path had accounted for.
- Submitters said we might have overestimated how many more geothermal electricity generation plants could be built.
- We heard there was now sufficient certainty around Genesis Energy's plans to transition to biomass fuel for its Rankine units at Huntly power station, for us to include this in our EB4 demonstration path.
- There was feedback that batteries could play a greater role in the electricity system, with costs likely to reduce faster than we had modelled.
- We heard broad support for energy efficiency measures, and that we might have underestimated energy efficiency potential in homes and buildings.
- Submitters expressed concern that non-cost factors, which make offshore wind electricity generation attractive, were not considered in the modelling. They suggested offshore wind should feature in the EB4 demonstration path.
- Biogas was also noted as missing from the EB4 demonstration path – submitters referenced existing projects and more planned.
- We also heard that carbon capture could play a greater role, including in cement production and for the oil and gas processing sector.

Industry:

- There was feedback that our assumption the electric arc furnace project at the Glenbrook steel mill could reduce coal use in steel making by 75% was not technically achievable.
- We heard support for, and concerns about, our assumed level of emissions reduction from hydrofluorocarbons (HFCs).
- Submitters noted carbon capture was a key action included in the Aotearoa New Zealand concrete sector's net zero 2050 roadmap.

How we responded

Forests and agriculture

For forests we revised our assumptions about the amount of exotic afforestation in the EB4 demonstration path. This was informed by consultation feedback and by new information received since the draft advice was published. The lower level of exotic afforestation in the EB4 demonstration path allows the country to meet and maintain the 2050 target with a buffer to accommodate uncertainties.

We did not change the amount of native afforestation used in the EB4 demonstration path. While we acknowledged that actual planting levels have been lower than this to date, the demonstration path serves as an example of the carbon removals that can be achieved with this level of ambition. We also incorporated new and updated afforestation and deforestation data.

No changes were made to the inputs to agricultural modelling, but there is less conversion of sheep and beef land due to a reduction in the afforestation levels. We note that we found mixed evidence of negative economic effects resulting from land-use change to forestry. For instance, while the patterns of employment in forestry and farming are different, they provide a similar number of jobs per hectare. A historical review also shows sheep numbers have been declining steadily since the mid-1980s, indicating that trends in this sector cannot be attributed solely to climate change policy.

How we responded (continued)

We received no new evidence to change our understanding of next generation methane-reducing technology – which we already recognise as uncertain. Nor was there new evidence produced about an approaching ceiling to improvements in dairy productivity. Our modelling assumes that the rate of improvement seen over the last 20 years continues. We considered the feedback that Government expectations of doubling exports would drive increases in the national dairy herd, but found that underlying economics already constrained stock numbers, and increased export returns were possible through other avenues, including from horticulture, which offered much higher per hectare returns.

Waste

We have made it clearer that structural change is needed to achieve the ambitious level of waste reductions set in the demonstration path. We did not change our assumptions about waste, which already have a future focus on non-municipal landfills. There is no evidence yet available about the accuracy of measurements of methane emissions from landfills.

Transport

We changed our assumptions about bio-fuel uptake to focus the use of low-carbon liquid fuels on hard-to-abate sectors using diesel and jet fuel.

We did not change our assumptions around behaviour change and shifts to active and public transport, but we have continued to test the impacts of higher and lower levels of change in our scenarios.

We already assume substantial growth in the number of hybrid vehicles entering the fleet, and are clear that we consider both battery electric and hydrogen to be potential zero emissions alternatives for decarbonising the freight sector.

We noted the new evidence about the willingness to adopt new technology in the heavy vehicle sector, despite barriers.

Energy

We made a number of changes to assumptions about energy supply and use:

- We increased the wholesale gas price path and reduced our expectations for methanol production.
- We reviewed our assumption about new geothermal generation, cross checked with Energy Link, and reduced the potential new capacity.
- We have included a planned transition from coal to biomass units at Huntly power station in our final EB4 demonstration path, although we assumed a more conservative timeframe than suggested by the industry.
- We lowered our battery costs, after reviewing and checking latest actual grid-scale battery project costs. We also noted the potential for greater uptake.

We have highlighted the possibly greater potential for energy, cost, and carbon savings through greater uptake of LED lighting beyond the assumptions we have already made about energy efficiency improvements in space heating/cooling and water heating in buildings.

How we responded (continued)

We also noted significant level of interest in offshore wind in this country, and sector interest in biogas. We noted feedback on a potential greater role for carbon capture, including in cement production (as a key action in the sector's net zero 2050 roadmap) and for the oil and gas processing sector.

Industry

We changed our assumption about coal use in steel making to a 50% reduction, in line with the original expectations of the impact of the electric arc furnace project at the Glenbrook steel mill.

We also moderated our assumptions about hydrofluorocarbon reductions, which reduce the ambitions for reduction from fluorinated gases (f-gases). We have now aligned our assumptions with the updated reference scenario.

Changes to the first, second and third emissions budgets

There was strong support for our approach to assessing whether changes were needed to the first three emissions budgets. This involved reviewing for methodological changes to the way that emissions are measured and reported, and also for significant changes to the matters considered when the budgets were set.

There was a high level of agreement with our proposal to revise set budgets for changes in the methodology for emissions accounting.

There was general agreement with our assessment of significant changes that could justify revision of a set budget. Feedback supported our proposal that the higher rates of exotic afforestation over recent years were a significant change. Some submitters, however, argued that forest planting rates had already peaked and would be much lower in the near term than the Commission anticipated.

We also heard these arguments for other significant changes:

- Submitters told us that natural gas supply and reserves were tracking substantially lower than the gas demand implied in the 2021 *Ināia tonu nei* demonstration path, which underpinned the first three emissions budgets.
- We heard about the potential for hydrogen to provide a viable alternative fuel for heavy freight transport.
- We heard the electrification of households, including for the light vehicle fleet, had reached a tipping point. Emissions reductions could go further, with more ambition and lower cost.
- We heard that higher ambition on domestic budgets would avoid the need for some offshore mitigation under the nationally determined contribution (NDC) commitments. This would avoid costs that may run to billions of dollars, leading to significant economic benefits.

How we responded

We maintained the approach set out in our draft advice to assess whether changes are needed to the first, second and third emissions budgets.

Methodological changes

We updated our assessment of the effects of changes in methodology for emissions accounting. We found methodological improvements from the 2024 release of New Zealand's Greenhouse Gas Inventory (GHG Inventory) have an effect on the first and second emissions budgets. However, they have no impact on the third emissions budget. In our draft advice we had proposed revision of all three set budgets.

We recommend the first and second emissions budget be revised for methodological changes.

Significant change

We have confirmed our assessment that the recent higher rates of exotic afforestation are a significant change, affecting the second and third emissions budgets. Our re-analysis, using the extra year of data for 2024 that became available after publication of our draft advice, shows the impact on the second and third budgets is greater than we originally estimated.

We have identified that higher rates of actual afforestation in recent years is the only significant change that has occurred since budgets were previously notified, and we recommend the second emissions budget and third emissions budget should be revised to account for this.

Level of revision

We have recommended these revisions to set budgets:

- Revise the first emissions budget down to 283 Mt CO_2e (reduced by 7 Mt CO_2e)
- Revise the second emissions budget down to 290 Mt CO_2e (reduced by 15 Mt CO_2e)
- Revise the third emissions budget down to 222 Mt CO_2e (reduced by 18 Mt CO_2e).

Changes that were not considered significant

We ruled out projected levels of *future afforestation* as a significant change because of the high uncertainty of future planting. This included consideration of new information from the 2023 Afforestation and Deforestation Intentions Survey, which indicated lower intentions for exotic afforestation in the near to medium term.

We considered the *changes in gas supply* that have occurred, but we did not find this to be a significant change. Gas supply is an evolving situation and it is not yet clear how the role of gas may change in the transition to a low emissions economy. With the situation still unfolding, our assessment is that it does not meet the criteria for significant change.

We received submissions about an increased role for hydrogen as a fuel for heavy freight transport and more ambition regarding household electrification. Both aspects were assessed as not meeting the threshold for being considered a significant change at the draft stage, and our assessment has not changed.

We also assessed the issue of cost of offshore mitigation to meet Aotearoa New Zealand's nationally determined contribution (NDC), but this did not meet the threshold for consideration as a significant change.

Measuring progress towards emissions budgets and the 2050 target

There was general agreement with our assessment that the Government should continue with the existing approach to measuring and calculating emissions. We received specific feedback in support of the Government updating its approach, highlighting advances in emissions accounting in other jurisdictions and the potential for Aotearoa New Zealand to be isolated in its reliance on a modified activity-based approach.

There was general agreement with our assessment of what the Government should consider when setting a reference level for forest management and when developing accounting methodologies for additional emissions sources and sinks.

How we responded

We have not changed our recommendation on what the Government should consider when developing accounting methodologies for additional emissions sources or sinks. Since publishing our draft advice, we received no new evidence or information to enable or justify a change.

We have strengthened our advice, urging the Government to complete and publish rigorous and transparent analysis of the options (e.g. averaging and forest reference level) including an assessment of their robustness, integrity, challenges, and drawbacks.

Te reo Māori glossary

Kupu/rerenga kupu Māori
English contextual translation

ā-tinana in person

hapori Māori Māori communities

hapū kinship group comprised of whānau who share a common ancestry

iwi extended kinship group of whānau and hapū who share a common ancestry and are associated with a distinct territory

kaitiaki guardians, stewards, trustees

kaupapa Māori issues and topics that have a specific focus on the Māori world

kawa protocols, practices

mana whenua authority over land or a specific territory

marae the open area in front of the wharenui, where formal greetings and discussions take place; often used to include the complex of buildings around the marae

mātauranga Māori Māori knowledge, the body of knowledge originating from Māori ancestors, including the Māori world view and perspectives, Māori creativity, and cultural practices

pakeke adults

rangatahi youth

rangatira chief, chiefly, noble

tamariki children

tangata whenua people born of the whenua – people of the land where their ancestors have lived

taonga treasure, anything prized: applied to anything considered to be of value including socially or culturally valuable objects, resource, phenomena, ideas, and techniques – children and future generations may also be regarded as taonga

te taiao the natural world, the environment

tikanga correct procedure, custom, habit, lore

urupā burial ground

wāhi, wāhi tapu place, sacred place

whakaaro thought, opinion, idea, understanding

whakapapa genealogy of how someone or something has come into being

whānau family

whenua land

Wāhanga 3 | Chapter 3

Te reanga ki te tahua tukuwaro tuawhā
Recommended level for the fourth emissions budget

The fourth emissions budget represents Aotearoa New Zealand's next step in the transition to a thriving, low emissions economy and towards achieving the 2050 emissions reduction target.

Emissions budgets signal the pace and scale of change required across the country to reach the 2050 target. It is important they are set at a level that is economically and technically achievable. Our recommendation for the level of the fourth emissions budget is 160 $MtCO_2e$. This means the annual average emissions in the budget period (2036–2040) would be 56% lower than they were in 2022.

The Government has choices in how it meets the fourth emissions budget. These choices involve decisions around the mix of actions and policies to reduce emissions and how much forestry will play a role to remove carbon from the atmosphere. These choices matter, as each decision will have benefits and consequences.

The Climate Change Response Act 2002 (the Act) sets out specific requirements for how the Commission advises the Government on emissions budgets. This includes providing recommendations on the level of the emissions budget, how much should be met by gross emissions reduction and how much can be contributed through removal of greenhouse gases (such as carbon dioxide absorption by forests). It also requires levels to be specified for different kinds of greenhouse gases in the budget and an outline of the likely actions needed to meet the budget.

We are required to look at a broad range of matters as we develop our advice. This includes how the country can realistically meet our recommended fourth emissions budget, the Crown–Māori relationship, te ao Māori, and specific effects on iwi/Māori, and the likely impacts on the economy, society, the environment, and future generations (see *Chapter 1: Introduction* under 'Matters we considered in developing this advice').

This advice will provide the Government with the basis to decide on a fourth emissions budget level, which will determine the trajectory of Aotearoa New Zealand's emissions reductions out to 2050 and beyond. It will also set a path for decisions that need to be made about how the emissions budget can be achieved through specific policies and actions – which will be set out by Government in the emissions reduction plan for that period.

Our analysis shows there are opportunities to reduce gross emissions on the path towards the fourth emissions budget that would bring a wide range of benefits for Aotearoa New Zealand. Analysis also shows that higher than projected rates of forestry planting in the last couple of years mean that less afforestation will be needed in the future to reach the net zero component of our 2050 target.

Achieving the fourth emissions budget this way would allow the country to reduce emissions in line with meeting the 2050 target, while accessing a range of opportunities and benefits for the economy, society, the environment and future generations. It would give Aotearoa New Zealand flexibility to respond to new information about the viability of different emissions reduction technologies and opportunities.

This chapter provides our advice and recommendations for setting the fourth emissions budget. It outlines the matters we have considered, and how they have factored into determining this advice, including the key judgements we have made.

Changes from the draft version of this chapter

In response to new evidence provided in consultation, and new information available since publication of our draft advice, we have changed some of the assumptions in our modelling and analysis, which underpin the recommended level of the fourth emissions budget. (The changed assumptions are reported in *Chapter 5: Sector contributions to meeting the fourth emissions budget*.)

As a result of our re-assessment, our recommended level for the fourth emissions budget has changed, to 160 $MtCO_2e$ from 134 $MtCO_2e$. This difference is mainly due to methodological changes in the 2024 edition of New Zealand's Greenhouse Gas Inventory (GHG Inventory)[6] and lower carbon dioxide removals as a result of less afforestation.

This chapter has been updated to reflect the new evidence and updated analysis that inform the considerations for the level of the fourth emissions budget.

We have also clarified our description of two other paths to meet the recommended budget level, which provide alternative options. These alternate paths provide insight into ways the recommended budget could be met if actions under the EB4 demonstration path do not unfold in the same way (for instance if methane vaccines do not become available).

What the Act requires for our advice

As detailed in *Chapter 1: Introduction*, the Act sets out the requirements for our advice on emissions budgets, including areas for the Commission to advise on and matters for the Commission to consider or have regard to. Our advice is framed to address these requirements of the Act, including our recommendations to Government, and has supporting analysis in all the chapters in this advice.

In addition to recommending an emissions budget level, the Commission must also advise on:

- the proportion of the emissions budget that will be met by domestic emissions reductions and removals, and the amount each greenhouse gas should be reduced
- the appropriate limit on offshore mitigation that can be used to meet the emissions budget, including an explanation of the circumstances justifying its use
- how the emissions budget, and ultimately the 2050 target, may realistically be met, including pricing and policy methods.

Box 3.1 provides further details on the 2050 target, and how the Act requires the Commission to advise on our proposed emissions budgets.

Box 3.1: The 2050 target and the Commission's usage of global warming potential values for emissions budgets

As stipulated in the Act, Aotearoa New Zealand has a 'split gas' target for domestic emissions. The country's 2050 target considers biogenic methane (from livestock and waste) separately from all other greenhouse gases, by identifying specific gross reduction goals for biogenic methane emissions.

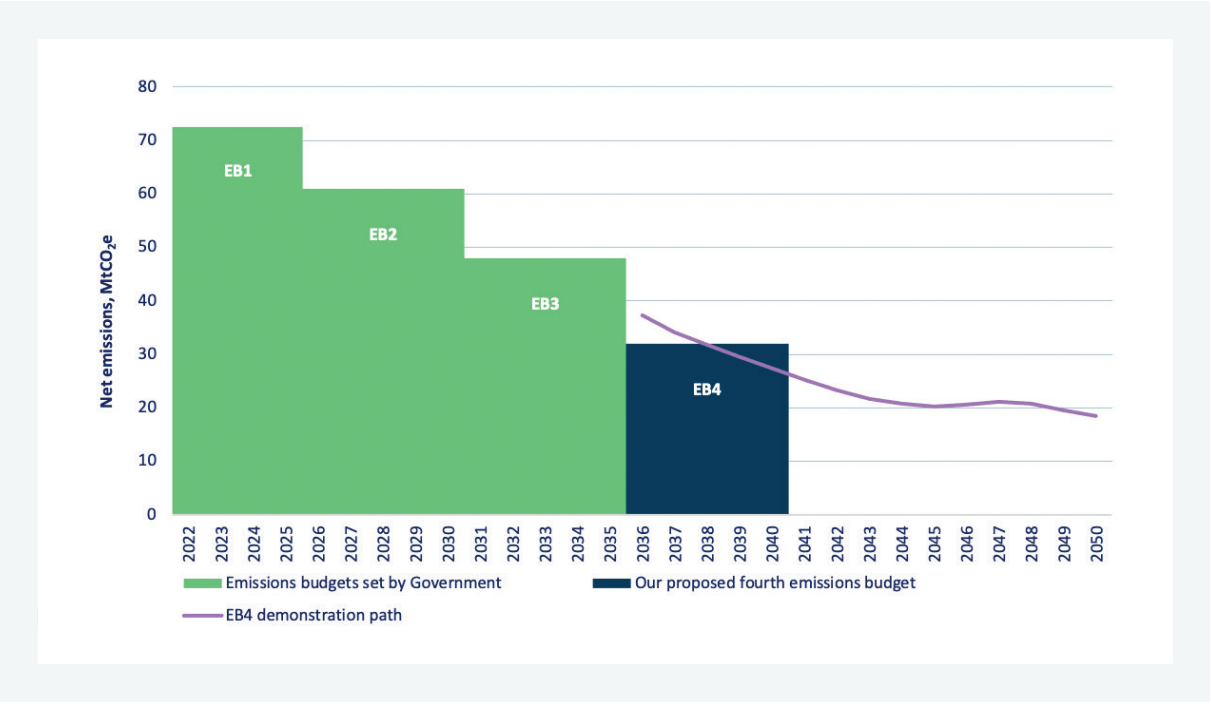
In addition to establishing the split-gas target, the Act also requires the Commission to recommend emissions budgets that are a total quantity of emissions for all greenhouse gases, in terms of the equivalent volume of carbon dioxide. Our recommendations use the global warming potential (GWP) values that are reported by the Intergovernmental Panel on Climate Change (IPCC). This ensures consistency with the methods agreed to by the Conference of Parties to the United Nations Framework Convention on Climate Change under the Paris Agreement. At present, this means the Commission must apply the IPCC's Fifth Assessment Report (AR5 methodology) which uses GWP_{100} values.[7] All carbon dioxide equivalents (CO_2e) presented in this report are on this basis.

Our recommended level for the fourth emissions budget

We are recommending a fourth emissions budget of 160 $MtCO_2e$, which means the annual average emissions in the budget period would be 56% lower than they were in 2022. **Figure 3.1** below shows the relationship between the first, second and third emissions budgets and the fourth emissions budget. This recommendation reflects our judgements of what decisions will balance ambition and achievability, provide flexibility for the future, and offer lasting economic, societal and environmental benefits that will likely exceed overall costs.

Details on the fourth emissions budget demonstration path (the EB4 demonstration path) underpinning this budget level can be found in *Chapter 4: Developing the path to the fourth emissions budget*, *Chapter 5: Sector contributions to meeting the fourth emissions budget* and *Chapter 6: The impacts on New Zealanders of meeting the fourth emissions budget*.

Figure 3.1: Our recommended fourth emissions budget alongside our EB4 demonstration path to 2050 and current budgets set by Government, net emissions of all greenhouse gases (using the AR5 GWP_{100} metric for conversion)

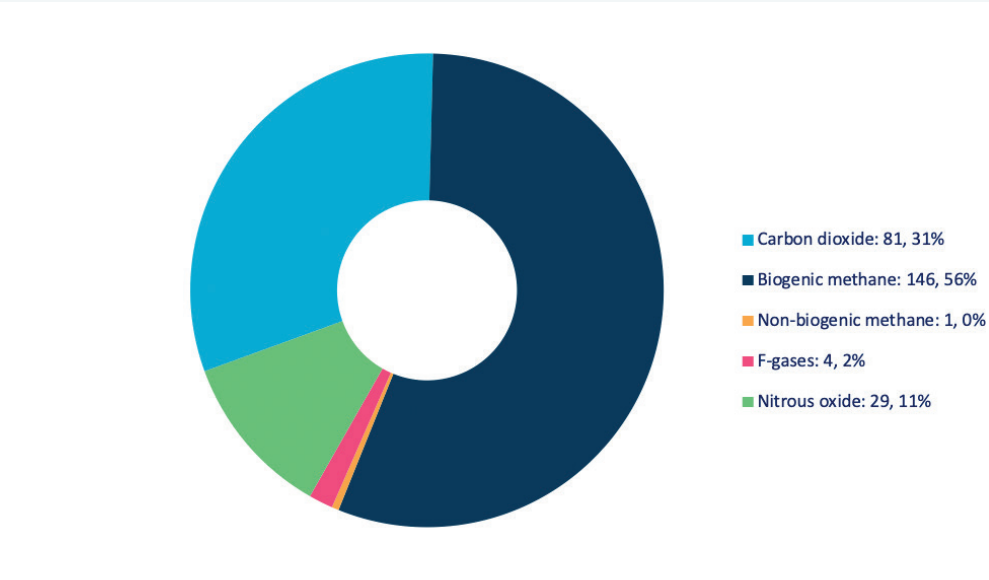


Source: Commission analysis

Breakdown of gross emissions by gas

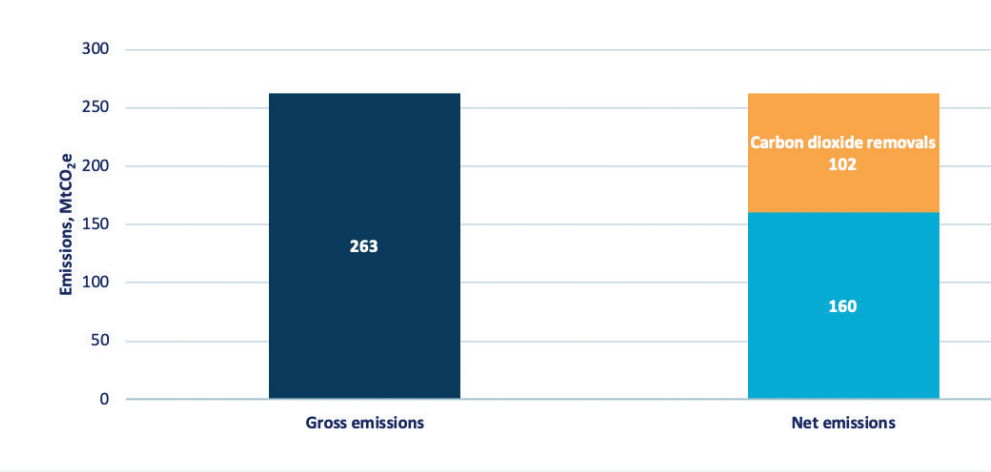
In terms of a breakdown of gross emissions of all greenhouse gases in the recommended fourth emissions budget, biogenic methane contributes 56% of these emissions, followed by carbon dioxide (31%), nitrous oxide (11%), fluorinated gases (f-gases) (2%) and non-biogenic methane (<1%) (**Figure 3.2**). Carbon dioxide removals by forests will balance out approximately 39% of total gross emissions (**Figure 3.3**).

Figure 3.2: Breakdown of gross emissions in our recommended fourth emissions budget by greenhouse gas ($MtCO_2e$, %)



Source: Commission analysis

Figure 3.3: Comparing gross emissions and net emissions in our recommended fourth emissions budget

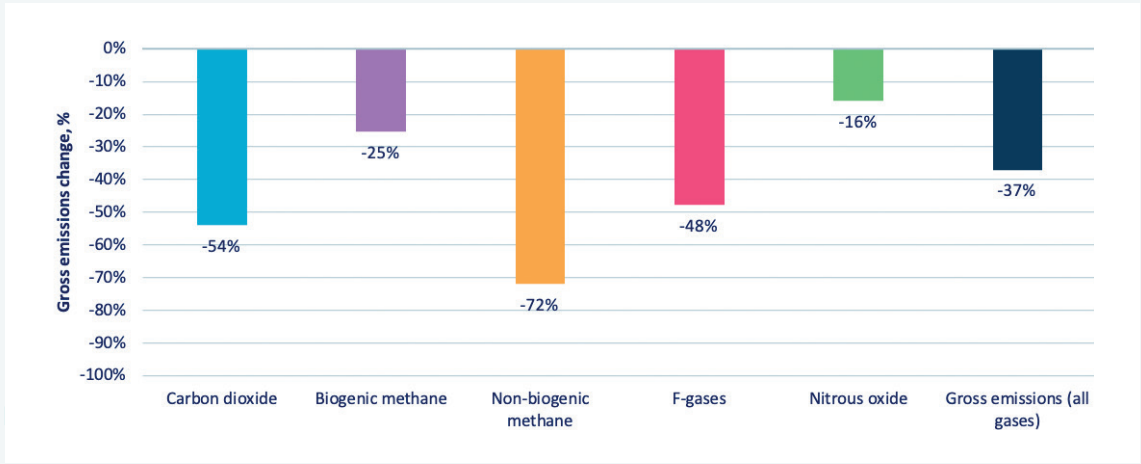


Source: Commission analysis

Reductions in gross emissions and level of removals by 2040

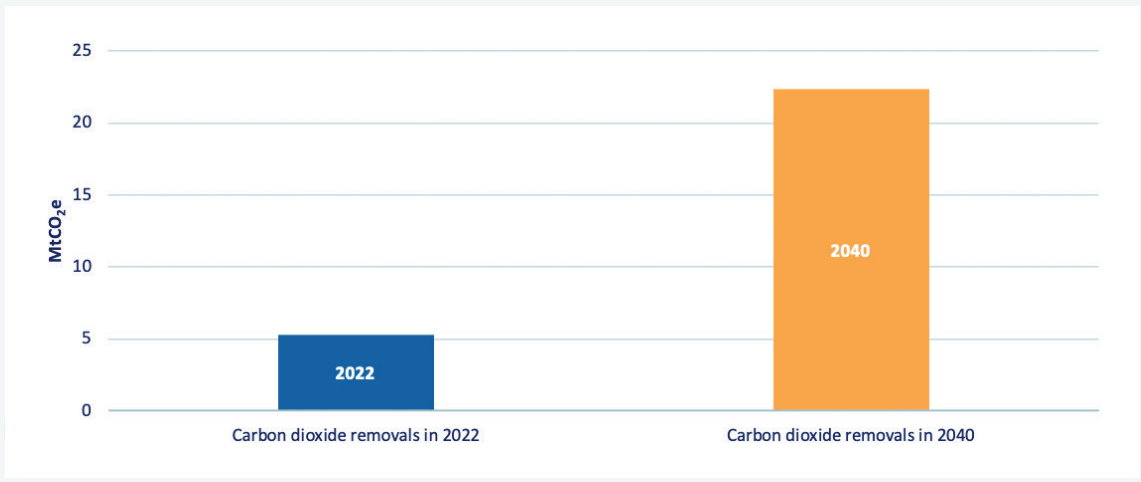
When comparing expected emissions in 2040 (the end of the fourth emissions budget period) to actual emissions in 2022,[x] gross emissions of all greenhouse gases will reduce by 37%, from 79 $MtCO_2e$ to 50 $MtCO_2e$ (**Figure 3.4**) while carbon dioxide removals by forests will increase from 5 $MtCO_2e$ to 22 $MtCO_2e$ (**Figure 3.5**). Reductions in carbon dioxide (54%) and biogenic methane (25%) will contribute most to overall reductions in gross emissions in 2040.

Figure 3.4: Changes in gross emissions by greenhouse gas by 2040 under the EB4 demonstration path, relative to 2022



Source: Commission analysis

Figure 3.5: Comparing carbon dioxide removals by forests under the EB4 demonstration path in 2040, compared with 2022



Source: Commission analysis

x Commission analysis using the 2024 edition of the GHG Inventory.

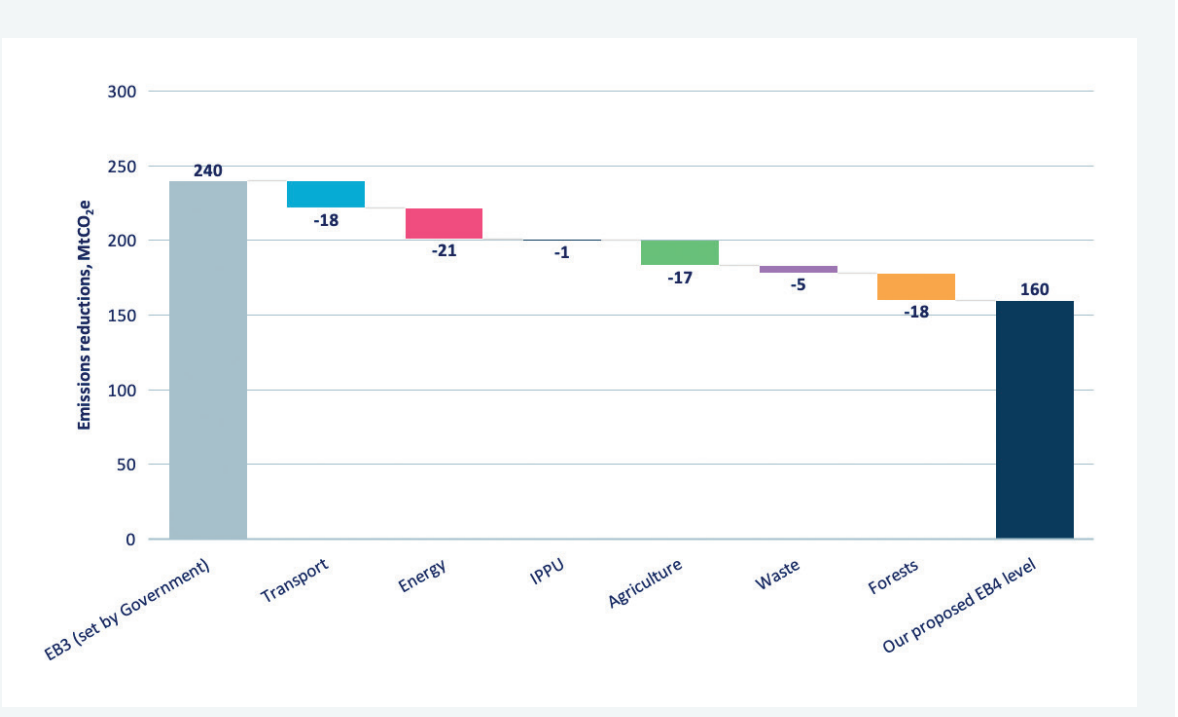
Sector contributions to emissions reductions for our proposed budget

Comparing our recommended fourth emissions budget level to the third emissions budget as set by Government in 2022,[xi] the largest reductions in gross emissions come from the energy (21 $MtCO_2e$), transport (18 $MtCO_2e$) and agriculture (17 $MtCO_2e$) sectors.

In terms of reductions by percentage of total emissions, the energy (37%) and transport (35%) sectors' gross emissions will reduce by the largest percentage. The forestry sector will increase carbon dioxide removals by 22%.

Reductions across sectors are summarised in **Figure 3.6** below. Details on specific sector activities in the EB4 demonstration path will be covered in *Chapter 5: Sector contributions to meeting the fourth emissions budget*.

Figure 3.6: Emissions reductions by sector for meeting our recommended level for the fourth emissions budget[xii]



Source: Commission analysis

xi The reductions in emissions by sector presented here draw on our 2022 update to our demonstration path as this path aligns with the levels that were set by the Government for the first, second and third emissions budgets in 2022. The demonstration path was updated as part of our advice on the second emissions reduction plan. The Government's second emissions reduction plan released by the end of 2024 will set out sectoral policies to achieve set budgets.

xii In this advice we have included f-gases as part of industrial processes and product use (IPPU).

The considerations that inform our recommended budget level

Under the Act, there is a wide range of matters we need to consider as part of our functions, including matters specific to advising on emissions budgets. These are outlined in *Chapter 1: Introduction*. We have summarised below how we have considered these matters and how they have informed our advice.

Latest information and trends on greenhouse gas emissions and removals

We have reviewed and updated our analysis to include the latest information on greenhouse gas emissions. The most notable recent developments since we advised the Government on the first three emissions budgets in *Ināia tonu nei* were:

- Updates made to the methods for calculating and reporting emissions through the 2024 edition of New Zealand's Greenhouse Gas Inventory (GHG Inventory) have resulted in an increase in overall historical emissions reported and projected from the 2023 edition of the GHG Inventory. Overall, emissions reported and projected (for the first and second emissions budget) are still lower than when the first three emissions budgets were set in 2022.
- Data released in the GHG Inventory and the Afforestation and Deforestation Intentions Survey 2023[8] (ADS) show the actual planting rates for exotic forests between 2020 and 2022, estimates for 2023, and anticipated for 2024 have been much higher than projected in *Ināia tonu nei*. Feedback through consultation and the ADS data suggest this level of planting is unlikely to continue, and much lower levels are expected in the near term.
- Announcements on the introduction of an electric arc furnace for steel production (enabling a reduction in coal use by 50%).
- Marsden Point refinery transitioning to an import-only terminal in April 2022.
- Tiwai Point aluminium smelter now expected to remain open until at least 2040.
- Slower growth projected in vehicle kilometres travelled (VKT) to 2030.
- A reduction in fossil gas production and a decline in estimated gas reserves. This has led to a shortfall in supply relative to demand, a dynamic which is expected to persist, at least in the short term.

On balance, these changes mean further reductions in gross and net emissions are possible for Aotearoa New Zealand than the scenarios presented in *Ināia tonu nei*.

New opportunities for emissions reductions and removals

We reviewed current evidence, alongside insights gained through public consultation and targeted engagement with sector stakeholders, to ensure we used the latest available information to understand what is possible and desirable for the fourth emissions budget. This included reviewing assumptions from mitigations considered in *Ināia tonu nei*, as well as potential new mitigations. Our analysis has considered abatement potential for mitigations alongside expected costs.

New evidence, including feedback from sector stakeholders, suggests further opportunities to reduce gross and net emissions of all greenhouse gases other than biogenic methane. This includes information that supports the potential for the conversion from coal use to biomass in electricity generation and new technology to provide carbon capture and reinjection for some geothermal.

A key judgement was made on how to incorporate the effect of new biogenic methane technologies when recommending the budget level

We also have evidence suggesting further reductions in biogenic methane could be feasible by the fourth emissions budget period, primarily through adoption of new methane-reducing technologies in agriculture.[xiii] The potential technologies include methane vaccines, inhibitors, and adoption of breeding for low-methane animals.

Methane inhibitors are already proven, but current inhibitors are less suitable for Aotearoa New Zealand's pasture-based systems.[xiv] The research we have commissioned suggests that methane vaccines for sheep, cattle and dairy cows and low-methane breeding for dairy cows and cattle are expected to become available in the future. As some of these technologies are expected to be ready for deployment in the fourth emissions budget period, we have included the effect of their adoption in arriving on the level for the fourth emissions budget.

While our evidence suggests that methane reducing technologies are expected to be available, their timing, cost and effectiveness are still uncertain. We have accounted for this in the design of our EB4 demonstration path. In the event some of these technologies are not available, our assumption is that those that are available can still achieve the level of reductions in biogenic methane required to achieve our proposed budget.

See Chapter 5: Sector contributions to meeting the fourth emissions budget for more details on these new technologies in our EB4 demonstration path.

The need for both removals and emissions reductions

In our previous advice on budgets and the emissions reduction plans to meet them, the Commission has consistently advised that pathways to meeting the 2050 target need to focus on reducing gross emissions to transition Aotearoa New Zealand to an inclusive and low emissions economy.

While there is an important role for removals[xv] to help meet the 2050 target, achieving and maintaining net zero emissions of all greenhouse gases (other than biogenic methane) beyond 2050 requires meaningful reductions in gross emissions. Gross emissions reductions provide effectively permanent reductions in the level of emissions, whereas removals of carbon dioxide from the atmosphere by forests sequester greenhouse gases only while the trees are growing. The more gross emissions are reduced at source, the less removals are required to achieve and maintain net zero emissions.

Reducing gross emissions often provides broader benefits to society than would be achieved by only increasing removals by forests – such as improved air quality,[9] warmer drier homes,[10] health benefits from active transport, jobs in new and innovative sectors,[11] and a more timely transition to a low emissions economy.

xiii We commissioned analysis from The Agribusiness Group on abatement opportunities for agriculture for the fourth emissions budget. We have published this as supporting evidence for our advice: https://www.climatecommission.govt.nz/public/Uploads/EB4/supporting-docs/Report-on-agricultural-mitigation-technologies-Final.pdf

xiv 3-nitrooxypropanol (3-NOP) is currently proven and is expected to be available for use soon. However, it is not well suited for Aotearoa New Zealand's pasture-based dairy systems. A slow-release bolus for 3-NOP in development may be better suited to pasture-based systems. Forests are currently the only removals accounted for in the inventory, but a broader portfolio of removal options (e.g. other nature-based solutions such as restoring peatlands and wetlands) may be used in the future.

xv Forests are currently the only removals accounted for in the inventory, but a broader portfolio of removal options (e.g. other nature-based solutions such as restoring peatlands and wetlands) may be used in the future.

We also considered the risks and uncertainties associated with different pathways to meet the 2050 target. Achieving more gross emissions reductions to meet the net zero component of the 2050 target decreases the ongoing reliance on carbon dioxide removals. This approach also results in lower residual emissions in the future, meaning it can help mitigate the impact of potential future damage and disturbances to forests.

Additionally, this balance of gross emissions reductions and removals would allow Aotearoa New Zealand to meet and maintain the 2050 target beyond 2050. This would also provide a buffer for potential changes outside the Government's control, including if some technologies are not developed or if there are methodological updates that increase estimated emissions.

The expected economic impacts of meeting the fourth emissions budget

We have assessed the likely impacts on our economy and society – both positive and negative – from meeting the fourth emissions budget. To do so we have used a range of models and approaches, which provide different perspectives and insights on the potential impacts, to make our assessment. We consider that it is only appropriate to draw conclusions about the likely impacts by considering the results of these analyses together. Focusing on a single perspective alone would provide a misleading and incomplete picture of the overall outcomes of the EB4 demonstration path.

Our analysis suggests that meeting the fourth emissions budget by following the actions in the EB4 demonstration path would result in overall economic and social benefits. Our modelling indicates that meeting the fourth emissions budget through the mix of actions in the EB4 demonstration path would not be expected to adversely affect the overall level of activity in the economy (as measured by gross domestic product, or GDP). Our analysis overall suggests the broader benefits of actions taken in our EB4 demonstration path are likely to exceed the costs. We estimate the direct financial savings from actions that reduce gross emissions to grow to $1 billion per year by the end of the fourth emissions budget. We have also quantified the benefits of improved air quality from a faster transition to electric vehicles and reducing private vehicle use, which are around $2.1 billion a year over the fourth emissions budget period.

These impacts are discussed in more detail in *Chapter 6: The impacts on New Zealanders of meeting the fourth emissions budget*.

Crown–Māori relationship, te ao Māori and specific effects on iwi/Māori

We have considered specific effects for iwi/Māori, as well as wider matters relating to te ao Māori and the Crown–Māori relationship. We heard through submissions that hapori Māori are being disproportionately impacted by severe weather events as they increase in frequency and severity. Climate change will have distinct and wide-reaching impacts on iwi/Māori, from threatening the unique relationship iwi/Māori have to whenua and te taiao, to the intensification of Māori health inequities. The Māori economy's level of investment in land-based activity also increases iwi/Māori exposure to climate change.

We also heard that many iwi/Māori are already helping lead the response to climate change, as tangata whenua, rangatira and kaitiaki, and almost all Māori submitters noted their communities' existing climate strategies or initiatives to reduce emissions and manage the effects of climate change. There was a call for local and central government to resource these plans and initiatives to support faster emissions reduction, to the benefit of the community, and ultimately all of Aotearoa New Zealand.

This feedback is consistent with what we have heard in consultation on our advice on the direction of policy for the Government's second emissions reduction plan and our engagement with iwi/Māori for the first progress report on the national adaptation plan.

The policy choices that Government has to address the opportunities and impacts of the transition to a low emissions economy, including for iwi/Māori, are the focus of our 2023 *Advice on the direction of policy for the Government's second emissions reduction plan*.

Our consideration of the Crown–Māori relationship, te ao Māori and specific effects on iwi/Māori is covered in greater detail in *Chapter 6: The impacts on New Zealanders of meeting the fourth emissions budget*.

Contribution to the global effort to limit warming

By defining the 2050 target in the Act, Parliament has set the direction for what domestic contribution Aotearoa New Zealand will make to the international effort to limit global warming to 1.5°C above pre-industrial levels. Emissions budgets need to be set at a level that will support meeting the 2050 target.

In this advice, we have developed scenarios and our EB4 demonstration path consistent with meeting the current 2050 target and contributing to the global effort to limit global average warming to 1.5°C above pre-industrial levels. We have released two other pieces of work at the same time as this advice – including the review of the 2050 target. You can find more information on the two other pieces of advice in *Chapter 1: Introduction*.

We have tested whether the recommended budget can be met by different actions

There are inherent uncertainties to arriving at a proposed budget level. Predicting the technologies and systems that will be available to contribute to emissions reductions in 12 years' time is a challenging task. This includes details on the effectiveness, cost, and scalability of new and emerging technologies from now to 2036 (and beyond, to 2050). To illustrate these challenges, international evidence suggests that even highly regarded projections regularly underestimated the level of deployment for renewable energy technologies while also overestimating their costs.[12]

There are a range of other factors that will also impact Aotearoa New Zealand's ability to meet our proposed budget, including social factors (such as population growth), economic factors (such as GDP growth rates, oil prices, energy prices), and sector specific factors (such as the number of ruminant animals on farms, and costs of EVs and batteries).

Our budget level has been recommended in light of these uncertainties. This means the Government will have choices about how to meet the budget. The flexibility to meet emissions budgets through a range of different combinations of actions gives greater confidence that future governments can meet the budgets under a range of circumstances.

We looked at different paths that could achieve the fourth emissions budget

To test how resilient our recommended emissions budget is to uncertainty, we have developed two alternative paths that also meet the recommended budget level. These were developed to understand how future governments could adjust the actions taken to meet the budget should some actions develop more slowly than we currently anticipate. These alternative paths draw on the insights gained from our analysis of scenarios to 2050.

Alternative path A examined a path that includes greater emphasis on systems change to achieve the budget level to compensate for slower progress on technology changes. In this path:

- coal use is eliminated from steel production, on the assumption that the electric arc furnace project enables a complete transition to a predominantly scrap steel-based production system. This would involve decommissioning the iron-making part of the process, which is where the coal is consumed. (This compares to a 50% reduction in coal use in the EB4 demonstration path)
- there would be further reductions in livestock and stocking rates of ruminant animals
- there would be a further reduction in vehicle kilometres travelled (VKT) across the transport sector
- no methane-reducing technologies would be applied
- an upgrade of the Kinleith pulp and paper mill, featuring a high efficiency recovery boiler, is delayed until 2035 (compared to an assumed 2030 upgrade date in the EB4 demonstration path).

Alternative path B examines the effects of meeting the budget through prioritising actions that apply new and emerging technologies – with less reliance on systems change to meet the budget. In this path there:

- would be faster cost reductions for EVs and batteries
- is higher aviation electrification and higher use of biofuels in road, rail and aviation
- is a full conversion to green-hydrogen-based urea production (no conversion in EB4 demonstration path)
- is adoption of zero carbon anodes to decarbonise aluminium production
- is a delayed phase out for pipeline fossil gas and LPG in residential/commercial/industrial uses (2060 vs 2050 in EB4 demonstration path).

A summary of the different actions under the alternative paths can be found in the assumptions logs published on our website.

Figure 3.7 below summarises the results of our analysis of these alternative paths. Both alternative paths match the total level of net emissions for the EB4 demonstration path. Further systems change in Alternative path A results in around 9 $MtCO_2e$ fewer gross emissions than the EB4 demonstration path as a result of greater reductions in all greenhouse gases, including biogenic methane. We have avoided alternative paths that would increase levels of biogenic methane or gross emissions of all greenhouse gases other than biogenic methane, as doing so could impact the country's contribution to warming and ability to meet the 2050 target.

Impacts to society and the economy vary depending on the pathway. As discussed earlier in this section, following Alternative path A means less reliance on technology, meaning a greater emphasis on systems change. There are a number of implications of this pathway, notably:

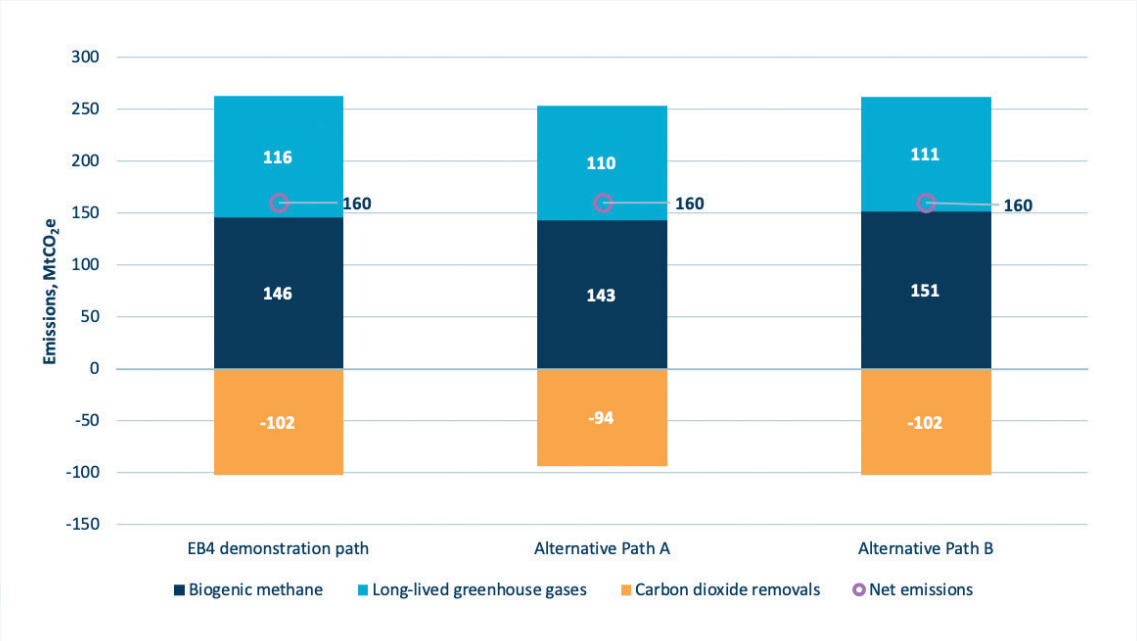
- in steel production, additional scrap steel may need to be imported from overseas should the quantity of scrap available domestically be insufficient. It would likely also require importing raw iron units to supplement the scrap
- lower production levels and less revenue for dairy, sheep and beef farmers (relative to the EB4 demonstration path)
- lower growth in overall VKT, alongside further growth in public and active modes of transport, meaning greater changes to travel habits relative to present day.

Following Alternative path B involves less of a focus on systems change while drawing more heavily on technology to achieve emissions reductions. Implications of this pathway include:

- a greater dependence on availability of suitable vehicles, aircraft and biofuels. This includes faster cost reductions for EVs and batteries than assumed in our EB4 demonstration path
- greater emissions from continuing to use pipeline gas and LPG over a longer timeline. Consequences of this include greater costs of maintaining gas pipeline infrastructure, continuing impacts on indoor air quality for those remaining on gas for longer, and unrealised savings that would come with a quicker transition from pipeline gas
- adoption of some technologies that could come at a higher abatement cost than other options for reducing emissions. These include zero carbon anodes for aluminium production, and full conversion to green-hydrogen-based urea production.

Our analysis suggests there will be multiple ways for Aotearoa New Zealand to achieve the fourth emissions budget at the level we are recommending. While we expect that the fourth emissions budget could be met through following any of the three paths, the EB4 demonstration path presents the Commission's judgement of the path that what would be ambitious and achievable, provide flexibility for the future, and offer lasting economic, societal and environmental benefits that will likely exceed overall costs.

Figure 3.7: Emissions for the fourth emissions budget from our analysis of alternative paths



Source: Commission analysis

Flexibility in meeting emissions budgets

The Act requires the Minister of Climate Change to set emissions budgets for Aotearoa New Zealand that can be achieved through domestic action. This requirement has been central to our recommended level for the fourth emissions budget, including the ability to meet these through a variety of pathways. This differs from nationally determined contributions (NDCs) set by Aotearoa New Zealand and other parties to the Paris Agreement, which can include offshore mitigation to supplement domestic action.

There is always uncertainty when projecting forward in time. The Act does provide some flexibility to help manage this uncertainty, which we cover in this section.

Banking and borrowing between budgets

If total emissions at the end of an emissions budget are lower than the level for that budget, the excess reduction can be carried forward to the next emissions budget period. This means the emissions budget for the next period is increased by the amount carried over (banked).

If total emissions at the end of the budget period are greater than the level of the emissions budget, up to 1% of the next emissions budget can be brought forward (borrowed).

In *Ināia tonu nei* we noted the risks of borrowing, notably making it harder to meet subsequent budgets. We also viewed it as preferable that:

- the Government's emissions reduction plans aim to overachieve budgets
- borrowing is limited to when the Government finds itself in a position where there is insufficient time to adjust policies to ensure emissions meet the budget level.

The Commission is required to advise on banking and borrowing as part of our report at the end of an emissions budget period. These reports are due to the Minister of Climate Change no later than two years after the end of an emissions budget period (see section 5(Z)(L) of the Act). Final decisions on banking and borrowing are made by the Minister of Climate Change.

The impact of banking and borrowing on both the adjacent budget and potentially later budgets should be considered. For example, if a gain from a budget period were banked, this would make the adjacent budget period easier to meet. Care would be needed to ensure efforts to reduce emissions are not lessened so later reductions can still be achieved, and to stay on course for meeting the 2050 target. Circumstances requiring banking or borrowing for the current budget will not be known until the first budget period finishes (the end of 2025).

Offshore mitigation

As emissions budgets are intended to be met through domestic action, the use of offshore mitigation should only be used as a last resort for meeting emissions budgets. In *Ināia tonu nei* we advised that offshore mitigation be limited to exceptional circumstances such as force majeure events, which are unpredictable, unpreventable and outside the control of the Government. These typically cause one-off increases in emissions, such as the need to rebuild following a disaster such as an earthquake or volcanic eruption.

Other uncertainties should be accounted for in the planning, setting, and revising of emissions budgets, as well as how Government chooses to implement its emissions reduction plans.

In our advice on emissions budgets, the Act requires the Commission to also advise on a limit on offshore mitigation that can be used. In *Ināia tonu nei* we recommended that the limit on offshore mitigation should be zero for the first three emissions budgets. We also recommended that the only circumstances that should justify use of offshore mitigation is as a last resort in exceptional circumstances beyond the Government's control. We are extending these recommendations to the fourth emissions budget.

Implications for policy

The choices that Government has in how it meets the recommended fourth emissions budget involve decisions around the mix of actions and policies to reduce emissions and how much forestry will play a role to remove carbon dioxide from the atmosphere. These choices matter, as each decision will have benefits and consequences.

The Act requires that our advice on the fourth emissions budget includes how we expect the budget, and the 2050 target, could be realistically met – and must show the corresponding levels of gross emissions reductions and removals, and the contribution of each greenhouse gas. To do so we have looked at what we think is the best course of action for Aotearoa New Zealand, with consideration to a range of matters under the Act.

This advice provides the Government with the basis to decide on a fourth emissions budget level, which will determine the trajectory of Aotearoa New Zealand's net emissions out to 2050. It will also set a path for decisions that need to be made about how the emissions budget can be achieved through developing and implementing clear and stable policies, consistent with the purpose of the Act, which will be set out by Government in the emissions reduction plan for that period.

Our analysis shows that there are opportunities to reduce gross emissions on the path towards the fourth emissions budget that would bring a wide range of benefits for Aotearoa New Zealand. Higher than projected rates of forest planting over the last few years mean that less afforestation is needed in the future to reach the net zero component of our 2050 target. This in turn means that investing in carbon capture and storage technologies may not need to play a large role.

Achieving the fourth emissions budget this way would allow the country to reduce emissions in line with meeting the 2050 target, while accessing a range of opportunities and benefits for the economy, society, the environment and future generations. It would give Aotearoa New Zealand flexibility to respond to new information about the viability of different emissions reduction technologies and opportunities.

In *Ināia tonu nei*, we included a number of policy implications of our proposed levels for the first three emissions budgets. A number of these remain highly relevant for the fourth emissions budget. We reiterate these, alongside further advice specific to what is required for policy for our recommended fourth emissions budget. Achieving our recommended fourth emissions budget will require:

- further electrification of light transport, including phase out of light internal combustion engine (ICE) vehicle imports by 2040, low-carbon fuel alternatives, and reductions in vehicle kilometres travelled
- continued growth in renewable electricity generation, for example through wind, solar and geothermal. This growth will need to be at a sufficient rate to balance risks of under- or over-investment, while ensuring secure, reliable and affordable electricity supply is maintained across the transition
- transitioning away from fossil fuels to low-carbon energy sources such as electricity and biomass for homes, buildings and industry (and ensuring sufficient supply of biomass to 2050 and beyond)
- going further on current available methane-reducing technologies and farm management practices and the introduction of new methane-reducing technologies that can contribute to emissions reductions for the fourth emissions budget
- a gradual decline in exotic afforestation from 2030 to 2050, with native afforestation increasing to 2030 and maintaining this level to 2050[xvi]
- a step change in ambition and action to improve the energy efficiency of residential, commercial, and public buildings
- increasing rates of active and public transport in urban areas.

In our *2023 Advice on the direction of policy for the Government's second emissions reduction plan*,[13] we showed that the New Zealand Emissions Trading Scheme (NZ ETS) as currently structured is highly unlikely to drive the gross emissions reductions in line with our demonstration path (and the sector sub-targets set out in Aotearoa New Zealand's first emissions reduction plan), particularly in a way that can be sustained. While the NZ ETS creates strong economic drivers for planting trees, it also allows carbon dioxide removals by forests to undermine the incentive to reduce emissions at their source. In the near term, this is expected to result in the NZ ETS driving extensive afforestation but only limited gross emissions reductions. Government policies will need to encourage both gross emissions reductions and afforestation, as both have essential roles to play in an equitable and sustainable low emissions transition.

xvi Exotic afforestation is at historically high levels in recent years. While exotic afforestation offers quicker reductions in net emissions, planting natives offers a longer-term carbon sink, as well as improving biodiversity and reducing erosion risk of marginal land classes. Native afforestation will have to increase significantly from recent levels to meet the level in our EB4 demonstration path, which peaks at 2030 and maintains this level to 2050.

The Government will need to use various policy levers to enable, incentivise, or require changes as appropriate. There will be challenges to meeting our recommended fourth emissions budget, but these can be overcome through targeted policy within a comprehensive and coherent policy package. This will need to consider the Government's relationship with Māori under Te Tiriti o Waitangi/ The Treaty of Waitangi, and to consider equity across society, including for those in lower socio-economic groups and for future generations.

There are policies that will need to be in place now or in the near term to ensure future emissions budgets can be met. For example, changing land use to produce a different product is only commercially viable if there is infrastructure to support that change. This can mean policies to support expanding supply chain infrastructure such as pack houses, accessing new markets for novel varieties, or changing regulations to facilitate land-use change. The Government will need to encourage a wider set of actions than the minimum necessary to achieve this emissions budget. This approach reduces the risk of not achieving emissions budgets, for example if some technologies are not available to the level required.

Flexibility in budgets means multiple possible pathways, and a diverse range of levers, for achieving them. This also allows government, industry, businesses, and households to be able to adapt to new information, technologies, and systems as they become available.

There are a number of mitigations that offer low-regret choices alongside significant co-benefits beyond emissions reductions (such as cleaner air and water, better public health outcomes, improved biodiversity of native species). These options should continue to be leveraged on any pathway to 2050.

Some policies and approaches of today and tomorrow risk constraining future options. For example, some infrastructure investments (or lack thereof) and urban planning decisions could constrain lower emissions ways of transporting people and goods, or ways of living that make it hard to take advantage of new technologies in the future.

Aotearoa New Zealand can continue to build on its strengths. It has a high proportion of renewable electricity generation, and a potential for more. Aotearoa New Zealand can utilise this opportunity to decarbonise industry and transport, which will also be cheaper than using fossil fuels for businesses, households and whānau over the long term. As new opportunities arise that offer cost-effective reductions to high emitting activities, government can work with the private sector to ensure timely adoption of these systems and technologies and management of risks where these are a barrier to investment.[14]

Uncertainty about the future is something to be managed, rather than a reason to delay further climate action. Having a diverse portfolio of levers ensures sufficient flexibility to manage uncertainties so that a low emissions future is achieved, alongside the benefits that a timely transition will offer for Aotearoa New Zealand.

Recommendations

This recommendation seeks to address a level for the fourth emissions budget to help enable Aotearoa New Zealand stay on course to achieve the 2050 target.

Recommendation 1 – Proposed budget level

We recommend that the Government set the fourth emissions budget (2036–2040) at:	160 $MtCO_2e$ (total, AR5 GWP_{100})

These recommendations seek to address the balance of emissions and removals by gas, including reductions by gas needed relative to 2022 levels, to enable Aotearoa New Zealand to achieve our recommended budget level.

In our advice on the second emissions reduction plan, we recommended that the Government commit to specified levels of gross greenhouse gas emissions and carbon dioxide removals for the second and third emissions budgets. If this recommendation is taken on board, and the approach extended to the fourth emissions budget, the values in Recommendation 2 can guide the Government's specified levels.

Recommendation 2 – Breakdown of the fourth emissions budget

We recommend that, to meet the fourth emissions budget (2036–2040), the Government implement policies that result in a balance of emissions and removals as outlined in this table*:

Total net emissions Annual average	160 $MtCO_2e$ 32.1 $MtCO_2e$
Total carbon dioxide removals Annual average	102 $MtCO_2e$ 20.5 $MtCO_2e$
Emissions – all greenhouse gases, other than biogenic methane Gross greenhouse gases	
• Carbon dioxide	81 $MtCO_2e$
• Nitrous oxide	29 $MtCO_2e$
• F-gases	4 $MtCO_2e$
• Non-biogenic methane	1 $MtCO_2e$
Emissions – biogenic methane Gross biogenic methane	5.23 $MtCH_4$

*All values listed in $MtCO_2e$ are calculated using the IPCC AR5 GWP_{100} values; components may not sum to total due to rounding.

Recommendation 3 – Reductions by greenhouse gas to meet the emission budget

We recommend that, to meet the fourth emissions budget, the Government implement policies that deliver reductions of each greenhouse gas as outlined in this table*:

	2022	Fourth emissions budget (2036–2040)
Total net emissions ($MtCO_2e$/yr) Annual average Reduction from 2022	73.6 $MtCO_2e$	 32.1 $MtCO_2e$ 41.5 $MtCO_2e$
Total gross emissions ($MtCO_2e$/yr) Annual average Reduction from 2022	78.9 $MtCO_2e$	 52.5 $MtCO_2e$ 26.3 $MtCO_2e$
Gross emissions broken down by:		
Carbon dioxide ($MtCO_2e$/yr) Annual average Reduction from 2022	31.9 $MtCO_2e$	 16.3 $MtCO_2e$ 15.6 $MtCO_2e$
Nitrous oxide ($MtCO_2e$/yr) Annual average Reduction from 2022	6.9 $MtCO_2e$	 5.9 $MtCO_2e$ 1.0 $MtCO_2e$
F-gases ($MtCO_2e$/yr) Annual average Reduction from 2022	1.6 $MtCO_2e$	 0.9$MtCO_2e$ 0.7 $MtCO_2e$
Non-biogenic methane ($MtCO_2e$/yr) Annual average Reduction from 2022	0.8 $MtCO_2e$	 0.3 $MtCO_2e$ 0.6 $MtCO_2e$
Biogenic methane ($MtCH_4$/yr) Annual average Reduction from 2022	1.35 $MtCH_4$	 1.05 $MtCH_4$ 0.30 $MtCH_4$

*All values listed in $MtCO_2e$ are calculated using the IPCC AR5 GWP_{100} values; components may not sum to total due to rounding.

Recommendation 4 – Limit on offshore mitigation for the fourth emissions budget and circumstances justifying its use

We recommend that, to meet the fourth emissions budget (2036–2040), the Government:

a. limit offshore mitigation for the fourth emissions budget to 0.0 $MtCO_2e$
b. only use offshore mitigation as a last resort in exceptional circumstances beyond the Government's control, such as force majeure events, where domestic measures cannot compensate for emissions impacts.

Wāhanga 4 | Chapter 4

Te whakawhanake i te ara o te tahua tukuwaro tuawhā
Developing the path to the fourth emissions budget

This chapter sets out how we have developed a proposed path to reach the country's fourth emissions budget. It reflects an ambitious but technically and economically achievable way to reduce emissions.

To give advice on the fourth emissions budget, we need to consider what changes will need to happen across the country and whether those changes are technically and economically feasible for Aotearoa New Zealand. This chapter explains how we have developed a path that sets out the actions that the country could take to reach the fourth emissions budget.

There are multiple ways to meet the 2050 target. The choices made about the path to that target need to take into account the current progress on emissions reduction, long-term projections, practical matters about feasibility, and also the effects of the changes required. At the heart of the judgements required is the need to both maximise the benefits and opportunities of this transition and minimise negative impacts.

Since the Government set the first three emissions budgets in 2022, the outlook for Aotearoa New Zealand's emissions reduction has changed. There have been significantly higher rates of forestry planting in the last three years than previously projected. There are also new opportunities for emissions reductions. This needs to be considered in our advice to Government on setting the next steps on the path to meet the 2050 target.

For this advice, we have built on the analysis we did for the first three emissions budgets, using the best evidence and information available. We have assessed opportunities and carried out scenario analysis to update a demonstration path to 2050 (the EB4 demonstration path). This path takes into consideration a wide range of matters as required under the Act to demonstrate the proposals for the fourth emissions budget are achievable.

The specific actions to achieve emissions budgets are set out in the Government's emissions reduction plan covering that period. He Pou a Rangi Climate Change Commission is required to provide advice on the contents of those plans, which are drafted and finalised by the Government. The process of setting emissions reduction plans one year prior to an emissions budget starting allows government to make decisions on Aotearoa New Zealand's path to 2050 and 'course correct' using the most updated information. The Government consulted earlier this year on the second emissions reduction plan, covering the second emissions budget (2026–2030), and is due to publish this before the end of the year.

This chapter sets out our approach to developing the EB4 demonstration path, which is the foundation of our recommended fourth emissions budget (see *Chapter 3: Recommended level for the fourth emissions budget*). It covers the current trajectory for emissions in Aotearoa New Zealand, our assessment of opportunities to reduce and remove emissions, our long-term scenarios out to 2050, and our 'EB4 demonstration path'.

The action required in different parts of Aotearoa New Zealand's economy and society to move along that EB4 demonstration path is set out in *Chapter 5: Sector contributions to meeting the fourth emissions budget*. This is followed by our assessment of what those actions are likely to mean for people, in *Chapter 6: The impacts on New Zealanders of meeting the fourth emissions budget*.

Changes from the draft version of this chapter

In response to consultation feedback we have changed some of the assumptions that underlie our EB4 demonstration path – which sets out the actions that the country could take to reach the fourth emissions budget.

The changes reflect new evidence provided by submitters on our draft advice, on the feasibility, cost, impacts or technical potential to adopt particular actions. We have also reflected new information available since the publication of our draft advice. We have revised the 'reference scenario' – which allows comparison of our EB4 demonstration path to current policies and measures – to draw on the latest available information from the Government on data and projections for greenhouse gas emissions in Aotearoa New Zealand (see **Box 4.1**).

The set of scenarios in this chapter, which demonstrate the range of the actions that could be taken to reduce emissions, have been updated to reflect new evidence and include latest available information. We have also revised the insights we draw from those four scenarios to provide further detail on the implications of each.

Where Aotearoa New Zealand's emissions are heading

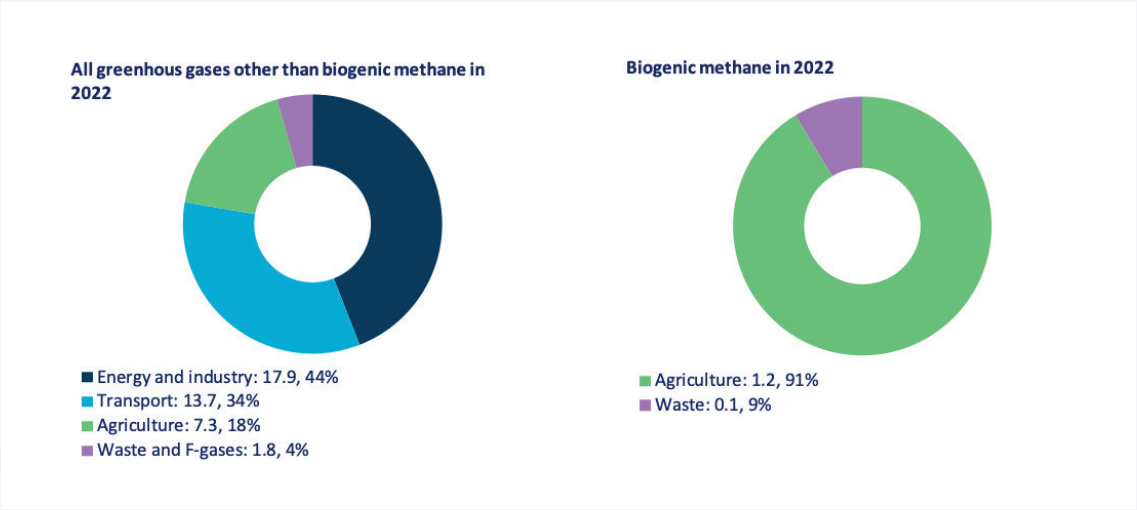
Aotearoa New Zealand's current emissions profile

The latest GHG Inventory data published by the Ministry for the Environment in 2024 shows that Aotearoa New Zealand reduced its gross greenhouse gas emissions between 2021 and 2022.[15] According to Stats NZ, that pattern of reduced emissions has continued to 2023, with total industry and household emissions decreasing by 1.8% from 2022 to 2023.[16] The GHG Inventory shows that in 2022, biogenic methane emissions totalled 1.3 $MtCH_4$, with gross emissions of all greenhouse gases other than biogenic methane equalling 40.7 $MtCO_2e$ (**Figure 4.1**).

In Aotearoa New Zealand, most biogenic methane emissions (approximately 91%) come from agriculture, primarily from ruminant livestock such as cows and sheep. The remainder (approximately 9%) come from the decay of organic waste.

More than three-quarters of long-lived greenhouse gas emissions come from transport, energy and industry, mainly through the burning of fossil fuels in vehicles, factories and homes. Close to 20% come from agriculture, mainly nitrous oxide emissions caused by livestock urine and fertiliser use. The remainder come from f-gases (which are commonly used as refrigerants), wastewater treatment, and the burning of waste.

Figure 4.1: Aotearoa New Zealand's emissions of all greenhouse gases other than biogenic methane ($MtCO_2e$, %), and biogenic methane ($MtCH_4$, %) in 2022



Source: Commission analysis of data from the 2024 edition of the GHG Inventory

Current policy is not on track to reach the 2050 target

Our analysis in this report draws on a reference scenario that allows comparison of our EB4 demonstration path to current policies and measures. Our reference scenario draws on the latest available information (see **Box 4.1**).

The reference scenario suggests gross emissions of all greenhouse gases other than biogenic methane will reduce by 27% by 2040 and 37% by 2050 from 2022 levels (**Figure 4.2**). The main contributors to this reduction in gross emissions come from energy – where increasing use of renewable energy for process heat is expected to reduce emissions, and transport – where take up of EVs is projected to reduce emissions.

As a result of 928,000 hectares of afforestation projected to 2050 in the reference scenario, removals of carbon dioxide by forests are projected to increase from 5 $MtCO_2e$ in 2022 to 22 $MtCO_2e$ in 2050.

This suggests that Aotearoa New Zealand would be off track to meet net zero emissions of all greenhouse gases (except biogenic methane) by 2050, not reaching net zero until 2062.[xvii]

xvii This is consistent with the findings from the Commission's first emissions reduction monitoring report which found that available emissions data and projections are consistent with the first emissions budget being met (though there are risk factors such as deforestation levels, dry years and rising transport emissions). However, there are significant risks to meeting the second and third emissions budgets and the 2050 target under current policies.

Box 4.1: Updates to our reference scenario

This reference scenario was developed based on the latest available information from government agencies as of 23 August 2024.

This includes the updated 2024 government projections for energy, transport, and fluorinated gases, which were used as inputs for analysis in the Government's second emissions reduction plan expected to be released before 31 December 2024.*

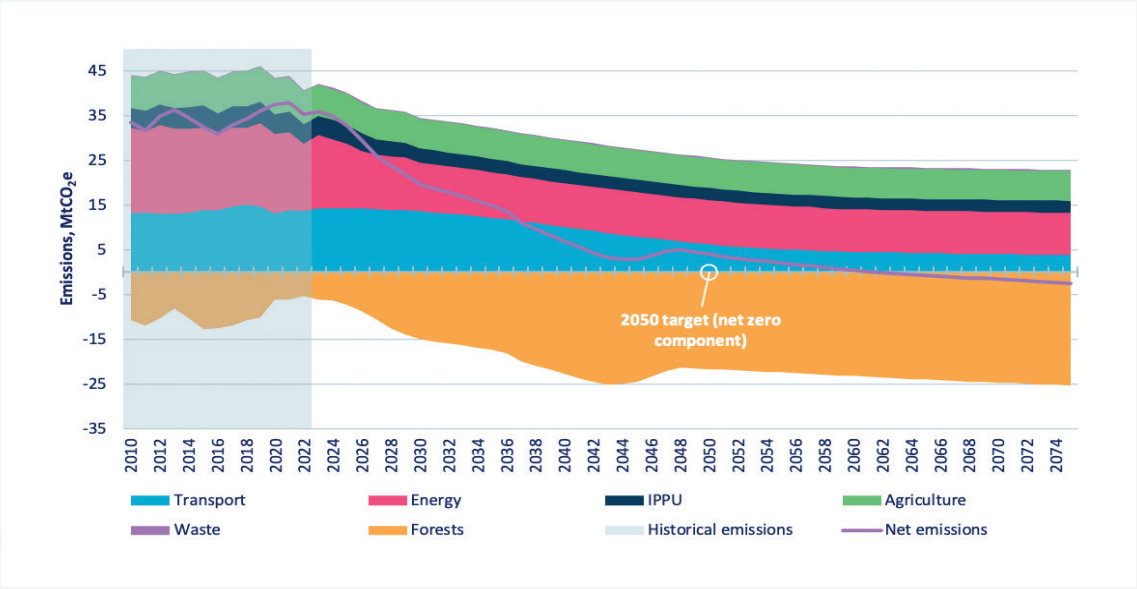
Updated 2024 projections were not available by 23 August 2024 for the agriculture, forestry and waste sectors. For these sectors we have used the Government's July 2024 interim emissions projections, published in the Government's draft second emissions reduction plan released for consultation over the period of 17 July – 25 August 2024.

There may be differences between the Government's projections that are released through publication of the second emissions reduction plan and the reference scenario we used for the analysis to create this advice. In this advice, the reference scenario provides a counterfactual for analysing impacts associated with the recommended level of emissions reductions. This would be a problem if there were a significant difference between our reference scenario and the Government's projections released as part of the second emissions reduction plan. We do not expect the difference between government projections and the reference scenario used to create this advice will be large enough to change our assessment of the overall impacts of the recommended budget.

More information on the reference scenario is provided in the supporting *Technical Annex: Modelling and analysis to support final advice on Aotearoa New Zealand's fourth emissions budget and the review of the 2050 emissions target including whether emissions from international shipping and aviation should be included* and related assumptions logs. These are available on the Commission website: https://www.climatecommission.govt.nz/our-work/advice-to-government-topic/preparing-advice-on-emissions-budgets/advice-on-the-fourth-emissions-budget/modelling-and-data-final-report

*Note that the fluorinated gas projection subset is the only component of energy and industry projections used directly in formulating the reference scenario.

Figure 4.2: Emissions of all greenhouse gases other than biogenic methane by sector in the reference scenario[xviii,xix]



Source: Commission analysis

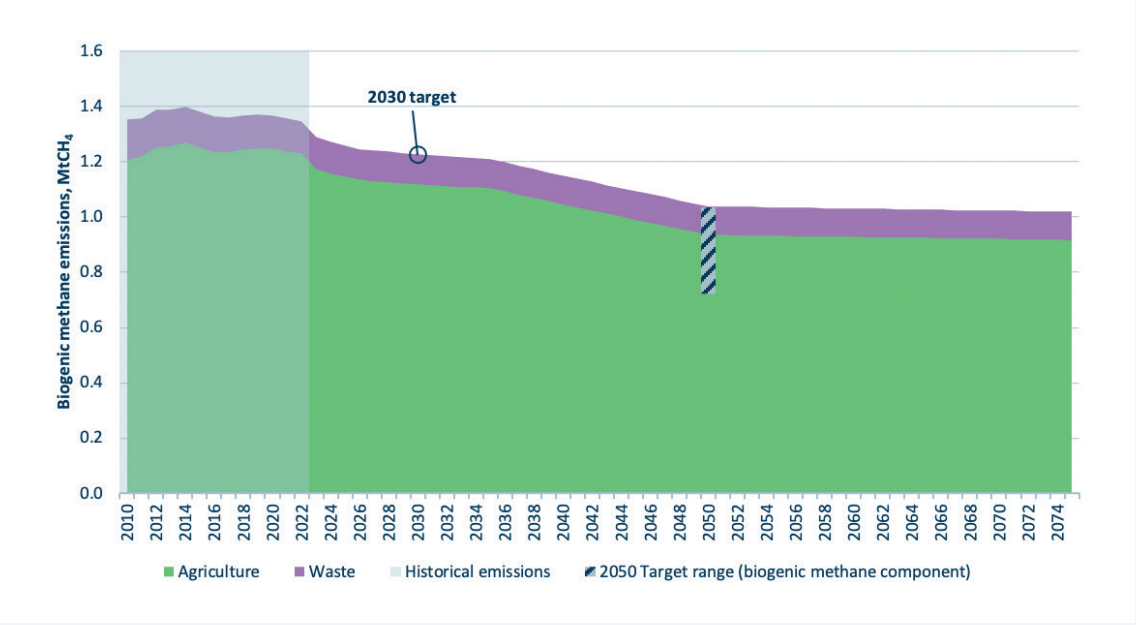
Reductions in biogenic methane in the reference scenario are the result of improvements in agricultural production efficiency, reductions in stock and land-use change away from ruminant livestock. At the level of reductions in this scenario, Aotearoa New Zealand would just reach the minimum 24% reduction in the biogenic methane component of the 2050 target (**Figure 4.3**).

It is important to note that achieving the 2050 target will require Aotearoa New Zealand to meet both the net zero component and the biogenic methane component of the target.

xviii In this advice we have included f-gases as part of industrial processes and product use (IPPU).

xix We have extended the timelines to 2075 to show the estimated impact of current policies beyond the 2050 target. There is uncertainty beyond 2050 as government projections do not always go beyond this year, for example afforestation projections from the Ministry for Primary Industries (which we have held constant at the 2050 value).

Figure 4.3: Emissions of biogenic methane by sector in the reference scenario



Source: Commission analysis

Assessing opportunities to reduce and remove emissions

To advise on the level of an emissions budget, we reviewed our prior demonstration path and updated this with the latest information and evidence available on emissions reductions and removals. For the fourth emissions budget, this means updating our demonstration path from *Ināia tonu nei*. Our advice on later emissions budgets will require further updates to our demonstration path.

To support our advice on the fourth emissions budget, we conducted research across sectors of the economy to understand the actions that Aotearoa New Zealand can take to reduce emissions to meet the 2050 target and contribute to global effort to limit warming to 1.5°C. In assessing opportunities for emission reductions we have considered what could be achieved though the Government implementing clear and stable policies and actions that are consistent with the purpose of the Act.

Our research has built on the existing evidence base developed to support our advice on the first three emissions budgets. This evidence base has been enhanced by feedback through consultation and discussions with stakeholders across a range of sectors and groups.

For each action to reduce emissions, we have considered a range of factors that influence their potential to contribute to emissions reductions. These include:

- the technical potential to adopt the action
- the action's feasibility for deployment in Aotearoa New Zealand
- the costs – and how these are expected to change
- the benefits – both direct and wider co-benefits
- interactions with other actions that could be taken
- broader impacts including consideration of perspectives from mātauranga Māori.

We have considered actions which reduce emissions that involve adopting lower emissions technologies to existing processes. We have also considered actions that involve changes to systems, processes and behaviours. In practice many of the actions we have identified would involve a combination of adopting different technologies and changes to systems, processes or behaviours.

In arriving at our scenarios we have considered how the 2050 target can be met and maintained beyond 2050. This includes considering the pace of change and the level of emissions before 2050. Our scenarios show progressive reductions in emissions over time as actions that reduce emissions are taken up.

Evidence on actions has been drawn from both domestic and international sources. We have sought to supplement the available evidence by commissioning new research for some actions that we assessed would be important to consider when advising on the fourth emissions budget. These included a review of potential on-farm mitigations for agricultural emissions and mitigations for decarbonising process heat for industry. The reports for these pieces of research are published alongside this advice.

We tested this range of actions through public consultation. This resulted in some changes to our assumptions where new evidence was provided on the feasibility, cost, impacts or technical potential to adopt the action.

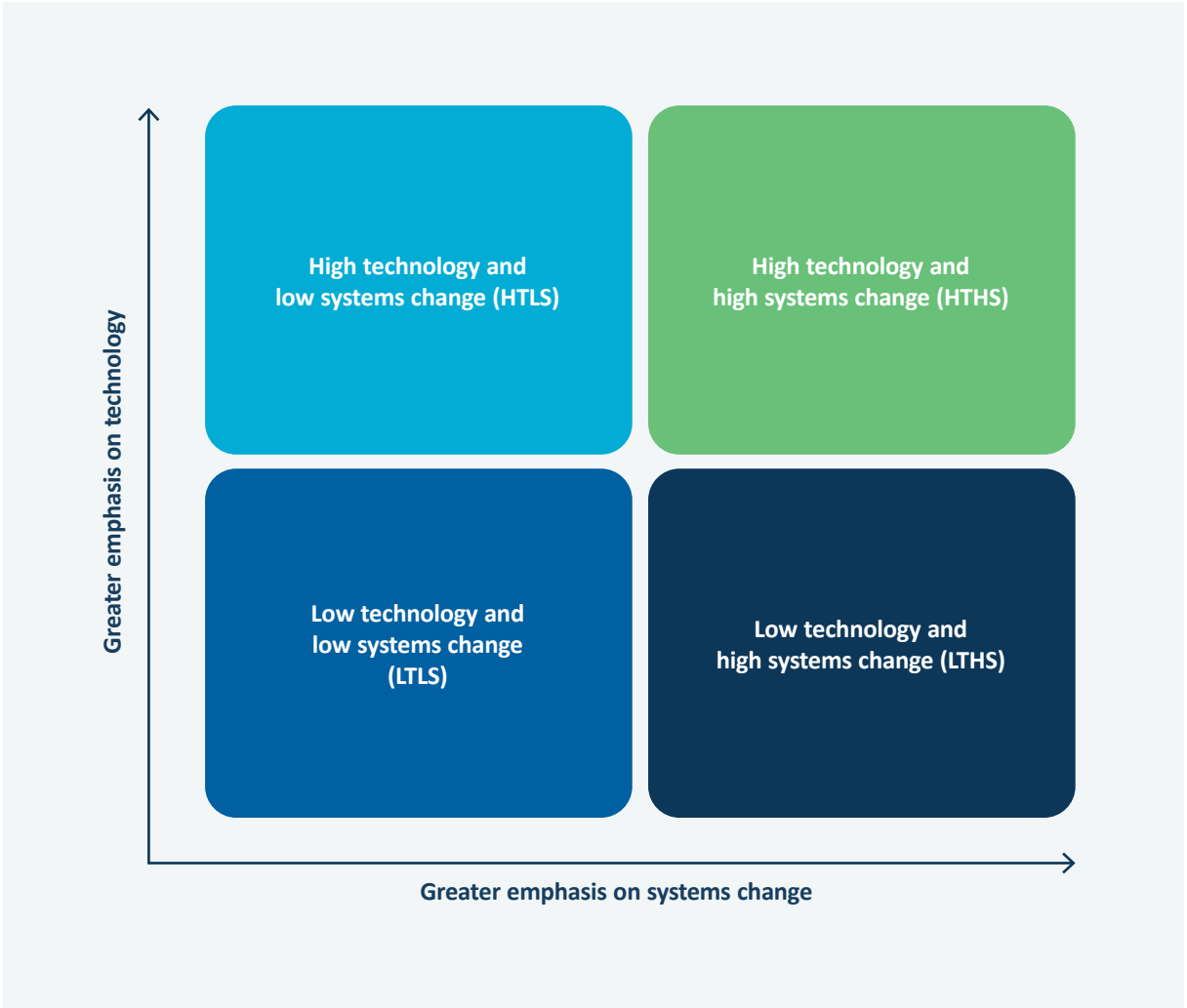
Understanding different pathways to 2050 through scenario analysis

Our 2050 scenarios show what is possible to reach the 2050 target

We developed a set of scenarios to demonstrate the range of actions that could be taken to reduce emissions, using dimensions of technology and systems change across sectors of the economy. This analysis focuses on what's possible rather than defining an optimal mix of actions. The scenarios were designed to understand different ways in which Aotearoa New Zealand could achieve the 2050 target and contribute to the global effort to limit warming to 1.5°C above pre-industrial levels.

Figure 4.4 shows the structure of our scenarios, and they are explained in more detail below.

Figure 4.4: Updated scenario structure



Source: Commission analysis

We have made one key change to the scenario structure we used for this advice compared to the scenario structure presented in *Ināia tonu nei*. We have changed the horizonal axis to "systems change" instead of "behavioural change". The former is inclusive of the latter. With a view to achieving a low emissions economy, "systems change" also reflects that it is possible to change fundamentally the type of good or service produced or drastically reduce life cycle emissions from traditionally high emitting activities. High systems changes may also offer significant co-benefits such as cleaner air and water or better public health outcomes. Examples of high systems change actions include higher rates of conversion of marginal and erosion-prone land to native forests, and higher rates of modal shift to public and active transport.

Low technology and low systems change scenario

In this scenario, Aotearoa New Zealand would minimise societal shifts by focusing on emissions reductions for each activity through proven technology options. Key examples of this are relying on electric vehicles to reduce emissions from light vehicle transport and adoption of low methane breeding for ruminant livestock.

High technology and low systems change scenario

In this scenario Aotearoa New Zealand would reduce emissions through adoption of new and emerging technologies while minimising societal shifts. This includes partial conversion of steel production to green hydrogen and adoption of green anodes for aluminium production. For agriculture this would mean introduction of methane-reducing technologies (modelled as a vaccine) to reduce biogenic methane emissions.

Low technology and high systems change scenario

In this scenario, Aotearoa New Zealand would embrace an approach to long-term emissions reductions where societal shifts play a more prominent role in reducing emissions, such as greater use of public and active transport. Compared to the low systems change scenarios, this scenario also scales up native afforestation on marginal and erosion-prone land, further reductions in stocking rates, higher levels of land-use change from dairy to horticulture, and further waste avoidance (including waste from food, gardens and paper products).

High technology and high systems change scenario

This scenario implements both new and emerging technologies and systems shifts with significant co-benefits. In this scenario, there is a faster reduction in costs for EV batteries, which drives greater adoption of electric vehicles earlier, including trucks, public ferries and small aircraft. This scenario also includes introduction of methane-reducing feed additives for dairy cows and higher diversion of organic waste from landfills to anaerobic digestion (energy recovery).

While the high technology and high systems change scenario (HTHS) is the scenario with the highest level of technological and structural change in our analysis, it does not represent the limit to what emissions reductions are possible for Aotearoa New Zealand. Further net emissions reductions would be possible, but may involve adopting higher cost technologies or be dependent on technology innovations, larger dependence on behaviour or system changes, or require greater land-use change into forestry.

For examples of high technology and high systems changes by sector, see **Table 4.1**.

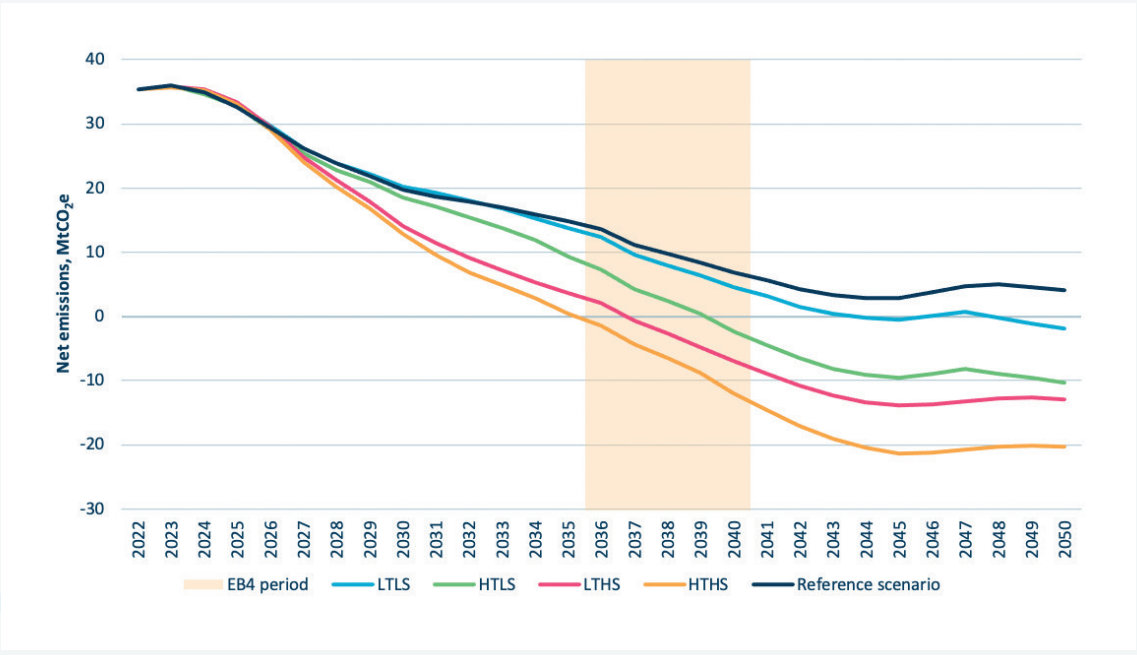
Table 4.1: Examples of high technology and high systems changes by sector

Sector	High technology change examples	High systems change examples
Transport	Faster adoption of battery electric trucks, faster reduction in EV battery costs, rapid deployment of public charging infrastructure, earlier adoption of electric small aircraft, quicker electrification of public ferries and coastal shipping.	Reduction in air travel demand, greater mode shift to active and public transport.
Energy	Faster cost reduction for building new renewable electricity generation, upgrade of the Kinleith pulp and paper mill, featuring a high efficiency recovery boiler.	Faster fossil gas phase out – by 2045 for process heat and by 2050 for buildings, reduced demand for heating from faster rates of retrofit.
IPPU (industrial processes and product use)	Deployment of green-hydrogen-based steel production, deployment of green anodes for aluminium, faster electrification of compressors in urea production.	Further transition to scrap-steel-based production, on the assumption that this is enabled by the electric arc furnace project along with improved scrap steel collection, faster phase out and better recovery of f-gases.
Agriculture	Methane reduction technologies for dairy/sheep/beef, greater ambition for low-methane genetics for sheep, inclusion of genetics for dairy.	Greater reductions in stocking rates, further land-use change to horticulture and forests, further reductions in nitrous oxide use, all urea coated with urease inhibitor.
Waste	Greater organic waste to anaerobic digestion, increased landfill gas capture efficiency.	Greater composting, greater waste avoidance, increased landfill gas infrastructure.
Forests	No change from LTLS scenario.	Retire pastoral (sheep and beef) land classed as land use capability (LUC) 8 to native. Likewise for erosion-prone LUC 7 pastoral land. Exotic afforestation on some sheep and beef land.

Key insights from scenarios for all greenhouse gases other than biogenic methane

Scenario results for all greenhouse gases other than biogenic methane alongside the reference scenario are shown in **Figure 4.5**. All four scenario pathways are consistent with meeting this component of the 2050 target. The assumptions in these scenarios build on one another. In this section we detail scenario insights by comparing the LTLS to the reference scenario, then look at the difference between the LTLS and HTHS. The full set of assumptions across each scenario can be found in the assumptions logs published on our website.

Figure 4.5: Scenario results for net emissions of all greenhouse gases other than biogenic methane



Source: Commission analysis

Insights from LTLS

Net zero emissions of long-lived gases is first achieved in 2044, but net emissions are positive in some subsequent years. In 2050 there are approximately 18 $MtCO_2e$ of residual gross emissions, noting these are balanced out by about 20 $MtCO_2e$ of removals by forests. Emissions for this scenario in 2050 are illustrated in **Figure 4.6**, alongside comparisons to the reference scenario, HTHS and a 2022 baseline.

Key drivers of emissions reductions in this pathway, relative to the reference scenario, include:

- increasing renewable electricity generation[xx] by 68% by 2040 (from 2022 levels, 29% increase for reference scenario), and expanding geothermal carbon capture and reinjection technologies[xxi]
- phasing out fossil gas in process heat, industrial processes, and space and water heating, by 2050
- decarbonising road transport through electrification, for example in 2040 EVs are a 50% share of light passenger vehicle travel, a 13% share of medium trucks and a 50% share of buses (compared to 38%, 7% and 25% respectively in reference scenario)
- higher planting levels for native forests (an average of 15,000 ha between 2022–2040, compared with 1,600 ha in the reference scenario).
- lower planting levels for exotic forests (an average of 26,000 ha between 2022–2040, compared with 33,000 ha in the reference scenario).[xxii]

Compared to the other scenarios, the LTLS scenario implies a slower transition with less change to current ways of producing and consuming goods, while drawing on technology and systems changes that are available today.

The implications of this scenario would be:

- higher residual emissions in 2050 than other scenarios which would require either further emissions reductions after 2050 or greater continued removals to maintain net zero beyond 2050
- it only just meets the net zero target therefore there is greater chance that the target would not be achieved if some actions do not deliver the expected emissions reductions.

Insights from HTHS

Further and faster action in this pathway would mean reaching net zero all greenhouse gases other than biogenic methane by 2036. There would be about 8 $MtCO_2e$ of residual emissions in 2050, balanced out by nearly 28 $MtCO_2e$ of removals by forests. See **Figure 4.6** for a comparison of emissions in this scenario in 2050 to those in LTLS, the reference scenario and a 2022 baseline.

xx not including co-generation
xxi to Ōhaaki field and 50% of new fields
xxii Table 4.2 provides a further breakdown of afforestation in this pathway.

Key drivers of emissions reductions in this scenario, relative to LTLS, include:

- a further 19% of renewable electricity generation by 2040, up from 68% in LTLS, and further expansion in geothermal carbon capture and reinjection[xxiii]
- phasing out fossil fuels in process heat by 2045 and coal in cement production by 2030
- further effort to decarbonise industrial processes including deployment of zero carbon anodes in aluminium production, and green hydrogen for 25% of steel production
- higher share of EVs in fleet for 2040, including 70% for light passenger vehicles, 30% for medium trucks and 67% for buses (50%, 13% and 50% respectively in LTLS)
- additional effort to avoid emissions of f-gases (beyond action required by the Kigali Amendment)
- higher annual average afforestation in the period of 2022–2040, for exotics (31,000 ha versus 26,000 ha in LTLS) and natives (50,000 ha versus 15,000 ha in LTLS).

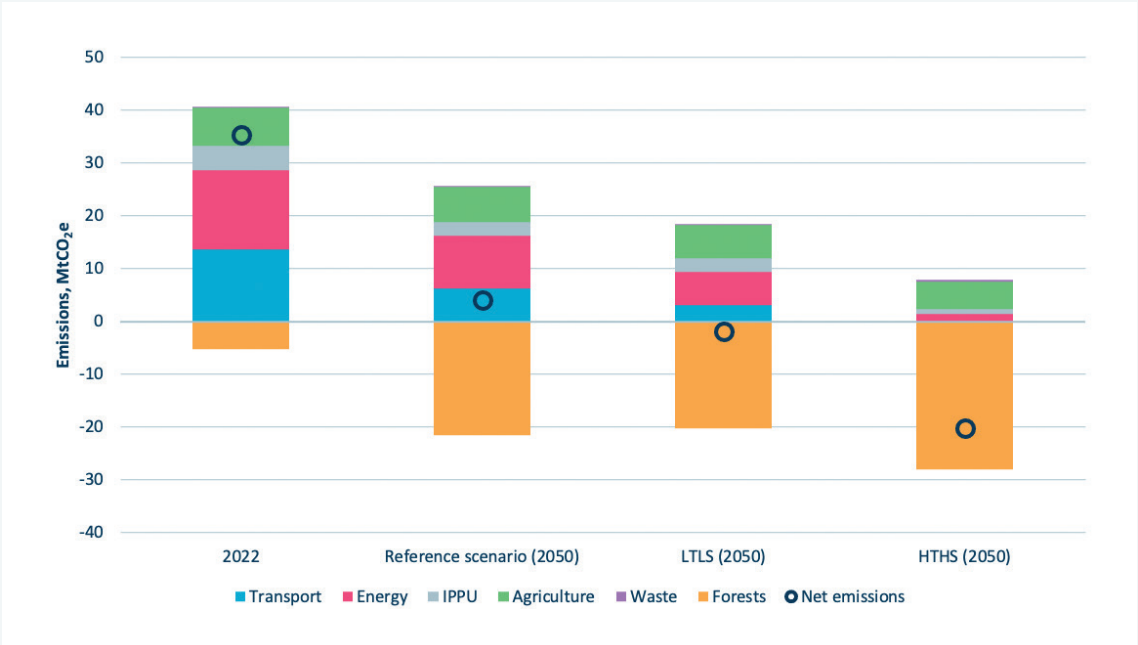
Compared to LTLS, this pathway implies faster and more ambitious emissions reductions across sectors. This includes more optimistic assumptions on technology, including some that are not yet available and others that could come at relatively high marginal abatement costs. This scenario would also involve greater system changes such as moving to higher use of public transport and increased land-use change to native forests. **Table 4.2** shows the levels of afforestation for the HTHS and LTLS scenarios in comparison to the reference scenario.

The implications of this scenario would be:

- residual emissions would be lower than other paths with remaining emissions coming from the agricultural sector and hard-to-abate industrial emissions
- greater gross emissions reductions, combined with increased removals, mean that net emissions would be substantially below net zero by 2050.

xxiii 100% of new fields and 83% of existing fields

Figure 4.6: Scenario results for all greenhouse gases other than biogenic methane in 2050 by sector in comparison to 2022



Source: Commission analysis

Table 4.2: Comparing levels of afforestation for lowest (LTLS) and highest (HTHS) ambition scenarios and the reference scenario

Scenario	Type of afforestation	Land area afforested from 2022–2050 (in thousands of hectares)
Low technology and low systems change (LTLS) (lowest ambition scenario)	Exotic	706
	Native	444
High technology and high systems change (HTHS) (highest ambition scenario)	Exotic	711
	Native	1,512
The reference scenario (current trajectory)	Exotic	894
	Native	35

Key insights from our scenarios for biogenic methane

Scenario results for biogenic methane are shown in **Figure 4.7**. All four of our pathways are consistent with meeting this component of the 2050 target. In this section we focus our analysis on the lowest ambition (LTLS) and highest ambition (HTHS) scenarios. **Figure 4.8** shows a breakdown of biogenic methane emissions by sector in 2050, including comparisons to the reference scenario and 2022 emissions.

Insights from LTLS

This scenario achieves a 24% reduction in biogenic methane emissions compared to 2017 levels. This is the lower end of the biogenic methane target range. Key drivers of emissions reductions in this pathway, relative to the reference scenario, include:

- further reduction in dairy herd size from 2022–2040 (8% compared to 6%)
- conversion of 3% of dairy land, or approximately 2,900ha per annum from 2022–2040, to lower emissions uses (compared to no change in dairy land area in the reference scenario)
- higher uptake and efficacy of low-methane breeding for dairy cows.

Compared to the higher ambition scenarios, LTLS just meets the current biogenic methane component of the 2050 target without adoption of new methane reducing technologies, such as methane vaccines and inhibitors. This scenario also has less of an impact on production levels and revenue for dairy. This scenario assumes similar levels of reductions in sheep and beef stock and stocking rates as the reference scenario, reflecting current trends and policies.

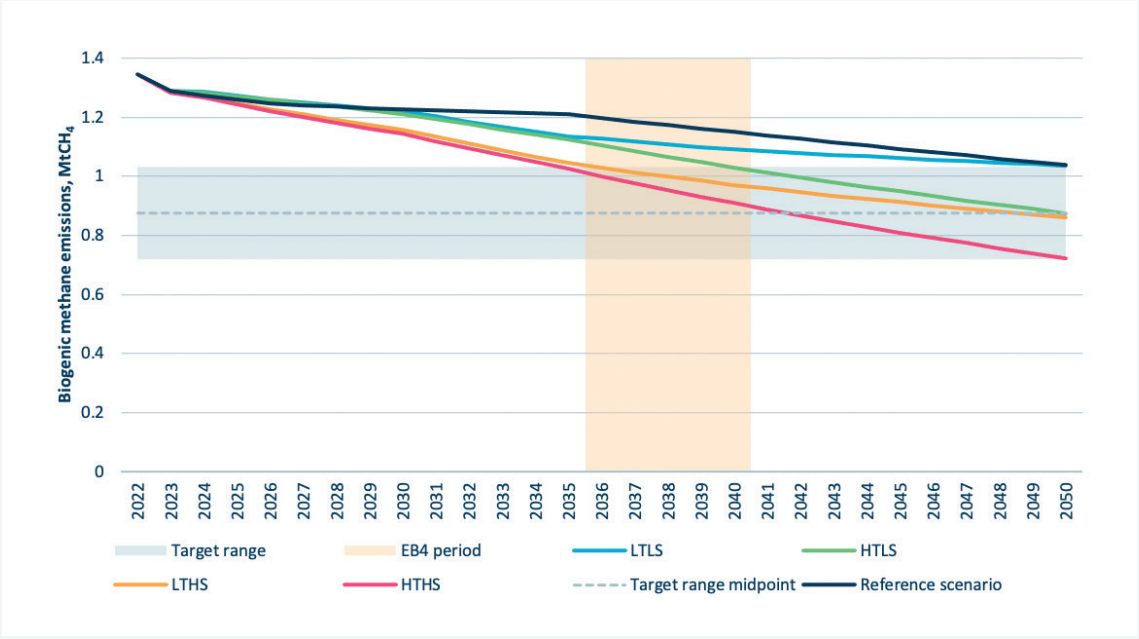
Insights from HTHS

We estimate that actions in this scenario could achieve the higher end of the biogenic methane target range (a 47% reduction from 2017 levels). Key drivers of further emissions reductions in this pathway, when compared to LTLS in 2040 include:

- further reductions in dairy stock and stocking rates (10% and 7% respectively)
- further reductions in sheep and beef stock unit numbers and stocking rates (12% and 2%, respectively)
- higher conversion of land from ruminants to lower emission uses (11% further reduction in sheep and beef land and 3% further reduction in dairy land)
- deployment of methane vaccines from 2035, and methane inhibitors from 2030
- greater diversion of organic waste from landfills, and higher efficiency and coverage for landfill gas capture.

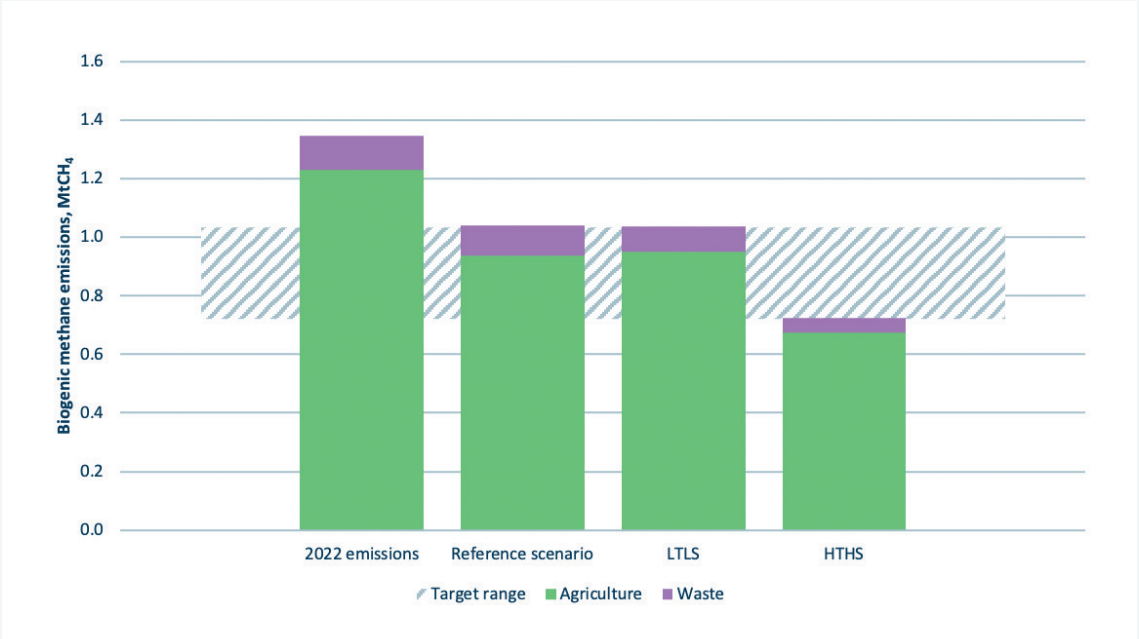
This scenario demonstrates that the highest ambition end of the target range can be met through a combination of reductions in stock and stocking rates, land-use change and deployment of new methane reducing technologies. It would result in lower levels of production and revenue from ruminant livestock, with potentially further stock reductions required if new methane reducing technologies are not available in projected timelines and efficiencies. While there would be new revenue opportunities for low emissions land uses, including horticulture and forestry, there could be substantial impacts on farmers with interests in dairy, sheep and beef.

Figure 4.7: Scenario results for biogenic methane



Source: Commission analysis

Figure 4.8: Scenario results for biogenic methane in 2050 by sector



Source: Commission analysis

The EB4 demonstration path

We have used the insights we have drawn from the scenarios to develop the EB4 demonstration path – a pathway for how Aotearoa New Zealand could meet the fourth emissions budget. The EB4 demonstration path is one set of measures and actions across sectors that would deliver our recommended emissions budget.

The remainder of this chapter sets out the emissions outcomes from following this path – along with sensitivity analysis of the EB4 demonstration path. Further details on assumptions and results for each sector are presented in *Chapter 5: Sector contributions to meeting the fourth emissions budget*.

Developing the EB4 demonstration path

To develop the EB4 demonstration path, we have considered the speed at which options may feasibly be deployed to reduce emissions. For many actions we have assumed levels of adoption near the midpoint of the assumptions made in the scenarios. However, for some mitigations where there is evidence to support adopting more ambitious uptake or where the economic costs are judged to be low, our assumptions in the EB4 demonstration path are closer to the high end of what is technically feasible. **Box 4.2** has more detail on how we have selected actions in the EB4 demonstration path.

We also presented a demonstration path in *Ināia tonu nei* for how the first three emissions budgets could be met. The EB4 demonstration path differs from the previous demonstration path to reflect a number of changes since that advice. These are:

- updated information and trends (on emissions, potential mitigations/actions to reduce emissions)
- changes to previous assumptions due to new evidence (since our analysis from *Ināia tonu nei*)
- updates to the Greenhouse Gas Inventory[xxiv]
- updated government projections.

xxiv Updated annually by the Ministry for the Environment

Box 4.2: How we have selected actions in the EB4 demonstration path

Our scenario analysis identified a broad range of possible actions to reduce domestic emissions, including levels of deployment for each scenario. The development of our EB4 demonstration path required the Commission's judgement of what would be ambitious and achievable, provide flexibility for the future, and offer lasting economic, societal and environmental benefits that will likely exceed overall costs. In doing so we considered matters from sections 5M and 5ZC of the Act, including consideration of actions that are ambitious while also being technically and economically achievable.

Not all possible actions for which there is evidence were included in the scenario analysis or EB4 demonstration path. This may be due to uncertainty over the development of some technologies, particularly where there are already existing technologies that could reduce emissions or where evidence suggests high costs of abatement. For example, we have modelled passenger transport transitioning to electric vehicles rather than hydrogen in part due to the technology readiness of EVs, as well as their lower capital cost and higher efficiency compared to hydrogen passenger vehicles. For some technologies, we tested the choices of technologies through our scenarios.

Some examples of potential actions that we have chosen not to include in the EB4 demonstration path are detailed below.

Methane inhibitors

A methane inhibitor is a chemical compound that blocks enzymatic pathways for microorganisms in the gut of ruminant livestock, restricting their ability to produce methane.

3-NOP is a methane inhibitor that is expected to be commercially viable in Aotearoa New Zealand prior to the fourth emissions budget period. This inhibitor is a feed additive that is used alongside supplementary feed for dairy cows. As domestic dairy farms are predominantly pasture-based, this inhibitor is expected to be less effective for reducing methane emissions from domestic dairy production. As such, we have not included it in the EB4 demonstration path.[xxv]

There is also a slow-release bolus[xxiv] methane inhibitor in development that could be better suited to reducing methane emissions from domestic dairy production. The evidence suggests that these may not be available commercially until 2039,[17] which is towards the end of the budget period. As such we have not included this methane inhibitor in our EB4 demonstration path.

Nitrification inhibitors

Nitrification inhibitors are chemical compounds that prevent microorganisms in the soil from producing nitrous oxide (a by-product from the conversion of nitrogen to nitrate). Evidence suggests that nitrification inhibitors are expected to be available commercially as soon as 2025.[18] They are likely to have a relatively high abatement cost compared to mitigations that reduce emissions for other greenhouse gases. As such we have not included nitrification inhibitors in the EB4 demonstration path.

xxv These decisions align with advice that we commissioned from The Agribusiness Group.
xxvi A bolus is a large time-release tablet that stays in the rumen of cattle and sheep

Hydrogen to decarbonise heavy vehicle transport

Battery electric vehicles and hydrogen fuel cells are two options for reducing emissions from heavy vehicles. Hydrogen fuel cells are expected to have higher range and faster refuelling. However, hydrogen fuel cells are an energy-intensive technology and producing green hydrogen via electrolysis would require further expansion of electricity networks that would compete with electricity needs from other sectors.[19] Battery electric vehicles are expected to be three times more energy efficient than hydrogen fuel cell vehicles. As such, the EB4 demonstration path assumes the more energy efficient battery electric vehicles are used for heavy transport. However, such decarbonisation could also be achieved by fuel cell trucks powered by green hydrogen fuel cells.

Decarbonising production of methanol

Methanol is a petrochemical feedstock used to produce a wide range of industrial and consumer products, as well as a fuel used for shipping. Methanol in New Zealand is produced from fossil gas. Methanol production can be decarbonised by using green hydrogen in place of fossil gas, combined with a clean source of carbon dioxide. This creates a product called e-methanol. Green hydrogen is produced by electrolysis of water using renewable electricity.[20] This is known to be an energy intensive process.

Replacing fossil gas with biogas is another potential pathway. Biogas is a mixture of methane, carbon dioxide and other gases produced through anaerobic digestion of organic matter.[21] Our assessment of this option is that while existing facilities can produce biogas, producing methanol would require volumes of biogas that are unlikely to be achieved domestically. Blending is an option, noting this would only be expected to cover a small portion of the feedstock that current production facilities require, and there will be competition for the usage of biogas for other activities.

Through engagement with domestic producers of methanol, we have heard they are still in early stages of investigating these options to decarbonise methanol production. Given current uncertainty regarding the feasibility of these options, we have chosen not to include these in our EB4 demonstration path.

Carbon capture and storage (CCS) and carbon dioxide removal (CDR) technologies

Our EB4 demonstration path includes reinjection of carbon dioxide for geothermal electricity generation. This involves capturing carbon dioxide from geothermal fluids and reinjecting it back into the geothermal reservoirs. These are avoided emissions rather than carbon removals.

Emerging carbon dioxide removal technologies have not been included in our EB4 demonstration path. This is due to their early stages of development, uncertainties about their application in Aotearoa New Zealand and the expected relatively high cost compared with other removal options (such as afforestation).

We cover these technologies in greater detail in *Chapter 5: Sector contributions to meeting the fourth emissions budget*.

Results of the EB4 demonstration path

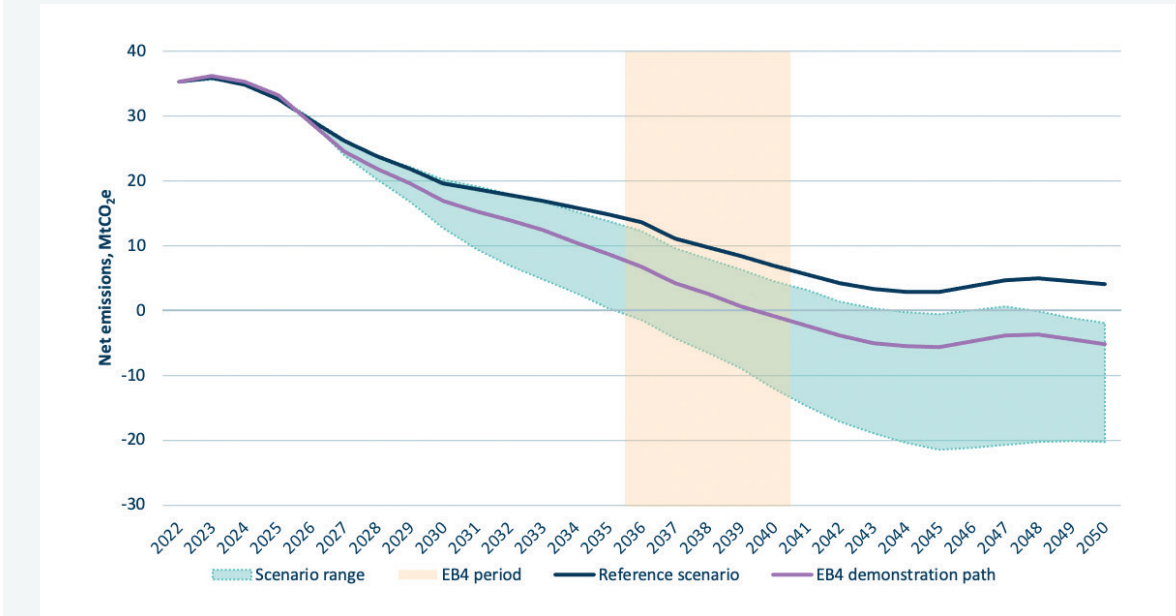
The EB4 demonstration path is shown in **Figure 4.9** and **Figure 4.10** below, alongside the reference scenario. The EB4 demonstration path represents a 25% reduction across the EB4 period (all gases), compared to the level implied by the reference scenario (or 54 $MtCO_2e$ fewer emissions between 2036 and 2040).

Between 2036 and 2040, net emissions of all greenhouse gases other than biogenic methane in the EB4 demonstration path are 36 $MtCO_2e$ lower than the reference scenario. In this same period the EB4 demonstration path has 1 $MtCO_2e$ fewer carbon dioxide removals by forests than the reference scenario (103 vs 104 $MtCO_2e$). Gross emissions reductions are driving the reduction in net emissions of all greenhouse gases other than biogenic methane, with a total reduction of 37 $MtCO_2e$. We estimate that 21 $MtCO_2e$ of these reductions of gross emissions would come from transport, with energy contributing a further 14 $MtCO_2e$.

In the EB4 demonstration path, net emissions of all greenhouse gases other than biogenic methane reduce by 41 $MtCO_2e$ from 2022–2050. Gross emissions of all greenhouse gases other than biogenic methane reduce by 26 $MtCO_2e$, a reduction of 64%. In this same period, biogenic methane emissions reduce by 0.50 $MtCH_4$, a 37% reduction.

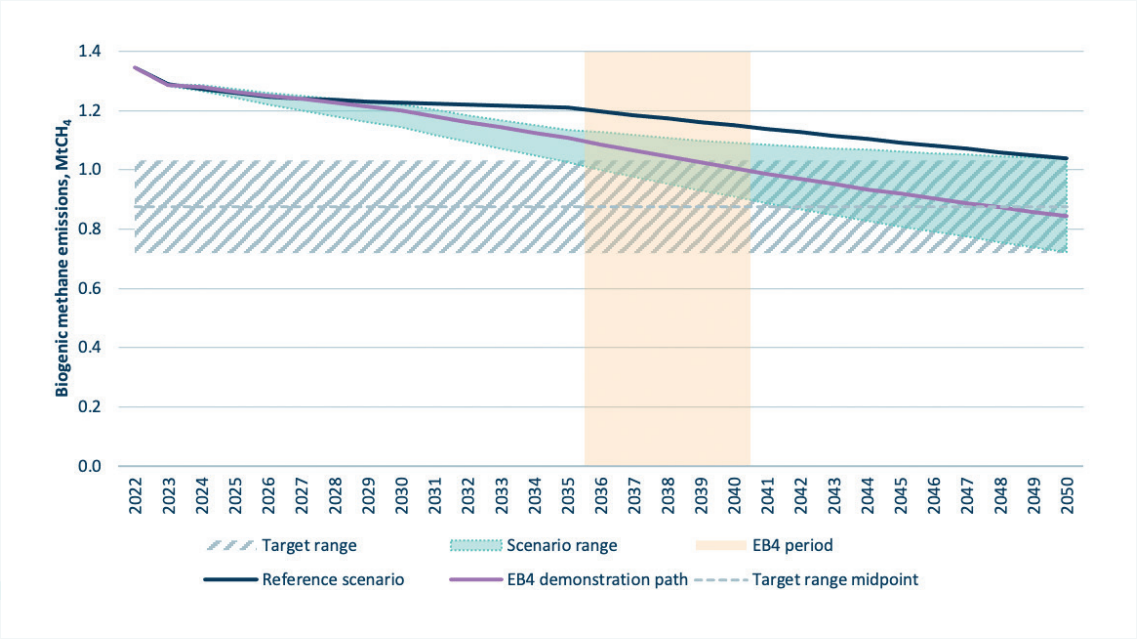
Emissions of biogenic methane across the fourth emissions budget period are 0.65 $MtCH_4$ lower in the EB4 demonstration path than the reference scenario, or 11% lower. Agriculture emissions are 10% lower in the EB4 demonstration path and waste emissions are 19% lower.

Figure 4.9: The EB4 demonstration path to 2050 for net emissions of all greenhouse gases other than biogenic methane



Source: Commission analysis

Figure 4.10: The EB4 demonstration path to 2050 for biogenic methane

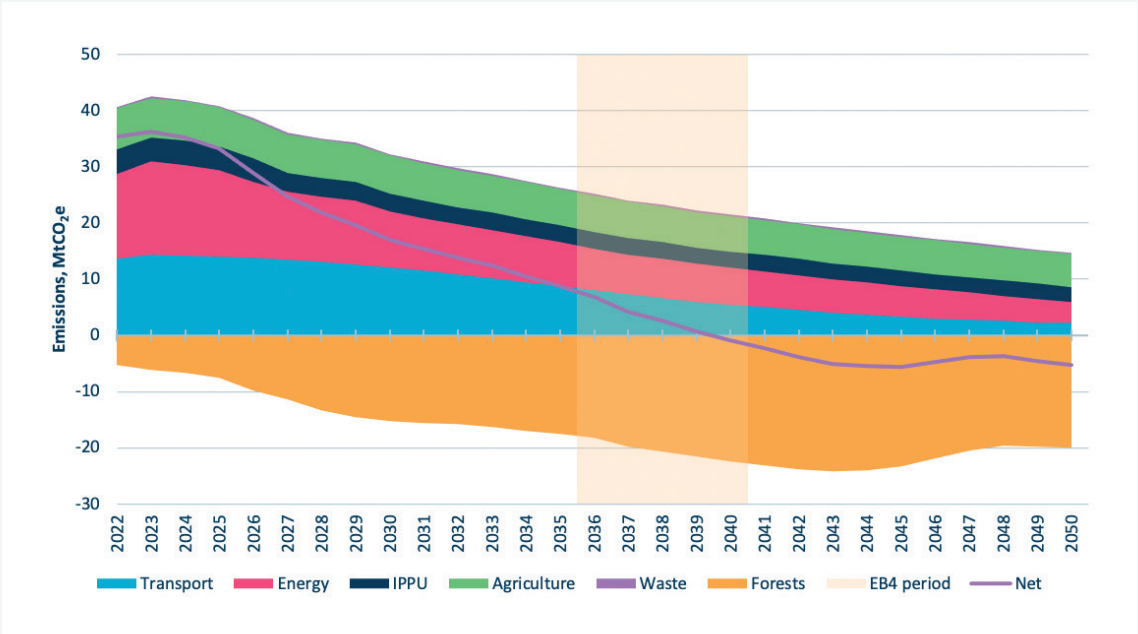


Source: Commission analysis

Summary of sector contributions to the EB4 demonstration path with emissions reductions to 2050

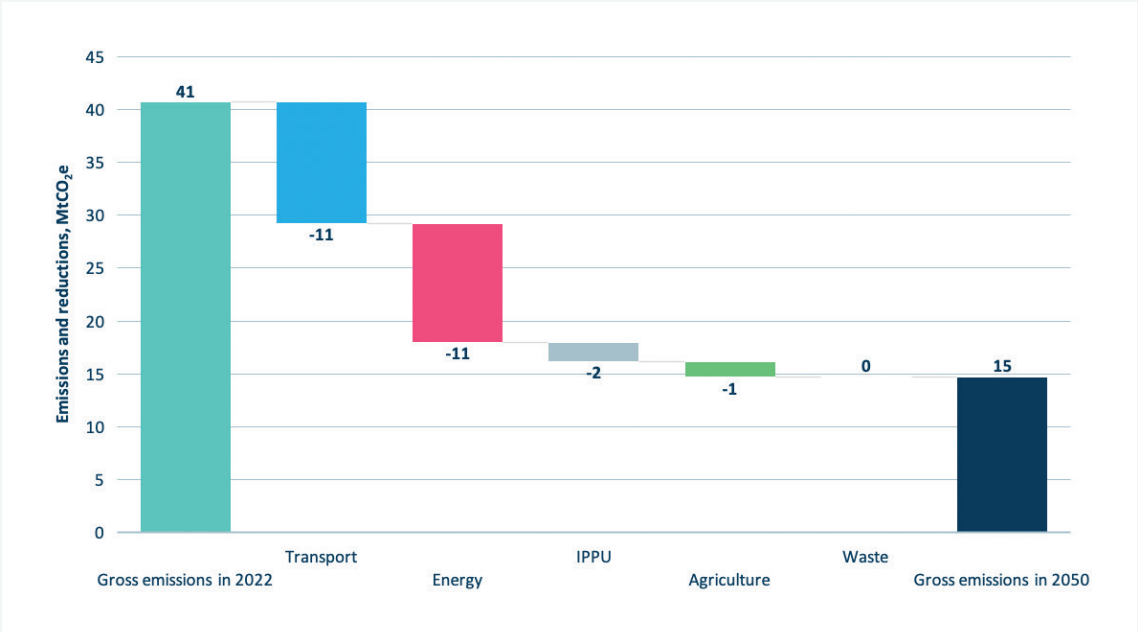
Figure 4.11 shows emissions of all greenhouse gases other than biogenic methane in the EB4 pathway by sector to 2050. In 2050, gross emissions of all greenhouse gases other than biogenic methane decrease to 15 $MtCO_2e$ from 41 $MtCO_2e$ in 2022. The transport and the energy sectors have the greatest reductions in emissions in 2050 (11 $MtCO_2e$ each). A full breakdown of emissions reductions by sector to 2050 is in **Figure 4.12**. Annual carbon dioxide removals from forestry increase by 15 $MtCO_2e$ between 2022 and 2050.

Figure 4.11: Emissions of all greenhouse gases other than biogenic methane by sector to 2050 in the EB4 demonstration path



Source: Commission analysis

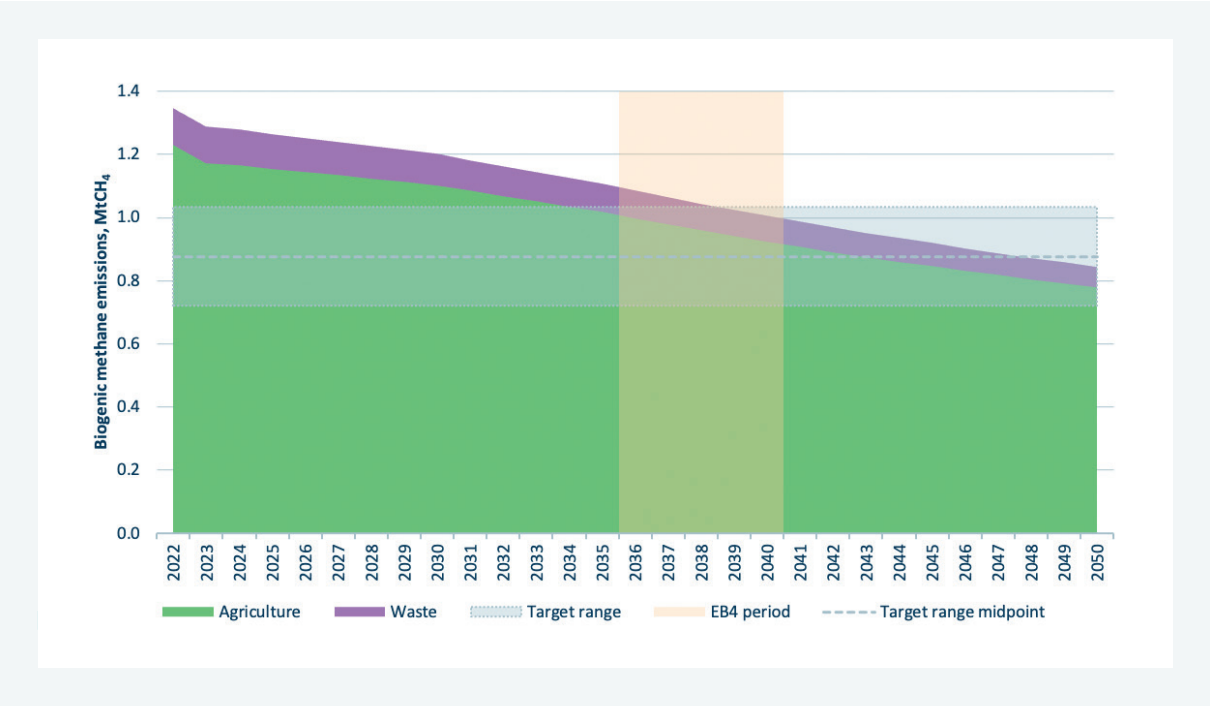
Figure 4.12: Gross emissions of all greenhouse gases other than biogenic methane in 2022 with reductions by sector by 2050 in the EB4 demonstration path



Source: Commission analysis

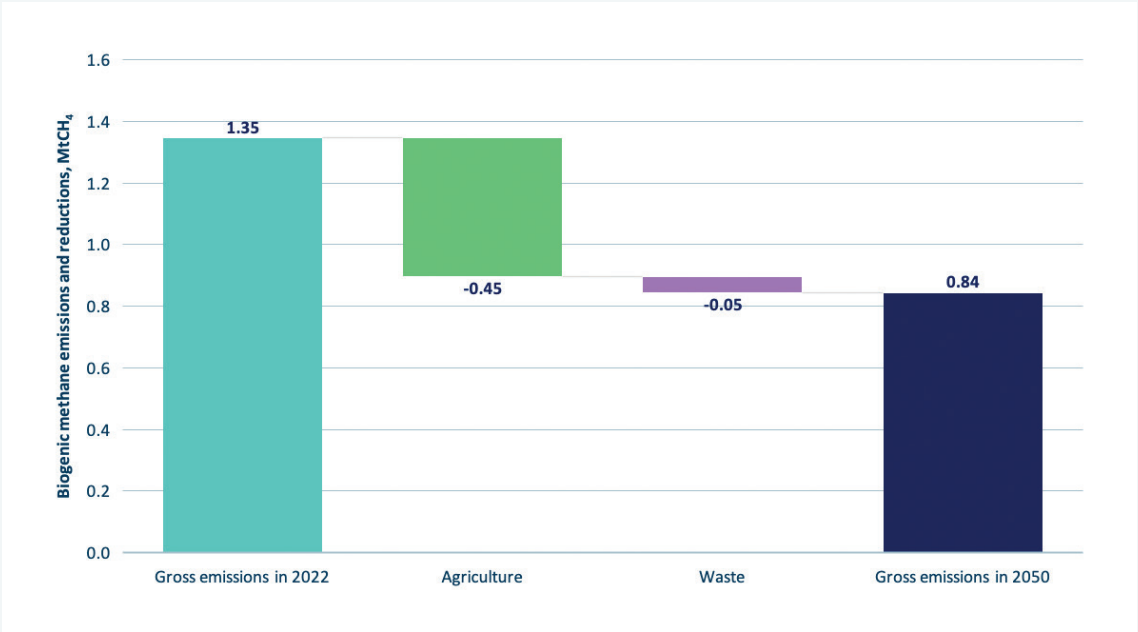
Figure 4.13 shows gross emissions of biogenic methane by sector, which reduce from 1.35 $MtCH_4$ in 2022 to 0.84 $MtCH_4$ in 2050. Between 2022 and 2050 waste sector emissions decrease by 44% (-0.05 $MtCH_4$), in addition to a 37% reduction for the agriculture sector (-0.45 $MtCH_4$) (**Figure 4.14**).

Figure 4.13: Emissions of biogenic methane by sector to 2050 in the EB4 demonstration path



Source: Commission analysis

Figure 4.14: Gross emissions of biogenic methane in 2022 and 2050 with sector reductions in the EB4 demonstration path



Source: Commission analysis

Further information on the assumptions that sit behind these values by sector can be found in *Chapter 5: Sector contributions to meeting the fourth emissions budget*.

We have undertaken sensitivity analysis to test how key uncertainties could impact the ability to meet our recommended fourth emissions budget

We have tested how some key uncertainties might impact Aotearoa New Zealand's ability to meet the recommended budget, i.e. where future trends or events could vary emissions from current estimates.

'Sensitivity analysis' is a standard process when using complex models to check what would happen if key factors were different from the assumptions made.

In this case, it allows us to assess real world risks to meeting the budget. As such, it is a critical step in demonstrating that the recommended budget level is achievable. This analysis also builds understanding of potential opportunities to reduce emissions further than modelled in the EB4 demonstration path.

The areas we tested are those expected to make a big difference if they changed, as well as areas of strong interest when we consulted on our draft advice. A complete list of factors and events tested in our sensitivity analysis is in the *Technical annex* published on our website.

In some cases, testing showed little effect on overall emissions reductions in the fourth emissions budget period (2036–2040). In other cases, small variations in particular factors had a large impact on emissions, meaning they could have a major effect on the country's ability to achieve the recommended emissions budget level. This information has been used to guide our overall advice, which provides Aotearoa New Zealand with a path to the country's 2050 emissions reduction target in a way that allows for the uncertainty that accompanies all future planning.

Figure. 4.15 shows the impact each of these factors has on the fourth emissions budget period. **Box 4.3** shows results of sensitivity analysis from C-PLAN, our Computable General Equilibrium (CGE) model that estimates overall economic impact of the recommended budget.

Summary of factors tested for sensitivity

Afforestation rates

In our EB4 demonstration path, forests, both native and exotic, play an important role in removing carbon from the atmosphere. We tested the sensitivity of our path to changes in forestry by increasing and decreasing afforestation rates by 10% from 2025 onwards. Increasing afforestation by 10% results in an additional emissions reduction of 4 $MtCO_2e$ for exotic forests and 1 $MtCO_2e$ for native forests. Reducing afforestation by 10% increases emissions by an additional 12 $MtCO_2e$ for exotic forests and 1 $MtCO_2e$ for native forests.

Stocking rates

We tested the impact of increasing or decreasing the stocking rates for dairy cows, sheep and beef cattle by 25% compared to the level in the EB4 demonstration path. This has the effect of changing overall livestock numbers and emissions from ruminant livestock.

Decreasing the annual rate of change in stocking rate by 25% increases emissions by about 3.5 and 1.6 $MtCO_2e$ for dairy cows and sheep and beef, respectively, whereas further increasing the annual rate of change in stocking rate by 25% reduces emissions by a similar amount in both sub-sectors.

Early or delayed closure of methanol facilities

Methanol is a large industrial emitter; we assume staged closure in 2026 and 2030. We have tested the impact of a delayed closure, where one train produces until 2040. Delayed closure would increase emissions in the fourth emissions budget period by 3.8 $MtCO_2e$.

Impact of changes in fossil gas prices

In our modelling, the price of fossil gas affects its use in electricity generation. We tested the impact of a higher fossil gas price path than what is in the EB4 demonstration path. In this higher price path, the fossil gas price reaches $20.50/GJ in 2030, the lower end of the expected cost range for which liquified natural gas (LNG) could be imported to Aotearoa New Zealand. The higher fossil gas prices reduce emissions by 0.2 $MtCO_2e$ during the fourth emissions budget period, compared to the EB4 demonstration path.

Residential rooftop solar uptake

We tested the impact of greater or lesser uptake of rooftop solar and found the impact on emissions during the fourth budget period to be negligible. This is because, in the model, adding rooftop solar simply reduces the need for other renewable generation. Refer to the 'Households and whānau' section of *Chapter 6: The impacts on New Zealanders of meeting the fourth emissions budget* for further detail.

EV costs

In the EB4 demonstration path, we modelled that light passenger EVs will reach purchase price parity to internal combustion engine (ICE) vehicles in 2031. We also tested the impact of achieving purchase price parity sooner (2028) and later (2034). Achieving purchase price parity sooner would reduce emissions by 1.2 $MtCO_2e$ compared to an additional 0.8 $MtCO_2e$ of emissions for achieving this later.

Uptake of low-carbon liquid fuels

Low-carbon liquid fuels are of non-fossil origin and can substitute for fuels from fossil sources for both transport and non-transport energy purposes. The EB4 demonstration path assumes a 12% blend in diesel by 2050. Achieving a 14% blend by 2050 could reduce emissions by 0.4 $MtCO_2e$, versus an additional 0.4 $MtCO_2e$ of emissions for a 10% blend.

Population and GDP growth

We have tested for population growth and GDP growth that is lower and higher than the Government's projections. For population we used low (0.3%) and high (1.1%) cases from the Government's 2023 projections. Our EB4 demonstration path uses a value of 0.7%. These values reflect average growth rates from 2022–2040.

For GDP, our EB4 demonstration path assumes an average growth rate of 1.9%. We used the Government's low case value (1.4%) and high case value (2.4%) for sensitivity analysis.

Given these values, lower population and GDP growth could reduce emissions by up to 1.7 $MtCO_2e$, whereas higher growth could increase emissions by 1.5 $MtCO_2e$.

Oil prices

Our EB4 demonstration path assumes an oil price of USD$84 per barrel in 2023, reducing to USD$65 from 2030. A higher oil price (USD$100 per barrel from 2025) could reduce emissions by 1.3 $MtCO_2e$, whereas a lower oil price (USD$40 per barrel from 2030) could increase emissions by 1.0 $MtCO_2e$.

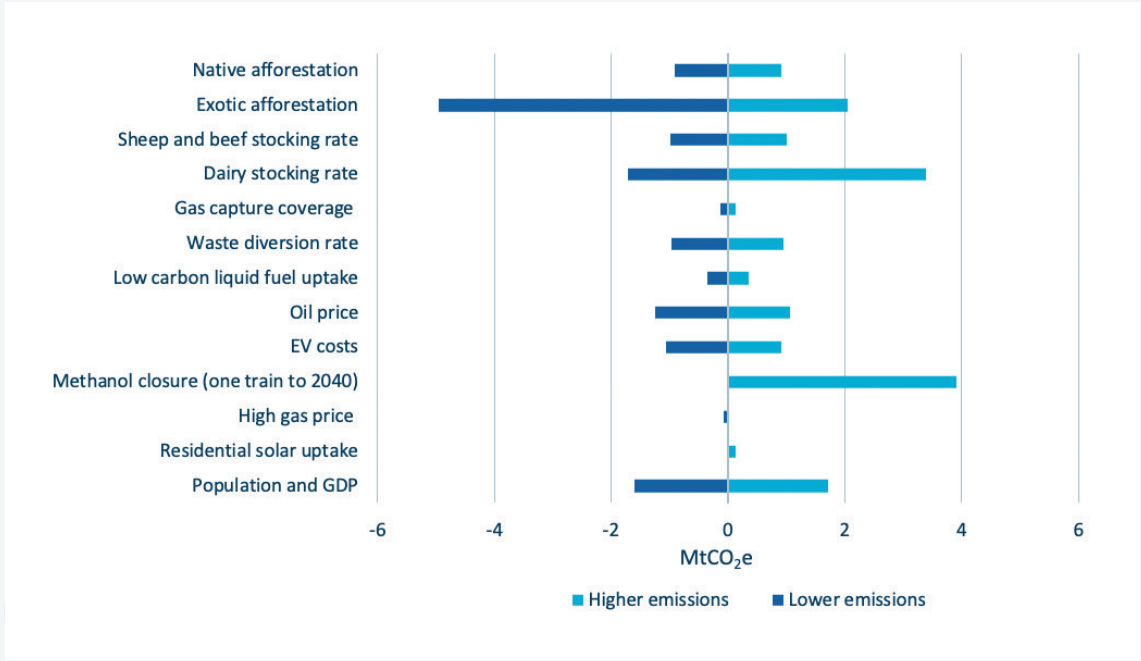
Waste diversion rates

Waste diversion redirects organic waste from municipal landfills to either anaerobic digestion or composting. We tested the impacts of varying organic waste diversion rates by 50%. Increasing waste diversion rates by 50% could save 1 $MtCO_2e$ compared to the EB4 demonstration path, whereas decreasing diversion rates would increase emissions by 0.9 $MtCO_2e$.

Landfill gas capture coverage

Landfill gas capture prevents biogenic methane being released from decomposing organic material in landfills. Gas captured can be used for other purposes. Higher coverage of landfill gas captured could reduce emissions by 0.1 $MtCO_2e$, and lower coverage could increase emissions by 0.1 $MtCO_2e$.

Figure 4.15: Sensitivity analysis of budget period emissions to selected factors or events



Source: Commission analysis

Overall assessment

The sensitivity analyses showed that the three biggest factors that result in material changes to emissions levels in the fourth emissions budget period are exotic afforestation, stocking rates and the timing of closure of methanol facilities.

There have been significant events in the fossil gas sector in Aotearoa New Zealand throughout 2024. At the time of writing, there is a high level of uncertainty about how the sector may evolve. While changes to the timing of fossil gas use for methanol showed a significant impact, the fossil gas price sensitivity did not show a large impact on emissions. This is because our sensitivity analysis looks at the impact of different fossil gas prices only on electricity generation emissions. It is reasonable to expect that other fossil gas users would be impacted by sustained and significant price increases, and this could affect industrial emissions significantly, but this is not shown in our sensitivity analysis. Although there may be implications for emissions levels depending on how the sector evolves, it does not affect a long-term requirement to reduce fossil gas use. See *Chapter 5: Sector contributions to meeting the fourth emissions budget*, Box 5.1 for further details.

The remaining factors we tested have a range of impacts less than 2% for the total emissions budget. These include factors such as oil prices, cost of EVs, uptake of low-carbon liquid fuels, and landfill gas capture coverage.

Our overall assessment is that the risks posed by these uncertainties are manageable. In addition to targeted policies and incentives, the Government can manage these risks by aiming to outperform the emissions budget in its emissions reduction plan. Our HTHS scenario provides examples of areas where the Government could go further than our EB4 demonstration path. Some key examples include:

- further use of biofuels to decarbonise transport
- higher modal share of public and active transport
- further decarbonisation of steel production through green hydrogen or greater utilisation of scrap steel
- adoption of green anodes for aluminium production
- further land-use change from dairy to horticulture
- adoption of methane-reducing feed additives.

Box 4.3: Sensitivity analysis in C-PLAN

We tested how sensitive the C-PLAN GDP results are to some key uncertainties in the economy. These include the international oil price, international emissions prices, and population and GDP projections (see **Figure 4.16**).[xxvii] We tested the changes to population and GDP growth together as a single sensitivity because the change in projected GDP is partly driven by higher or lower population growth.

When testing these sensitivities, we looked at how the changes to input assumption(s) affect the estimated impact on GDP of meeting the emissions budgets. This is the difference in GDP between the EB4 demonstration path and the reference scenario.

The level of GDP under the reference scenario is an input assumption, rather than something that is generated by the model. This reference GDP path is held constant across the sensitivity tests – except for in the 'population and GDP' test where we deliberately tested the effect of lower or higher future growth rates. This method isolates the change in the impact of meeting the recommended emissions budget in each sensitivity test.

While some of the sensitivity tests do affect the modelled impact on GDP, the effect is within 0.3 percentage points. Population and GDP, when significantly higher or lower than government projections, has the biggest impact on making budgets more or less expensive to meet.

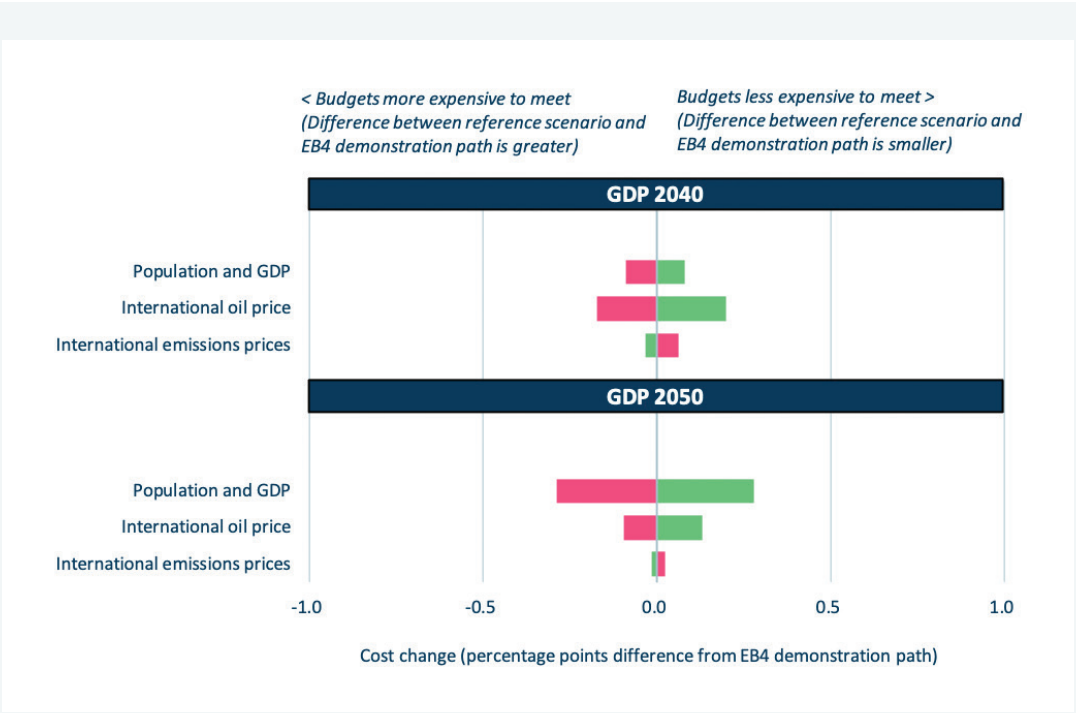
Beyond 2040, GDP is less impacted by changes to international oil prices as the economy is further along in its transition away from fossil fuels.

International emissions prices, doubled and halved in our testing, have a relatively small effect. There are competing effects from higher international emissions prices – for example, our more emissions-intensive exports are relatively cheaper (boosting GDP), but our more emissions-intensive imports (including inputs to manufacturing) are relatively more expensive, reducing GDP. On balance, these competing effects mean that the higher price is slightly better in GDP terms, and the lower price is slightly worse. However, the effect is so small that, given modelling approximations, it is approximately zero.

Continued on next page.

xxvii In *Ināia tonu nei* we also tested for potential closing dates for the Methanex methanol plants and the NZAS aluminium smelter. The impact of these factors was small. We expect this will also be the case for the fourth emissions budget. These factors will likely have similar cost impacts across our EB4 demonstration path and reference scenario.

Figure 4.16: Impact of selected factors on GDP



Source: Commission analysis

Wāhanga 5 | Chapter 5

Te ahumahi me ōna whakatutukinga i te tahua tukuwaro tuawhā
Sector contributions to meeting the fourth emissions budget

This chapter covers the changes needed in different sectors to achieve the recommended fourth emissions budget.

The role of He Pou a Rangi Climate Change Commission (the Commission) in advising the Government requires us to consider the likely actions needed to meet the fourth emissions budget and 2050 target. This is important to enable the Government to make decisions on whether the recommended budget is achievable and plan for the changes that will need to occur across all parts of the economy. It is important that these changes happen at a scale and pace that provides the maximum benefits for the country.

Our EB4 demonstration path (see *Chapter 4: Developing the path to the fourth emissions budget*) is a tool to illustrate what changes might need to happen and when, based on our analysis. It shows how each of these changes affects Aotearoa New Zealand's emissions reductions.

In the EB4 demonstration path, the largest emissions reductions in the fourth emissions budget period come from energy, transport, and agriculture. Achieving these emissions reductions will rely on significant change happening over the first three emissions budget periods. Actions required across the first three budgets build on our previous advice in *Ināia tonu nei* by taking into account the latest information on emissions, trends, and opportunities.

The EB4 demonstration path will see some new changes, primarily based on new evidence on adoption of methane-reducing technologies from the 2030s.

Gross emissions of long-lived greenhouse gases reduce significantly in the EB4 demonstration path, while maintaining current momentum to achieve reductions in net emissions through forest removals.

This chapter sets out the changes in the EB4 demonstration path to 2050, focusing on how emissions reductions are achieved in the fourth emissions budget period at a level that meets the recommended budget. More detail on assumptions underpinning our EB4 demonstration path can be found in the *ENZ assumptions log* on our website.

Impacts of the changes in the EB4 demonstration path on Aotearoa New Zealand are discussed in detail in *Chapter 6: The impacts on New Zealanders of meeting the fourth emissions budget*.

Changes from the draft version of this chapter

In response to new evidence provided in consultation, and new information available since publication of our draft advice, we have changed some of the assumptions in our modelling and analysis. This includes key changes to our assumptions on emissions reductions from energy, industrial processes and product use (IPPU), transport, and forests.

In energy, we made a number of changes to assumptions about energy supply and use, including wholesale gas prices, methanol production, geothermal electricity generation, use of biomass in power generation, and battery costs and uptake. In response to feedback we have highlighted potential for greater uptake of LED lighting, carbon capture including in cement production and oil and gas processing, and sector interest in offshore wind and biogas.

Since the publication of our draft advice, there have been notable developments in the fossil gas sector. We have added a section on fossil gas supply and demand to explain how this is incorporated into our advice.

For IPPU, we changed our assumption about coal use in steel making and moderated our assumptions about hydrofluorocarbon reductions, which reduce the ambition for reduction for fluorinated gases (f-gases).

In transport, we have changed our assumptions about biofuel uptake to focus the use of low-carbon liquid fuels on hard-to-abate sectors using diesel and jet fuel.

For forests, we revised our assumptions about the amount of exotic afforestation. We did not change assumptions about levels of native afforestation. We also incorporated new and updated afforestation and deforestation data. No changes were made to the inputs to agricultural modelling, but there is less conversion of sheep and beef land due to a reduction in the afforestation levels. We also more clearly identified that extensive systems change is needed to achieve the ambitious levels of waste reductions set in the demonstration path.

Energy

Energy emissions result from burning fuels to produce useful energy (for example, heat). They also include fugitive emissions which can occur, for example, in fossil gas production and geothermal electricity generation. They include emissions resulting from electricity generation, heating buildings, and industrial heat. They account for 19% of our current gross emissions profile.[xxviii] In our EB4 demonstration path, energy emissions reduce by 56% by 2040 compared to 2022.

The electricity system plays a critical role in supporting other sectors to reduce emissions. To meet the increasing electricity demand, Aotearoa New Zealand will need to considerably increase its capacity to generate and distribute renewable electricity. Biomass and low-carbon liquid fuels would also become important energy sources for process heat and for sectors that are hard to electrify.

xxviii Commission analysis using the 2024 edition of the GHG Inventory.

Box 5.1: Fossil gas supply and demand

There have been significant events in the fossil gas sector in Aotearoa New Zealand throughout 2024. At the time of writing, there is a high level of uncertainty about how the sector may evolve, and what it might mean for the energy mix in the future.

Fossil gas production and estimates of fossil gas reserves have declined. Fossil gas production dropped by 12.5% in 2023,[22] and reserves (as of 1 January 2024) decreased by 20%.[xxix] About half of the decrease in reserves is due to fossil gas extracted and consumed. The other half is due to revised estimates of available fossil gas, indicating that operators now believe there is less total fossil gas than previously thought, or that it will be more difficult or costly to extract. These revisions to reserves signal a potential for longer-term impacts.[23]

Tight fossil gas supply is impacting the electricity system and industrial energy users. The electricity system has been under stress during the winter of 2024 due to limited gas availability and low hydro and wind generation. This led to very high wholesale electricity prices throughout much of this period, with prices spiking to record levels during the month of August in particular. High energy costs were cited as a contributing factor by pulp and paper manufacturers who recently decided to cease operations.[xxx]

Methanex, the country's largest fossil gas user, mothballed its Waitara Valley production facility due to a lack of fossil gas in 2021. It further reduced methanol production in the first half of 2024 at its remaining Motunui plant. In August 2024, Methanex stopped production entirely to on-sell its fossil gas to electricity generators and has since indicated it may only restart half of Motunui's production capacity, indefinitely idling Motunui's second production line.[24]

Gas reserves and resources are inherently uncertain. They are classified depending on how certain it is that reserves exist, and the commercial viability of extracting and bringing it to market. The key classifications, listed from most certain to least certain, are:

- 2P – Proven plus probable reserves
- 2C – Contingent resources
- 2U – Prospective resources.

xxix Relative to the years prior, based on Gas Industry Company and MBIE petroleum reserves data respectively.
xxx In September 2024, Oji Fibre Solutions and Winstone Pulp International confirmed the closure of plants in Auckland and Ruapehu respectively.

Historically, 2P reserves have typically been about 10 years' worth of the then-annual fossil gas produced. The updated petroleum reserves data from MBIE released in July 2024 shows that 2P reserves are now estimated to be about 8.5 years' worth of current demand.[25] While this decline is not insignificant, it should be noted that gas extraction and consumption depletes 2P reserves every year. Gas producers regularly undertake development work that leads to firming up and reclassifying 2C reserves as 2P, assuming the development work is successful. There is no evidence to suggest this dynamic cannot continue to at least some degree. However, there is significant uncertainty about the volumes of fossil gas that producers may ultimately bring to market through 2C or 2U development. Other than existing classified 2P reserves, additional gas supply sources may include:

- **Existing resources (i.e. 2C or 2U) that may become profitable to develop**. Estimates suggest there are significant fossil gas resources that are currently uneconomic or too difficult to bring to market. As technology or economic conditions change, these resources may become viable for development.
- **New fossil gas discoveries** may increase supply in the long term, however, any discoveries resulting from exploration are expected to take at least 10 years to bring any additional fossil gas to market.
- Aotearoa New Zealand could begin **importing Liquified Natural Gas (LNG)** to cover the unmet demand for fossil gas. LNG can be used in all applications in which domestically produced fossil gas is used. Historically LNG has been significantly more expensive than domestically produced fossil gas, however, this may change as fossil gas production falls and prices increase. The embodied emissions of some LNG sourced from overseas could also be significantly higher than that of domestically produced fossil gas.[26]

There are multiple ways in which the fossil gas sector in Aotearoa New Zealand may evolve. Regardless fossil gas consumption would need to reduce in the longer term, relative to current levels, to achieve the fourth emissions budget. In the proposed EB4 demonstration path, fossil gas use declines significantly. Small amounts of fossil gas are still used until at least 2050, particularly for electricity generation, although gas only comprises a small portion of total generation – averaging about 2% during the EB4 period.

The MBIE data release identified a likely short- to mid-term supply shortfall of approximately 10 PJ relative to recent annual demand.[27] To address this shortfall requires either fossil gas supply to increase, or demand to reduce. The response to date has been demand reduction through curtailment of industrial production by Methanex, as mentioned above. This appears likely to continue in the immediate term given that any additional supply would take time to come to market.[xxxi]

xxxi Based on knowledge at the time of writing in October 2024 and subject to change depending on how the sector evolves.

The key purpose of our work is to advise on the level of the fourth emissions budget. As such, we have focused on considering the longer-term impacts of the changing information on gas supply. See further discussion throughout this chapter for more detail. We have chosen not to adjust short-term gas demand in our EB4 demonstration path in response to the supply shortfall MBIE has identified. This is because there are multiple ways the supply/demand imbalance could be resolved, and it is not clear which path will eventuate. For example:

- Our path does not assume further curtailment of industrial production in response to the gas shortfall, to meet existing or proposed budgets.
- Similarly, meeting the recommended emissions budget does not require gas to be consumed at the level modelled in the EB4 demonstration path. If there is less gas supply available compared to the level of demand in the EB4 demonstration path, our analysis suggests that, while the mix and level of energy sources used may change, all budgets would still be comfortably achieved.

Furthermore, the cumulative fossil gas use to 2075 implied by the EB4 demonstration path is not inconsistent with existing domestic reserves and resources: for example, if, in addition to 2P reserves, 30% of 2C and 2% of 2U resources are developed, then there would be sufficient gas supply to meet the demand in the EB4 demonstration path to 2075. Alternatively, developing 2P reserves and 39% of 2C resources would provide this same level of supply.[xxxii] In other words, assuming sufficient contingent and/or prospective resources are delivered to market, there is no clear need for new oil and gas exploration or to import LNG. This finding – that some ongoing development of known reserves and resources is likely to provide sufficient gas for an orderly transition to net zero – is consistent with our previous analysis and other similar work.[28,29]

In summary, while challenging, the current situation does not affect a longer-term requirement to transition to lower fossil gas use. The Commission does not assume or endorse a requirement for ongoing fossil gas consumption at a specified level. Regardless of how the fossil gas sector evolves in Aotearoa New Zealand, fossil gas consumption would need to significantly reduce from current levels to meet the fourth emissions budget. The actions of government and the private sector will determine the timing and speed of the fossil gas decline leading up to the fourth emissions budget period.

xxxii Commission analysis.

Renewable energy would increase substantially to meet demand

Electrification of key sectors sees electricity demand in our EB4 demonstration path increasing by 63% from 2022 to 2050, compared to a 31% increase in the reference scenario.

This demand is primarily driven by the electrification of transport and industry. However, we also anticipate new businesses would be attracted to Aotearoa New Zealand due to the country's low-carbon electricity supply. This would put additional demand on electricity supply. For example, in the EB4 demonstration path, we assume new data centres approximately equivalent to 600 MW of new load by 2030, based on announcements of data centre development identified by Transpower.[30]

Industry developments, as well as information received through the call for evidence process, suggest that demand-side response can play a key role in helping to reduce peak electricity demand and hence electricity supply costs. This has the potential to save consumers money on bills and minimise the emissions associated with running fossil-fuelled plants to meet demand peaks. As such, the EB4 demonstration path assumes some demand-side measures are deployed, such as some industrial manufacturers reducing production at times of high demand and smart EV charging. Improving the way electricity use is managed, along with energy efficiency measures, reduces the overall amount of new capacity needed in the EB4 demonstration path compared to what would be needed without such measures.

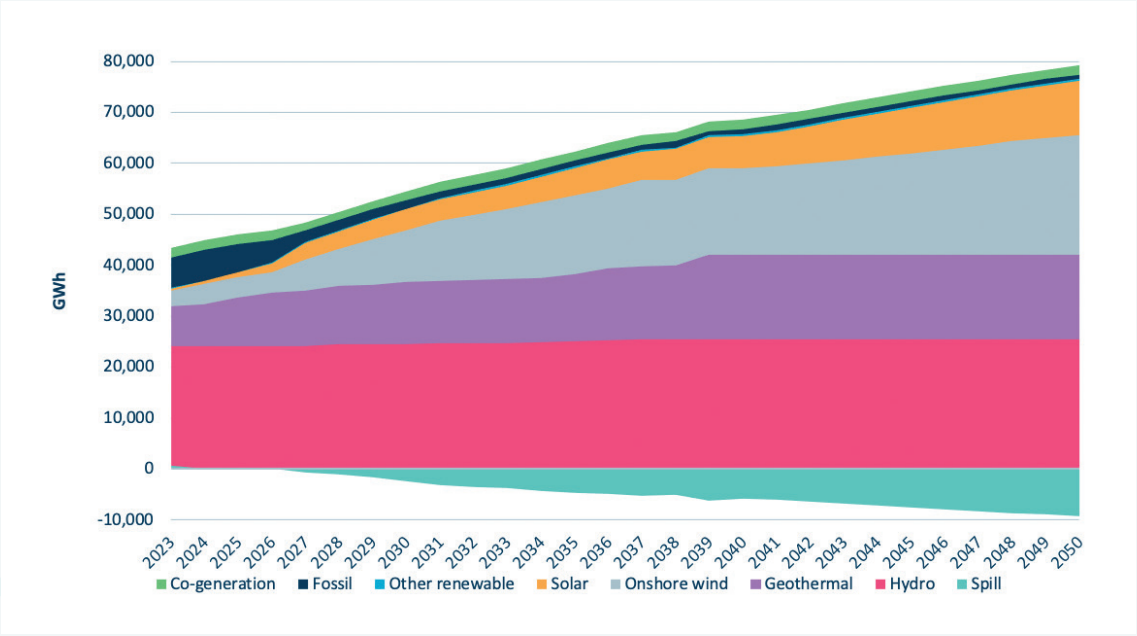
Meeting the expected increase in electricity demand would require a step change in new generation capacity being built relative to recent years. Our assumptions are in line with projections made by others. For example, Transpower anticipates a 68% increase in demand by 2050, which would require additional generation capacity of 400–550 MW per year, while MBIE suggests an increase of 57% by 2050, requiring new capacity of around 350 MW per year.[xxxiii,31,32] To give an idea of scale, the additional capacity needed is equivalent to around two to three large wind farms being commissioned annually.

As shown in **Figure 5.1**, to meet the increasing demand for electricity, the EB4 demonstration path would see significant growth in solar, wind, and geothermal generation, with relatively small increases in hydro generation.[xxxiv]

xxxiii Based on the reference scenario in MBIE's 2024 Electricity Demand and Generation Scenarios (EDGS) modelling.

xxxiv The model considers a range of generation technologies, including hydro, solar, onshore and offshore wind, geothermal, and fossil gas. The particular generation mix shown in **Figure 5.1** is a result of the model selecting the most cost-effective generation type to build next. This accounts for factors like the cost of building the generation and how often it will actually generate electricity (for example, solar panels only generate when it is sunny).

Figure 5.1: Electricity generation by technology in the EB4 demonstration path[xxxv]



Source: Commission analysis

During consultation, submitters expressed concern that non-cost factors that make offshore wind electricity generation attractive are not considered in the modelling. It was suggested that the demonstration path include offshore wind. We acknowledge there is significant interest in developing an offshore wind industry in Aotearoa New Zealand, with multiple developers actively working on several potential projects, and that the Government expects to have a permitting regime in place by mid-2025.

Offshore wind features in alternative paths we have modelled, and it is possible offshore wind could join the mix of renewable technologies to meet the projected increase in demand.

The role of fossil fuels in generating electricity would decline

Currently Aotearoa New Zealand's highly renewable electricity system relies on fossil fuel plants to provide electricity in situations where alternative options are not available (for example, when hydro lakes are low or in times of high demand). There are also some fossil fuel plants that provide stable electricity generation, which can run most of the time.

xxxv In the figure "spill" represents an oversupply of electricity from renewable technologies generating electricity at times it is not needed.

Owing to the success of the Ngāwhā Geothermal Power Station in reducing emissions through CO_2 reinjection (see **Box 5.2**), we see geothermal playing a significant role in the EB4 demonstration path. Unlike wind and solar, which can vary due to weather, geothermal plants provide a stable electricity supply. However, through consultation we heard that we may have overestimated the amount of new geothermal generation capacity that could be built, as some geothermal resources are unlikely to be developed due to environmental or social factors. Following a subsequent review with Energy Link, we have reduced the amount of new geothermal capacity available in our modelling assumptions.

As costs to build renewable plants decline and rising carbon prices make it more expensive to run fossil-fuelled power plants, it would become more cost-effective to replace the role of fossil fuels in providing reliable additional supply when needed, with some oversupply of renewable energy. Some submissions questioned the above finding. To clarify, we expect a combination of some degree of renewable overbuild, along with flexible thermal generation, demand response, and batteries, will achieve an optimal outcome for electricity consumers. This aligns with findings from similar assessments.[xxxvi,33]

During consultation, we heard that grid-scale battery costs are already lower, and are likely to fall faster, than we had assumed, and hence these batteries could play a greater role in the electricity system than we had modelled. We reviewed battery cost data provided by submitters alongside wider data, including costs of recently announced grid-scale battery projects in Aotearoa New Zealand.[xxxvii,34,35] We have adjusted grid-scale battery costs in our model as a result and now expect these to contribute more to providing flexible supply to meet daily demand peaks. This could be particularly important in the context of reduced fossil gas availability, given it has historically been gas that has provided this short-duration peaking supply.

With increased deployment of demand response and batteries in the medium to longer term, there are likely to be more options to manage daily peaks. The key challenge for the electricity sector will be covering multi-day or seasonal supply shortfalls, such as during longer periods of low wind, or extended low inflows to our hydro generation systems.

In our draft advice, the EB4 demonstration path included small amounts of coal-fired generation through to 2050. Submissions received during consultation suggested there is now sufficient certainty around Genesis Energy's plans to transition to biomass fuel for its Rankine units at Huntly power station for us to include this in our demonstration path. We now assume a conversion to biomass will occur from 2032. [xxxviii,36]

Since we released our draft advice, information releases have shown lower-than-expected production of fossil gas and lower reserves (see **Box 5.1**). We have reflected this in our modelling by increasing the assumed wholesale fossil gas price path.[xxxix] This resulted in higher costs for fossil gas electricity generation, meaning that it becomes cheaper to displace it with renewable generation more quickly.

xxxvi For example, see pages 62 and 132 of Boston Consulting Group's 2022 publication *The Future is Electric*.

xxxvii For instance, we note Contact announced in July it had reached a final investment decision to proceed with a 100 MW / 200 MWh battery next to the Glenbrook steel mill, while Genesis has committed to stage one (100 MW / 200 MWh) out of a potential battery storage pipeline of 400 MW for its Huntly site, with construction scheduled to begin in 2025.

xxxviii This aligns with MBIE's assumption in their recent Electricity Demand and Generation Scenarios modelling (EDGS); however, we note this may be a conservative estimate compared to the timeframe the industry hopes to meet. We understand from engagement with stakeholders that the availability of sufficient biomass supply is the current limiting constraint and that the industry hopes to start replacing coal with biomass in the late 2020s.

xxxix We have aligned the fossil gas price path with the assumption used in MBIE's Electricity Demand and Generation Scenarios reference scenario.

Box 5.2: Carbon capture and storage

We have considered the potential role of carbon capture and reinjection and Carbon Capture and Storage (CCS)[xl] in the EB4 demonstration path.

There have been recent successful trials at three geothermal fields (Ngāwhā, Te Huka, and Ngātamariki), of reinjection of CO_2 from geothermal fluids back into the geothermal reservoir. These trials, alongside stakeholder intentions to roll out this technology more widely, give us high confidence that reinjection of fugitive geothermal emissions can contribute to emissions reductions for the fourth emissions budget.

We heard some support through submissions during consultation for including CCS in other applications in our demonstration path. No new evidence was provided, however, with submitters pointing to existing material such as Wood Beca's March 2023 report *Review of CCUS/CCS Potential in New Zealand*. This found that the most likely application for CCS was to capture emissions from production at the Kapuni gas field, with an estimated abatement cost of less than NZ$50/tonne of CO_2e. However, conditions in the oil and gas sector have changed markedly since the release of that report, and recent engagement with stakeholders suggested a significantly higher abatement cost.

We also heard that the economics of a potential CCS project on gas production strongly depend on how soon it can be implemented. This is because the amount of gas produced reduces over time as a field depletes, so CCS would need to be applied as soon as possible to ensure sufficient gas can be produced post CCS implementation to pay off the investment in the CCS infrastructure. The Government consulted on a proposed CCS regulatory regime in July 2024, however it is not clear when it will be finalised. We understand that CCS at Maui East, the other gas field identified as a potential candidate, is likely to be significantly more expensive than for Kapuni.

In our draft advice we also noted:

- the early stage of development of CCS technologies and their application in Aotearoa New Zealand
- the expected relatively high cost of these technologies compared with the other main removal option to reduce net emissions (afforestation)
- the availability of other technologies and actions that can reduce gross emissions from most activities

We do not consider these factors to have significantly changed since consultation. For this reason, and those outlined further above, we consider there to be insufficient certainty to include CCS on gas production in the EB4 demonstration path. This does not preclude the Government from pursuing these technologies to help achieve net zero emissions and maintain it after 2050, for greenhouse gases other than biogenic methane, if it believes there are benefits from doing so.

The Commission will continue to reconsider the role of CCS and its role to achieve carbon dioxide removals (CDR) when combined with direct carbon capture from the atmosphere or from bioenergy and carbon capture and storage as new evidence emerges on the potential, costs, and suitability of applying these technologies in Aotearoa New Zealand.

xl CCS is a process in which a relatively pure stream of CO_2 from industrial or energy-related sources is separated (captured) at or near a point source, conditioned, compressed, and transported to a permanent storage location for long-term isolation from the atmosphere. Permanent storage is generally geological (underground geologic formations, rocks, minerals).

There is a large potential to improve the energy efficiency of buildings

For existing buildings, renovations offer an opportunity to replace fossil fuel heating systems and make large improvements in energy efficiency through improved insulation or more efficient forms of heating (such as heat pumps). New commercial and public buildings can be built to higher standards with new technologies to monitor and control energy use.

In the EB4 demonstration path, we have assumed that the energy efficiency of buildings would improve over time, reducing the demand for heating by 19% for residential buildings and 43% in commercial buildings by 2050, relative to 2019 levels.[xli] These are based on underlying assumptions on rates of energy efficiency improvements and rates of retrofit, which are consistent with those used in *Ināia tonu nei*.

During consultation, submitters suggested that there may be opportunities to achieve greater efficiency gains in the operational energy use of buildings. After reviewing the evidence provided, it appeared further gains are possible in residential and commercial lighting efficiency than we had modelled.[37,38] While we have not reflected this in our final modelling, we acknowledge that rapid and widespread adoption of highly efficient LED lighting could offer significant energy cost savings for businesses and households, while helping to reduce peak electricity demand and hence electricity generation emissions.[xlii]

We also assume coal will be phased out in residential buildings by 2032 and commercial buildings by 2037,[xliii] and fossil gas will be phased out in all buildings by 2050. Phasing out fossil gas from these uses could enable greater availability of limited fossil gas resources for use in highest value sectors, and our analysis suggests it is already economic in many cases for households to switch to electricity.

We have reviewed evidence on the potential for biogas integration,[xliv] including material received through the call for evidence process, as well as feedback provided through consultation. Our position in the draft advice was that it is not clear that a sufficient quantity of biogas would be available at a price point that would make it competitive with electricity or biomass as a decarbonisation solution for pipeline gas. We understand several entities are investigating biogas projects, and that biogas or biomethane may prove attractive for some situations, including as a potential low-carbon alternative to LPG. These projects may help alleviate the impact of fossil gas supply shortages in the medium term, however we did not receive enough new evidence to justify a change in assumption.

xli On a per-building basis.
xlii While not explicitly noted in our draft advice, our modelling includes energy efficiency improvements for water heating (assumed at half that for space heating), and for appliances, in addition to the explicitly noted space heating improvements.
xliii This is based on analysis of past data of coal use in commercial buildings.
xliv Biogas integration in this case refers to the blending of biomethane into existing fossil gas pipelines. This means gas consumers would be burning a mixture of fossil gas and biomethane. As biomethane is chemically identical to fossil gas, consumers would not notice anything different about their gas supply and existing appliances could continue to be used unmodified.

Biomass and low-carbon liquid fuels are important alternatives to electrification for some sectors

The use of biomass, biofuels, and other low-carbon liquid fuels would be important for reducing emissions in some sectors, in addition to using electricity. For instance, solid biomass fuel is a key low-carbon option for process heat. Given its higher cost, in the EB4 demonstration path we assume the main long-term role of low-carbon liquid fuels would be for sectors that are hard to electrify, such as some industries, long-haul aviation, and shipping.[xlv]

Low-carbon liquid fuels may be derived from biomass, or produced using renewable electricity via green hydrogen in combination with a clean source of CO_2. The latter are often referred to as e-fuels.

The main source of biomass for energy use in Aotearoa New Zealand is exotic forestry. Our modelling assumes biomass demand, be that solid biofuel, or as a feedstock for liquid biofuel, is met through wood waste or residues from forest harvest as well as from low-value pulp logs. The amount of supply available in our model is potential new supply – i.e., net of existing demand.

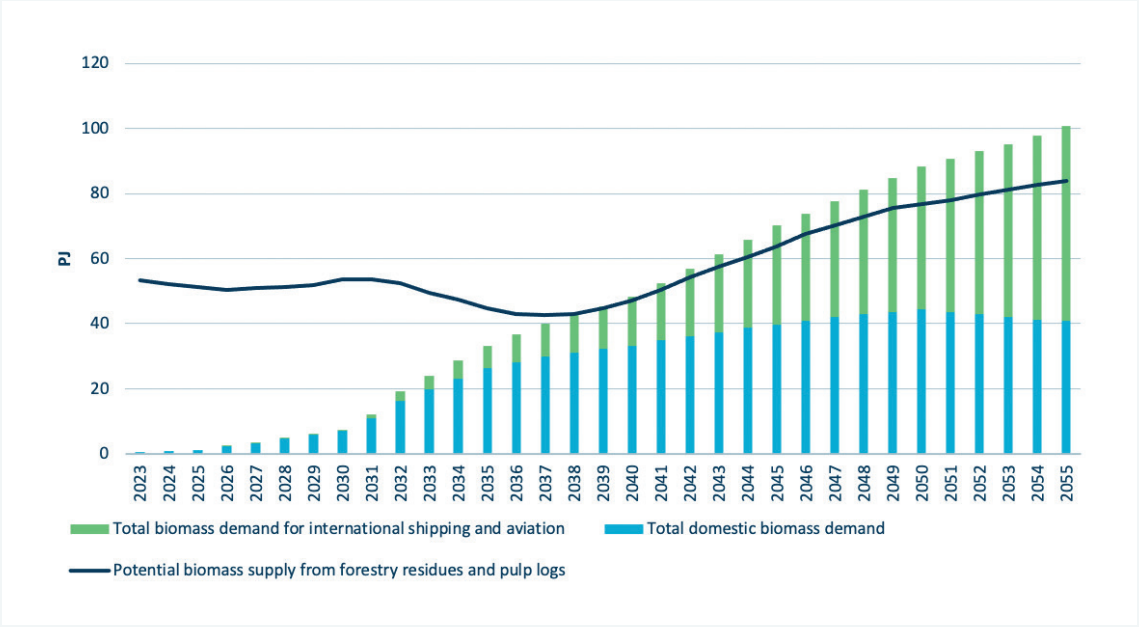
A concern we heard through consultation was that there could be many competing uses for biomass, and hence there may not be sufficient supply available. For low-carbon liquid fuels, demand could be met through either domestic production or from overseas imports. It is also possible that the demand for low-carbon liquid fuels may end up lower than initial projections as alternative technologies develop – for instance, if battery technology breakthroughs make electrification more viable in uses where it currently is not expected to be an option, such as in longer distance air travel. The opposite may also occur.

As shown in **Figure 5.2,** our analysis suggests that domestic biomass supply will be sufficient to meet demand for both solid biofuels and low-carbon liquid fuels until the 2040s.[xlvi,39]

xlv While the emissions from international aviation are not included in Aotearoa New Zealand's emissions, or the EB4 demonstration path, we do model the use of low-carbon liquid fuels in the sector to build an understanding of total potential demand. This set of assumptions does not pre-suppose the Government's response to the advice on our review of international shipping and aviation emissions. We also note that the International Maritime Organization (IMO) and the International Civil Aviation Organization (ICAO) have stated that low emissions fuels will be part of both sectors' futures, regardless of the NZ Government's choices.

xlvi Note that this chart assumes all low-carbon liquid fuels are biomass-derived, hence the biomass demand presented here is likely an overestimate. We understand other studies have similarly concluded that at an aggregated level (i.e., on an island level or nationwide basis) New Zealand will have enough biomass. See, for example, EECA's South Island Regional Energy Transition Accelerator (RETA).

Figure 5.2: Potential biomass supply and demand under the EB4 demonstration path



Source: Commission analysis

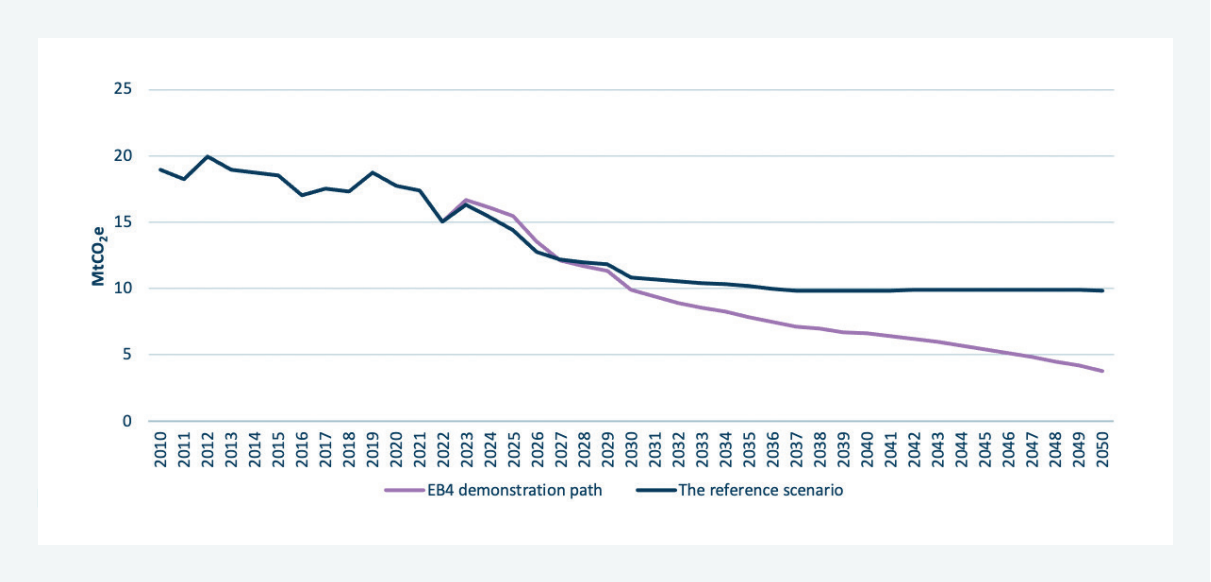
Increased renewable energy and phase out of fossil fuels would reduce emissions rapidly

Demand for coal, oil, and fossil gas is expected to reduce under the EB4 demonstration path as industry, businesses and households are assumed to switch to lower emissions energy sources. Our EB4 demonstration path would see fossil gas demand in Aotearoa New Zealand reduce by about 73% between 2022 and 2040, compared to 52% under the reference scenario. This therefore results in a decrease in fossil fuel production.

Figure 5.3 shows that actions to reduce the role of fossil fuels and improve efficiency in the EB4 demonstration path would lead to relatively steady declines in energy emissions (excluding emissions from transport) through to 2050, compared to actions in the reference scenario. The step change reductions in 2026 and 2030 are a result of the assumed staged closure of methanol production in those years. This assumption broadly aligns with the government's 2024 updated projections and reflects the declining fossil gas outlook (see **Box 5.1**).

The steady declines are driven by phase outs of fossil fuels, replaced by renewable energy sources, across several sectors including electricity generation, industrial process heat, residential and commercial space, and water heating.

Figure 5.3: Emissions from energy (excluding transport) in the EB4 demonstration path and the reference scenario



Source: Commission analysis

Fossil fuels phased out in industrial process heat by 2050

Process heat is energy used primarily for industrial processes and manufacturing. There are proven options for decarbonising low- and medium-temperature process heat in industry. These include switching fuel from coal and fossil gas to biomass and electricity.

The EB4 demonstration path, and all of our scenarios, are consistent with existing regulations mandating a phase-out of coal in low-to medium-temperature industrial process heat by 2037.[40] This would see a steady, but reasonably rapid, rate of conversion to be on track to eliminate coal use for food processing before 2037. This change would be the equivalent of converting one to two large dairy processing plants away from coal each year or converting a larger number of smaller plants.

We assume fossil gas will be phased out of process heat in the EB4 demonstration path by 2050. This assumption is based on our assessment of what could reasonably be achieved. Modelling undertaken by Deta found that it would be possible to decarbonise process heat by 2050. However, it would require concerted efforts to grow and upskill the workforce to ensure there are sufficient skilled workers to deliver the decarbonisation projects.[xlvii]

Along with boiler conversion, the EB4 demonstration path assumes significant improvements in energy efficiency across the food processing sector, averaging around 1.1–1.3% per year.

Based on publicly available information[41] and stakeholder engagement, we now also assume that the level of coal substitution for biomass and tyre-derived fuel in cement production can increase to 100% from the current level of 50%. We assume this will occur by 2035.

xlvii More information on modelling undertaken by Deta for this report can be found in the *Technical annex*.

For some industrial activities that are hard to decarbonise, such as high-temperature furnace heat, our EB4 demonstration path assumes liquefied petroleum gas will replace fossil gas until gas can be fully phased out. This is because as fossil gas phases down, it is likely to become less viable to maintain fossil gas transmission and distribution infrastructure as there will be too few consumers to generate the revenue required.

Mobile machinery and off-road vehicle emissions

These include emissions from vehicles used in forestry, construction, mining and agriculture, as well as fishing vessels and recreational watercraft. These types of machinery are more difficult to electrify, so the transition will likely take longer. In *Ināia tonu nei*, we assumed that electrifying off-road vehicles would happen at the same rate as heavy on-road transport. But while we are starting to see electric trucks on the road, EV uptake off-road is very limited. We now assume the uptake of electric off-road vehicles would lag on-road heavy vehicles by five years, and low-carbon liquid fuels would play an important role. Challenges for electrifying off-road vehicles include the scale of the market (i.e. fewer numbers of large machinery), access to charging structure, EV capability, and cost.

Industrial processes and product use

In addition to industrial energy emissions discussed in the section above, some industries in Aotearoa New Zealand emit greenhouse gases as a by-product from the underlying processes. These emissions are included in the industrial process and product use (IPPU) category, along with emissions from product use – mainly refrigerants.

Emissions from industrial processes and product use currently make up about 6% of Aotearoa New Zealand's gross emissions profile.[xlviii] In our EB4 demonstration path, IPPU emissions reduce by 36% by 2040 compared to 2022. This can be achieved by reducing emissions from large industrial processes such as steel or aluminium production and phasing down the use of fluorinated gases.

Industry transition to low emissions alternatives

Recent developments in technologies mean we are assuming industries are likely to be able to go further in reducing IPPU emissions in the EB4 demonstration path than we previously projected in *Ināia tonu nei*. For example, as per recent announcements regarding NZ Steel's electric arc furnace project,[42] we now assume a 50% reduction in coal use for steel production from 2027.[xlix] Since our modelling was finalised, NZ Steel has publicly stated that they expect to achieve a slightly larger reduction in coal use, reducing emissions by "up to 1 Mt" per annum, compared to the 800 kt initially planned. They also hope to bring commissioning forward from 2026 to begin in 2025.[43]

xlviii Commission analysis using the 2024 edition of the GHG Inventory.

xlix In 2023, the Government announced it would partner with the Glenbrook steel mill to install an electric arc furnace. This investment would approximately halve emissions from steel production by reducing coal use by about 50%. The agreement contains incentive payments if NZ Steel installs the electric arc furnace by 2027 and if it can achieve greater levels of emissions reductions by 2030.

For industries where greenhouse gases are a by-product of the production process, emissions can be hard to avoid. In *Ināia tonu nei* we had assumed that the NZAS aluminium smelter would close in 2024. We now assume it will remain open until at least 2050, as there is no clear evidence to suggest it would close at any particular date. In our draft advice, we assumed methanol production (through the Methanex plants) would undergo a staged closure – with one of its two remaining plants closing down in 2029 and the second in 2039. This was based on publicly available information on Methanex's fossil gas supply contracts. We now assume closures for the two production trains at the end of 2025 and 2029 (i.e., closure taking effect in 2026 and 2030), with these dates being informed by the 2024 updated government projections.[l]

Submissions received through consultation highlighted that carbon capture forms a key part of Concrete NZ's Net Zero Roadmap to 2050.[44] While we do not consider there to be sufficient certainty regarding the application of this technology in cement production to include it in our EB4 demonstration path at this stage, we acknowledge the possibility of deeper emissions reductions relative to our current path.

Fluorinated gases reduce in line with international commitments

Fluorinated gases (known as f-gases), particularly hydrofluorocarbons (HFCs), are greenhouse gases primarily used as refrigerants in fridges, freezers, and air conditioning systems.

The EB4 demonstration path assumes greenhouse gas emissions from HFCs reduce by 41% by 2035 and 49% by 2040 relative to 2022, in line with the actions Aotearoa New Zealand takes under the Kigali Amendment to the Montreal Protocol, as well as other policy measures. This assumption is slightly more ambitious than *Ināia tonu nei* where we assumed HFC emissions would reduce 32% by 2035 relative to 2019.

Our assumptions for the EB4 demonstration path are directly based on projections from the Ministry for the Environment[li] around what can be achieved with current policy including:

- reducing the import of HFCs contained within products
- reducing the leakage of HFCs in equipment
- increasing end-of-life recovery of products that contain these gases.

l As noted in Box 5.1 however, Methanex have signalled that when the Motunui plant is returned to production in November 2024, it will be one production train only, and that they will likely operate just the single train for the foreseeable future. The Government may wish to reflect this when responding to our advice.

li The Ministry for the Environment projections include high, low and mid levels of emissions reductions from HFCs based on current policy. We used the low emissions projections.

During consultation, we heard mixed views about our assumed level of emissions reduction from HFCs. In particular, it was suggested that the current focus on end-of-life capture and destruction of f-gases misses the fact that most emissions result from leakage during the operational life of existing refrigeration systems. Submitters believed achieving higher levels of reductions in f-gas emissions would require a refocus onto whole of supply chain visibility, where custody of refrigerants and associated transactions are closely tracked, allowing for improved management of leaks as well as end of life capture and destruction.

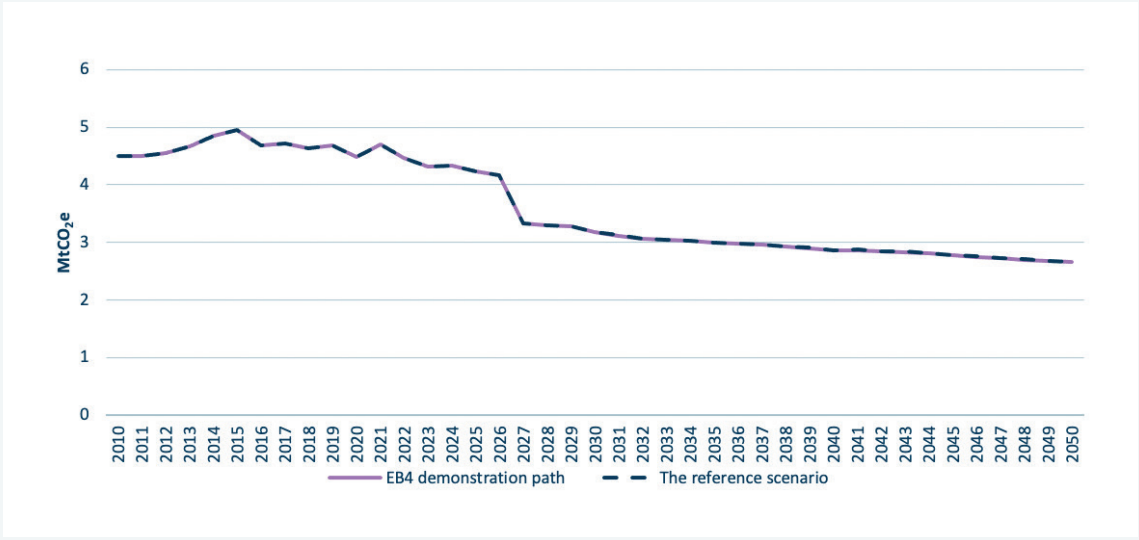
We also understand that the Ministry for the Environment projections have a significant degree of uncertainty, partly due to the difficultly in accurately estimating f-gas emissions.

As a result of these two factors, we have moderated our assumption to align with the government's central projection for f-gases.

Industrial process and product use emissions would reduce as fossil fuels are phased out

As shown in **Figure 5.4**, the actions in the EB4 demonstration path and the reference scenario would result in emissions from industry reducing significantly from 2023 through to 2050. We would see a steep decline in 2027 for both scenarios due to the reduction in coal use in steel production enabled by the electric arc furnace project. The phasedown of hydrofluorocarbons (HFCs) also leads to a decreasing trend in emissions. The assumptions and emissions in the EB4 demonstration path align with those in the reference scenario as we have not identified technically and economically feasible decarbonisation actions beyond what is in the reference scenario.

Figure 5.4: Industrial process and product use emissions in the EB4 demonstration path and the reference scenario



Source: Commission analysis

Transport

Emissions from transport currently make up 17% of Aotearoa New Zealand's gross emissions profile.[lii] In our EB4 demonstration path, these emissions would reduce by 60% by 2040 compared to 2022.

Moving to EVs plays a large role in reducing emissions as well as more use of public transport, walking and cycling. By 2040, we anticipate more than 73% of light vehicle travel[liii] (cars, utes/vans, and motorcycles) and all new and used vehicles entering Aotearoa New Zealand would be electric. Low-carbon liquid fuels would play an important role for transport that is hard to electrify such as air travel and heavy off-road vehicles.

More people would be walking, cycling and using public transport

We assume the total distance travelled by walking, cycling, and public transport would have grown to 15% of all passenger kilometres travelled by 2040. This compares to 5% in the 2021–2022 Household Travel Survey.[45] This assumes that public transport in major centres like Auckland and Wellington will achieve a 20% share of passenger kilometres travelled by 2040. This will require substantial investment in public transport, and cycling and walking infrastructure.

This increase in mode shift and some reduced demand for travel (for example, due to more working from home and more dense urban form) would reduce the overall distances travelled by light vehicles by 19% in 2040, compared to the reference scenario (see Technical annex).

Submitters expressed differing views on the ambition behind our assumptions related to the uptake of active and public transport as a result of behaviour change. We have kept the same assumptions for the EB4 demonstration path as we used in consultation and tested the impacts of higher and lower shifts in our scenario assumptions.

Mode shift and reduced travel demand produce co-benefits for health, congestion, and road safety (see *Chapter 6: The impacts on New Zealanders of meeting the fourth emissions budget*), and reduce dependence on electrification to reduce transport emissions in the EB4 demonstration path.

All light vehicles entering the fleet will be electric by 2040

Electrification is central to transport decarbonisation in our EB4 demonstration path. By 2040, we assume all light vehicles, both new and used, entering the fleet would be zero emissions battery EVs. This results in 73% of light vehicle travel being done in EVs by 2040.

Following changes to policy settings for EVs, the share of light vehicle registrations between January and August 2024 has fallen to 4%, from 14% in 2023.[46] To achieve the EB4 demonstration path, EV uptake must surpass 2023 levels by 2026 and grow rapidly from there.

While the cost of purchasing an EV is currently higher, on average, than a petrol or diesel vehicle, recent trends in battery prices have been showing these costs are coming down.[47] By 2040, we expect the cost of purchasing a new battery EV to be 16% lower than a new petrol vehicle.

lii Commission analysis using the 2024 edition of the GHG Inventory.
liii Light vehicles are those under 3.5 gross tonnes and heavy vehicles are those over 3.5 gross tonnes.

During consultation, submitters pointed to the opportunities to achieve emissions savings from improved vehicle efficiency including the adoption of conventional hybrids. While not explicitly discussed in our draft advice, our analysis does include assumptions about improvements to conventional vehicle efficiency. For example, hybrid vehicles in the demonstration path are assumed to make up 70% of entries to the light passenger ICE vehicle fleet in 2030, which is the same as the reference scenario.

Almost all new trucks would be zero emissions by 2040, with some mode shift from road to rail and coastal shipping

In contrast with the light fleet, the switch to zero emissions heavy vehicles[liv] has been slower than projected in *Ināia tonu nei*. We expect it would take longer for capital costs to reach price parity with petrol and diesel vehicles, when compared to light vehicles – but total cost of ownership for heavy vehicles would be lower in the early 2030s due to the lower cost of operating a zero-emissions heavy vehicle compared to a petrol or diesel equivalent.[lv] In a recent survey of heavy vehicle fleet operators, half had committed to reducing their carbon emissions. However, current barriers to the adoption of new technology include cost and the practicality of operation.[48] Our modelling uses total cost of vehicle ownership to project uptake of new technology into the vehicle fleet. Other barriers identified by the survey include operational constraints such as access to and speed of charging/refuelling. Overcoming these barriers will be key to achieving the EB4 demonstration path.

In addition to switching to zero emissions vehicles, we also assume shifts to lower emissions modes like rail and coastal shipping at the same levels we assumed in *Ināia tonu nei*. This would lower the vehicle kilometres travelled (VKT) of heavy vehicles by 10% by 2040 compared to the reference scenario.

Aviation would decarbonise by switching to electric and utilising low-carbon fuels

Although air travel faces more challenges for reducing emissions than land transport, due to limited potential for electrification, there are some emerging opportunities for lower emissions flights. For example, approximately 40% of Aotearoa New Zealand's domestic air travel is (short haul) regional flights, for which electrification is more viable.[49] In the EB4 demonstration path, we assume battery electric aircraft are gradually deployed, making up 13% of regional trips (5% of total travel) by 2040.[lvi] For inter-regional jet aircraft, the use of low-carbon liquid fuels and improving efficiency are the main mechanisms for reducing emissions. Use of low-carbon liquid fuels grows, gradually reaching 7% by 2040, and 22% by 2050.

We assumed a slower rate of efficiency improvement and electrification than in *Ināia tonu nei*. This is based on improved modelling showing the challenges the sector faces to decarbonise, and our assessment of new evidence around the viability of electrification.[50] For the final advice, in addition to the changes made in the EB4 demonstration path from new evidence, we have incorporated new demand projections that align with those used by the Government. Combined, these changes have resulted in emissions from aviation in the EB4 demonstration path being 59% higher by 2040 than in *Ināia tonu nei*.

liv While we modelled battery electric vehicles, hydrogen is also an emerging technology for decarbonising heavy freight.
lv This is for an 'average' truck, but each vehicle's operating environment will determine where the crossover point is.
lvi Excludes pipeline emissions.

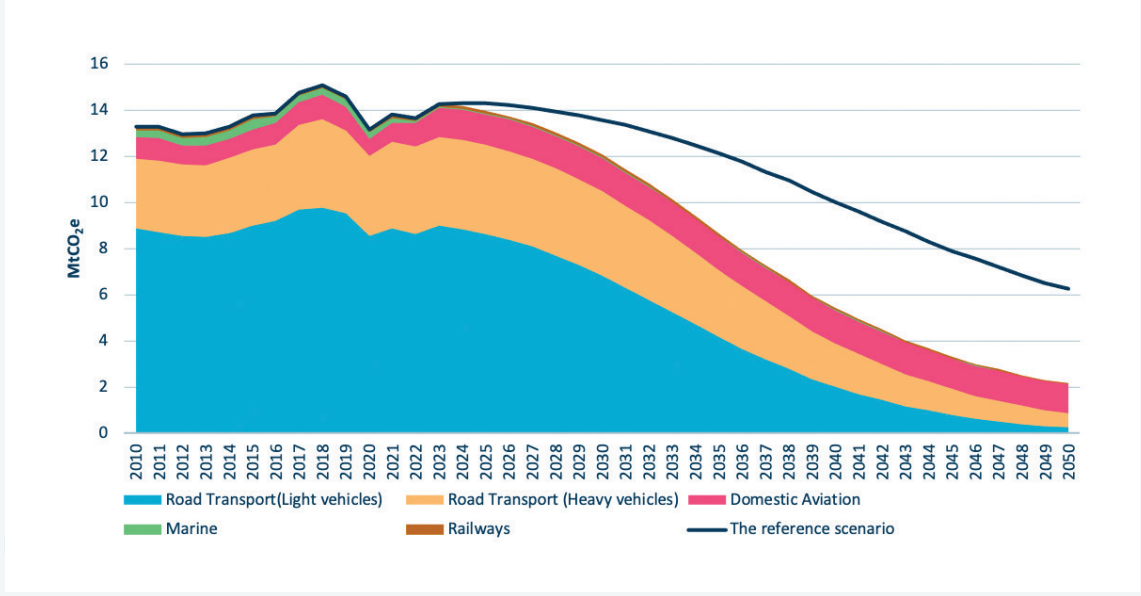
Emissions from transport would reduce dramatically

In our EB4 demonstration path, emissions from light vehicles, which currently make up 63% of total transport emissions, fall steeply from 2022 to 2040 (8.6 $MtCO_2e$ in 2022 to 2.0 $MtCO_2e$ in 2040), as shown in **Figure 5.5**. This is due to the distance travelled by vehicles reducing through greater use of public transport and walking and cycling, and the switch to electric vehicles.

Other parts of the transport system are slower to decarbonise. Heavy vehicle emissions are reduced by half (from 3.8 $MtCO_2e$ in 2022 to 1.9 $MtCO_2e$ in 2040) from the gradual introduction of low emissions vehicles and mode shift to increasingly electrified rail and coastal shipping.

Driven by growing demand, domestic aviation emissions grow between 2022 and 2040 (1.0 $MtCO_2e$ in 2022 to 1.4 $MtCO_2e$ in 2040). While this is a substantial increase, 60% of the increase occurs in 2023, which reflects actual fuel consumption by the sector reported by MBIE.[51] By 2040, aviation is 26% of the remaining transport emissions compared with 8% in 2022.

Figure 5.5: Transport emissions in the EB4 demonstration path and reference scenario[lvii]



Source: Commission analysis

lvii Excludes pipeline emissions.

Agriculture

Agriculture emissions currently make up 53% of Aotearoa New Zealand's gross emissions profile.[lviii] In our EB4 demonstration path, these emissions would be reduced by 23% by 2040 compared to 2022. This is primarily due to land-use change, changes in farming practices and uptake of methane reduction technologies.

Changes in farming practices would reduce emissions

The work of the Biological Emissions Reference Group (BERG), the New Zealand Agricultural Greenhouse Gas Research Centre, and others, has identified that changes in farm management practices, such as reducing stocking rates and fertiliser on some farms[lix] can reduce emissions while improving animal performance (productivity).[52]

In the EB4 demonstration path, stocking rates are reduced by 20% for dairy and 15% for sheep and beef farms by 2050, with an associated 12% reduction in nitrogen fertiliser use, compared to 2022.

Lower stocking rates in combination with land-use change results in 1.3 million (21%) fewer dairy cattle, and 11 million (25%) fewer sheep and beef stock units in 2050 compared to 2022.

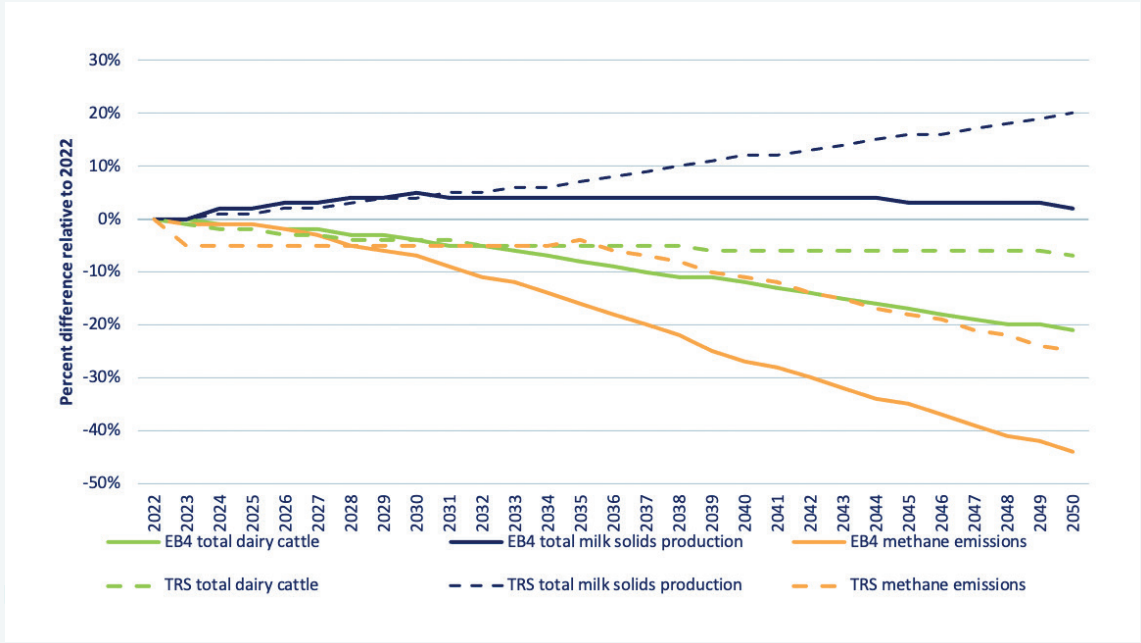
Figure 5.6 shows that it is possible to reduce methane emissions from the dairy sector while maintaining relatively stable levels of milk solids production, with reductions in total dairy cattle numbers. This assumes that improvements in on-farm efficiency continue at a similar rate to recent trends. However, this means that production and revenue would not grow as projected under the reference scenario.

In the EB4 demonstration path, total meat production from the sheep and beef sector would reduce by 17% by 2050 compared to 2022. This is similar to what we would expect under the reference scenario and is shown in **Figure 5.7**.

lviii Commission analysis using the 2024 edition of the GHG Inventory.

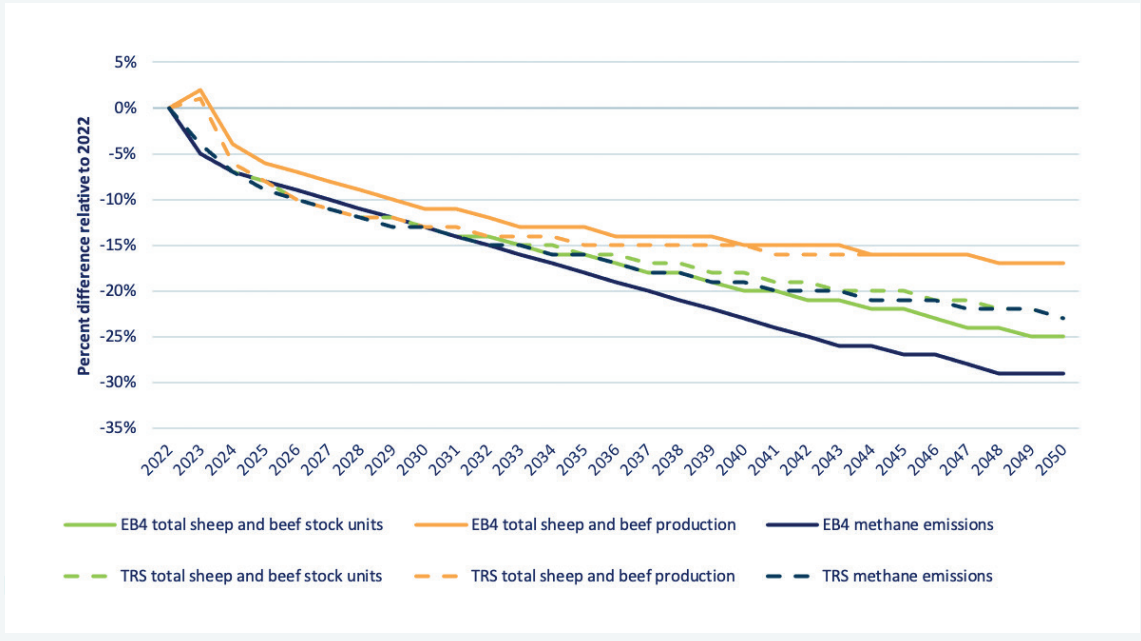
lix Farms that are already operating at close to optimal efficiency may not be able to reduce emissions without reducing profitability, but some farms are expected to be able to reduce emissions while maintaining or increasing profitability.

Figure 5.6: Dairy cattle numbers, milk solids production and methane emissions for dairy in the EB4 demonstration path and the reference scenario (TRS) relative to 2022 dairy values



Source: Commission analysis

Figure 5.7: Sheep and beef stock unit numbers, meat production and methane emissions in the EB4 demonstration path and the reference scenario (TRS) relative to 2022 sheep and beef values



Source: Commission analysis

Developing technologies offer more potential to reduce emissions

The biggest driver of changes in agricultural emissions in our EB4 demonstration path compared to *Ināia tonu nei* is new research around when new and emerging methane reduction technologies are likely to be adopted.[lx]

In our EB4 demonstration path, we assume that urease inhibitor, farm effluent treatment, and low methane producing sheep genetics are introduced. These technologies are already available and being adopted to different extents. We now also expect the ability to genetically select for low emitting dairy cattle before 2030.[53]

For other technologies, the future is more uncertain. There is much research being done on methane-reducing technologies, including methane vaccines and methane inhibitors. While there are methane inhibitors available overseas, they are currently not suitable for Aotearoa New Zealand's pasture-based agriculture.[54] Methane vaccines are also not currently available – research suggests that a vaccine could be available for dairy and sheep and beef by 2035.

To account for this uncertainty in the EB4 demonstration path, we assume generally that some methane-reducing technologies would be taken up but do not specify the technology. In total we expect methane-reducing technologies would reduce emissions by 4.4 $MtCO_2e$ in the fourth emissions budget period.

Unlike *Ināia tonu nei*, we are not assuming nitrification inhibitors would be taken up as the costs are high compared to the other technologies (around NZ$1,700 per tCO_2e compared to options such as selecting for low methane animals that could cost NZ$34 per tCO_2e).[lxi]

Converting land to lower emissions uses

In the EB4 demonstration path, some land is converted to uses that have lower emissions.

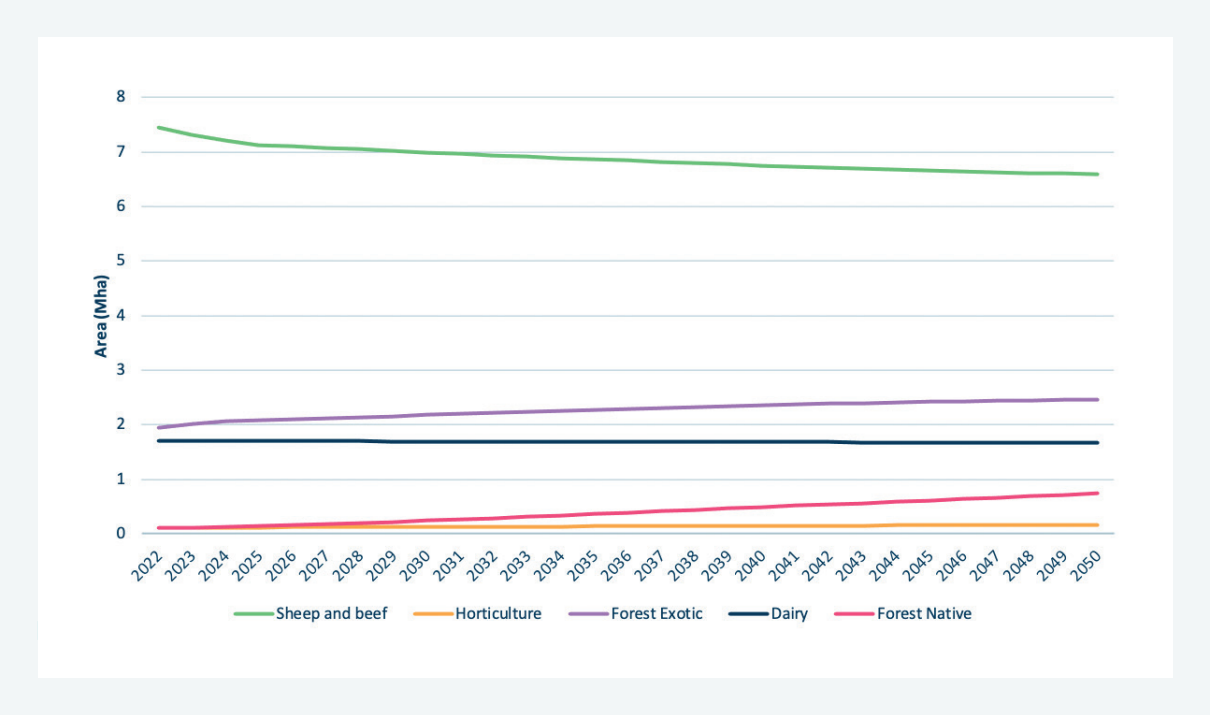
We heard concerns from submitters about the rates of land-use change from sheep and beef land into exotic forestry in our consultation draft. There were concerns in the agricultural sector that conversions of farms to forests had an adverse effect on local communities. In our final advice, less sheep and beef land is converted to forestry, as rates of exotic afforestation were reduced in the EB4 demonstration path after consultation (see Forests section). Overall, sheep and beef land area decreases approximately 853,000 ha (11%) by 2050 compared to 2022 (**Figure 5.8**). By 2050 the area used for sheep and beef farming would be approximately 184,000 hectares (3%) greater in our EB4 demonstration path than under the reference scenario.

In the EB4 demonstration path, land used for dairy decreases 32,000 ha (2%) by 2050 compared to 2022, a more gradual decline than the actual reduction in dairy land that occurred between 2017 and 2022. While land used for dairy, and for sheep and beef decreases, horticultural land increases 54,000 ha (48%) between 2022 and 2050, a similar rate of increase as between 2017 and 2022.

lx Our assumptions for the EB4 demonstration path are based on a report by The Agribusiness Group that reviewed the latest evidence on agricultural technologies. We have published this report as part of the supporting information and data that accompanies this advice.

lxi In *Ināia tonu nei*, we assumed nitrification inhibitors would be used after 2035.

Figure 5.8: Summary of projected land use from 2022 to 2050 in the EB4 demonstration path



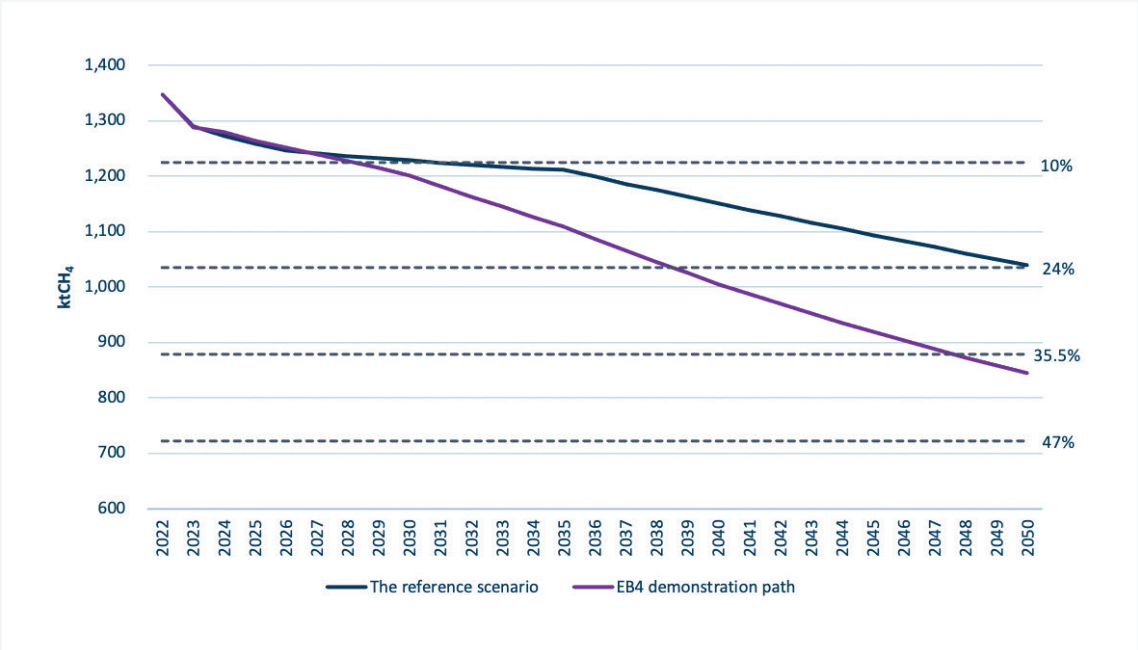
Source: Commission analysis

Impact on emissions

More technology being available in the EB4 demonstration path, alongside improved practices, would mean emissions could reduce considerably to meet the fourth emissions budget. Recent changes in land use and smaller dairy herds mean emissions from this sector are starting at a lower point since *Ināia tonu nei*. Our analysis shows it is possible to achieve a 38% reduction of biogenic methane relative to 2017 levels (about the midpoint of the biogenic methane target range) by 2050 (**Figure 5.9**).

This compares to *Ināia tonu nei* where our analysis suggested Aotearoa New Zealand could only reach the less ambitious end of the target range – based primarily on implementing practices that are already available. This reflected the technology and systems we expected would be available for the first three emissions budgets. With an additional five years until the fourth emissions budget and the developments in relation to methane-reducing technologies discussed above, we assume increasing availability of technologies in the fourth emissions budget period.

Figure 5.9: Reduction of biogenic methane from agriculture and waste in our EB4 demonstration path in relation to the 2050 target



Source: Commission analysis

Forests

Aotearoa New Zealand's forests play an important role in the country's transition by removing carbon from the atmosphere. This carbon removal activity allows net emissions to be lower than they would be from gross emissions reductions alone.

In addition to storing carbon, forests provide the supporting service of habitat to other species, while their regulating services include functions like water quality, air quality, and land stabilisation. Production forests also provide many of these wider ecosystem services, in addition to the provisioning service of timber production and biomass, which supports the bioeconomy and the energy transition, such as biomass for process heat. However, some management practices of production forestry, for example clear-fell harvesting, can reduce benefits and result in negative outcomes.

There is less exotic forestry in the EB4 demonstration path than in previous advice

The overall amount of exotic forestry in the EB4 demonstration path is lower than that modelled in *Ināia tonu nei*. Since actual planting rates of exotic forestry in 2020–2022 were much higher than projected in *Ināia tonu nei*, and due to the opportunities for gross emissions reductions, not as much exotic forestry is needed through to 2050 to reach and maintain the net zero portion of the 2050 target. We have incorporated lower exotic planting rates for the next few years through to 2030, based on intentions signalled in the 2023 Afforestation and Deforestation Intentions Survey and the long-term (1990–2022) average, reflecting what we heard through consultation on the EB4 draft advice and other engagements over the past year (see **Figure 5.10**). After 2030, the amount of exotic afforestation in the EB4 demonstration path reduces each year, to a level that would be consistent with providing removals that would maintain net zero emissions of long-lived gases beyond 2050, given assumptions about gross emissions levels.

The EB4 demonstration path also implements a much higher level of native afforestation and reforestation compared to current planting rates to provide a long-term carbon sink (see **Figure 5.10)**.

Over the entire period (2022–2050), exotic afforestation totals 588,000 ha and native afforestation totals 641,000 ha in the EB4 demonstration path (see **Table 4.1** for comparison to other scenarios).

The amount of permanent deforestation (i.e., land-use change) included in the EB4 demonstration path is lower than the reference scenario.

Figure 5.10: Exotic and native afforestation and deforestation in the EB4 path

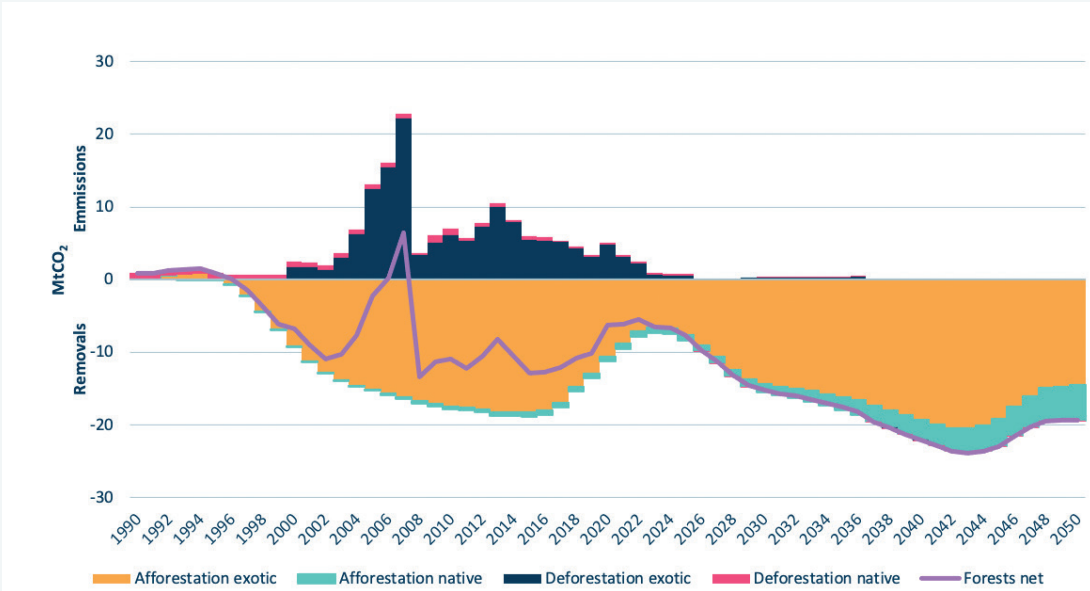
Source: Commission analysis

Carbon dioxide removals from exotic forests comprise most of the carbon dioxide removals in the EB4 demonstration path until 2050, but native forests play a role over the longer term (**Figure 5.11**). Some native forests have slower growth rates (and thus slower carbon removal) than some exotic species. Whereas exotic forests can generally sequester carbon quickly, removals from native forests continue over a longer time period.

Native forests generally store more carbon per hectare over a longer period so can provide an enduring carbon sink for Aotearoa New Zealand for tens to hundreds of years, with significant co-benefits.

Overall, exotic forests remove 90 $MtCO_2e$ and native forests remove 12 $MtCO_2e$[lxii] during the fourth emissions budget period in the EB4 demonstration path.

Figure 5.11: Carbon dioxide emissions and removals by exotic and native forests in the EB4 demonstration path



Source: Commission analysis

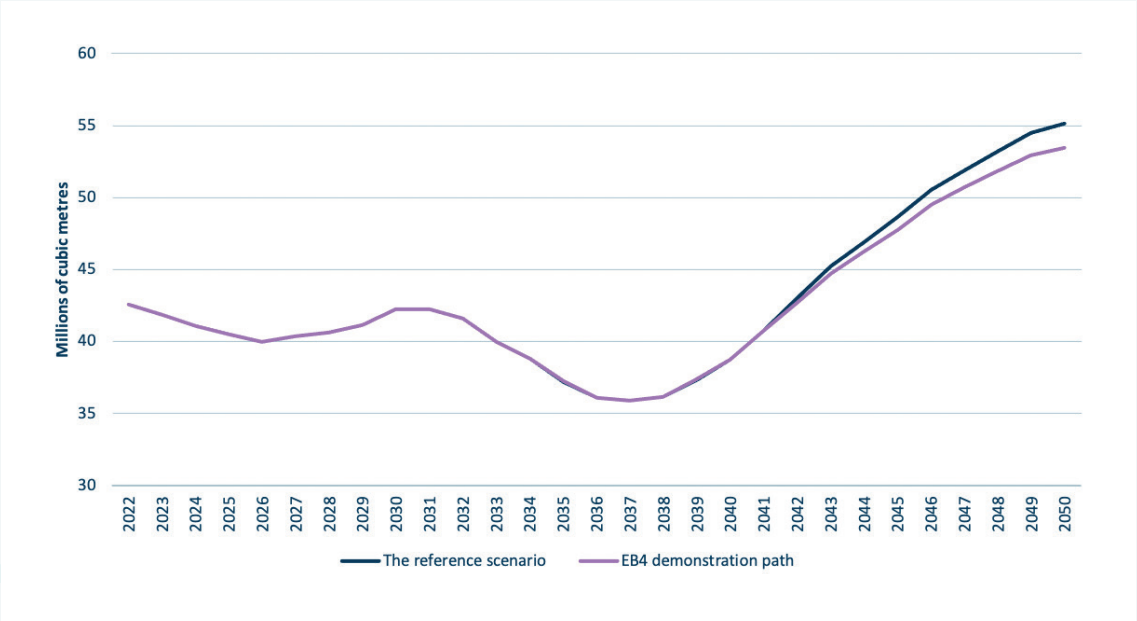
lxii The accumulation of carbon dioxide sequestration in native forests may be a conservative estimate, as the model's carbon table for native forests is limited. Likely, higher rates of carbon accumulation may occur in some types of planted tall native forests, which can be reflected in future models when data become available.

Volume of wood products would decline after 2040

Over the fourth emissions budget period (2036–2040), the volume of wood products harvested in the EB4 demonstration path matches the level in the reference case until the early 2040s (**Figure 5.12**). This is due to the same amount of planting activities until 2023, assuming exotic forests follow 28-year harvesting cycles.

From 2042, fewer harvested wood products are produced relative to the reference scenario to 2050. In 2050, there are 1.7 million cubic metres fewer harvested wood products (total recoverable volume) in the EB4 demonstration path. This difference is due to the lower level of exotic afforestation from 2024 onwards, and therefore fewer harvested wood products.

Figure 5.12: Volume of harvested wood products in the EB4 demonstration path and reference scenario



Source: Commission analysis

Waste

Emissions from waste account for 4% of Aotearoa New Zealand's current gross emissions profile.[lxiii]

Under our EB4 demonstration path, these emissions would be reduced by 26.7% by 2040 compared to 2023.

Reusing and recovering waste materials is a key part of moving to a more circular and lower emissions economy. The EB4 demonstration path would see a reduced amount of waste generated and a focus on reducing the amount of organic waste (such as food, wood and paper) going to landfill.

We can go further on organic waste

Organic waste is the largest source of emissions in the waste sector as it produces methane when it breaks down in landfill.

Through consultation we heard from submitters that the overall level of waste reductions in the EB4 demonstration path is very ambitious and will require extensive systems change, especially with regard to organic waste diversion. We have kept our assumptions the same, but acknowledge that achieving these outcomes will require the Government to put policies and plans in place through future emissions reduction plans.

Overall, our EB4 demonstration path assumes the amount of organic waste going to landfill will approximately halve by 2050. This would mean much less organic waste going to landfill than we anticipated in *Ināia tonu nei* (where we assumed 34% less by 2050). Activities such as commercial and household food waste diversion would contribute to this goal. Modelling assumes that effective regulation will also be in place to support a significant reduction in organic waste disposal to landfill.

Our assessment that there are more abatement options for this sector builds on analysis in our *Advice on the direction of policy for the Government's second emissions reduction plan*.[lxiv] We estimate that increased action could:

- double the amount of wood being diverted from landfill to other uses (for example through product stewardship schemes)[lxv]
- divert 80% of food and 95% of garden waste to composting or anaerobic digestion by 2050.

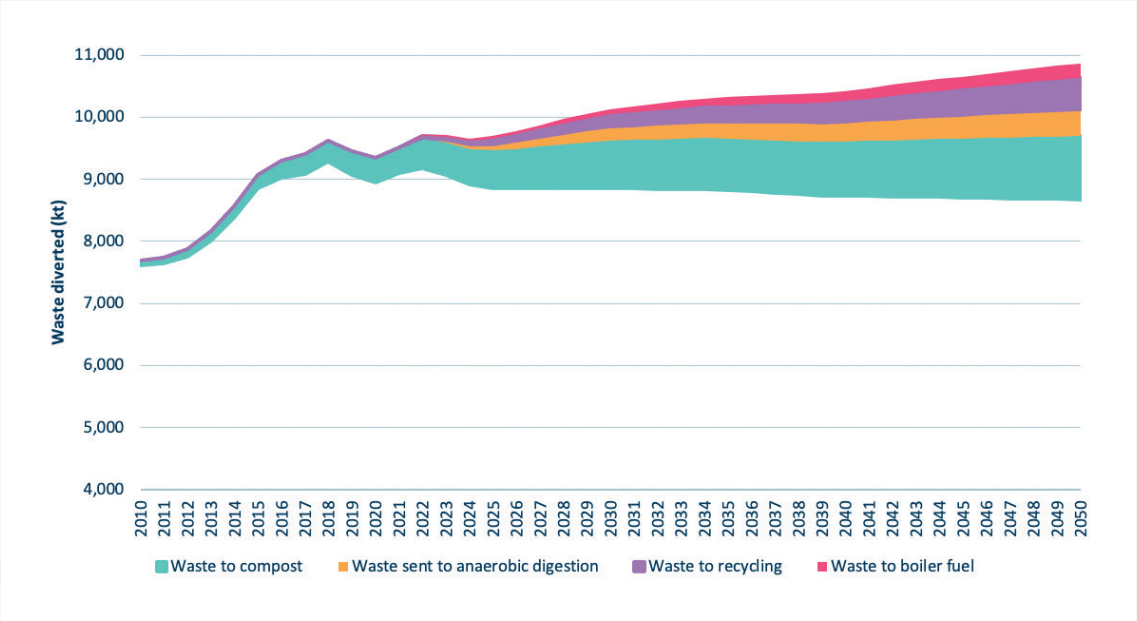
As shown in **Figure 5.13** a large portion of diverted waste would go to compost or anaerobic digestion facilities.

lxiii Commission analysis using the 2024 edition of the GHG Inventory.

lxiv For example, recommendation for regulated product stewardship for construction wood/waste and planned Government policy, regarding the circular economy, behaviour change and policy intervention to reduce food and garden waste to landfill.

lxv Product stewardship is where producers, brand owners, importers, retailers, or consumers participate in an accredited product stewardship scheme which reduces the harm caused by products at end-of-life and supports the recovery of raw materials that are normally lost when these products become waste.

Figure 5.13: Amount of waste (kt) diverted from landfill in the EB4 demonstration path



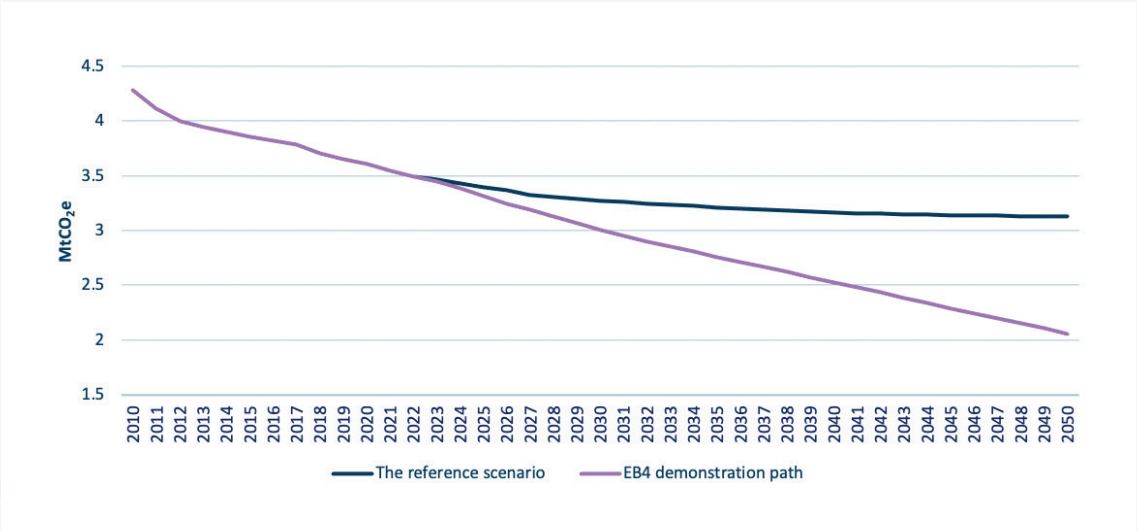
Source: Commission analysis

Consistent with our draft advice, the EB4 demonstration path also assumes that operative non-municipal landfills will install landfill gas capture systems and 30% of methane generated by non-municipal landfills will be captured by 2050.

Impact on emissions

As shown in **Figure 5.14**, for the fourth emissions budget period, we assume total emissions from waste would be 1.1 $MtCO_2e$ less than in the reference scenario.

Figure 5.14: Emissions from waste in the EB4 demonstration path compared to reference scenario



Source: Commission analysis

Wāhanga 6 | Chapter 6

Te whiunga ki a Aotearoa i tōna whakatutukinga i te tahua tukuwaro tuawhā The impacts on New Zealanders of meeting the fourth emissions budget

This chapter sets out what the changes to achieve the proposed fourth emissions budget might mean for people, in terms of opportunities and challenges across the country.

The role of He Pou a Rangi Climate Change Commission (the Commission) in advising the Government requires us to consider the implications of decisions about emissions reduction for the country as a whole. This is fundamental for informing key judgements we need to make in preparing advice on the fourth emissions budget, and will be important for the Government to consider when making final decisions.

The impacts of meeting an emissions budget cover all the changes that can be expected, both positive and negative, from the actions required to achieve the new level of emissions reductions. We take into account the opportunities and risks, and the way these might vary in size and timing depending on choices about how emissions are reduced.

The wide range of matters we consider includes social, cultural, environmental and ecological circumstances, including differences between sectors and regions. We consider the Crown–Māori relationship, te ao Māori, and specific effects of our advice on iwi/Māori. The Climate Change Response Act 2002 (the Act) also requires consideration of the distribution of impacts across regions and communities, and from generation to generation.

The first section sets out how we make this assessment of changes that might be felt in a future period, and how they are measured. This builds on the approach the Commission used to assess the potential impacts of meeting the first three emissions budgets and the 2050 target as part of *Ināia tonu nei*, when we provided advice on the level of the first three emissions budgets.

The following sections step through different potential impacts of the EB4 demonstration path set out in Chapters 3–5. Understanding the likely opportunities and challenges enables us to understand how New Zealanders will be affected by the fourth emissions budget, and if the impacts on the economy, businesses, households and whānau, regions and communities, iwi/Māori, and the environment can be managed in an equitable way.

Changes from the draft version of this chapter

This chapter reflects our reassessment of the potential impacts of actions to reduce emissions, which was informed by new evidence and insights from consultation.

The revised modelling results had only a small effect on our estimates of the quantified impacts, including economic and health impacts.

Generally, our assessment of how changes could affect people, businesses and communities over time and across the country is largely unchanged from draft advice. In many places in this chapter, however, we have revised our description of impacts to reflect insights provided in feedback. This includes our reporting of effects specific to iwi/Māori to better articulate the whakaaro heard in engagement around our draft advice.

We have also responded to feedback about household costs and opportunities in the transition to a low emissions economy. We added a section about options for rooftop solar, home batteries and electric vehicle use; and we also updated information about electricity prices, and petrol and diesel prices.

How we assessed the possible impacts

The range of matters that need to be considered is broad. We look at the effects across Aotearoa New Zealand's wider economy, society and environment, and consider the Crown–Māori relationship, te ao Māori and the specific effects for iwi/Māori. This is required in the Act, as shown in *Chapter 1: Introduction*, under 'Matters we considered in developing this advice'.

Assessing the consequences of choices for a future period is challenging, even as an idea. We have followed the process set out in our earlier work on the first three emissions budgets, as set out in *Ināia tonu nei*.

The first step is to identify what actions would be needed to achieve the proposed greenhouse gas emissions reductions, in this case for the fourth emissions budget for 2036–2040. This is what is covered in the 'EB4 demonstration path' as shown in *Chapter 3: Recommended level for the fourth emissions budget*. The focus is on the difference between 'what would be happening already' and 'what would need to change to achieve further reductions'.

Our analysis uses the modelling explained earlier. We compare what is already expected to happen, as shown in our 'reference scenario', with what needs to happen for our EB4 demonstration path. For example, when we look at the savings from electric vehicles, we estimate this based on the difference in the number of electric vehicles in the reference scenario, and the number of electric vehicles in the EB4 demonstration path.

Comparison with the reference scenario allows us to isolate the specific actions needed to reduce greenhouse gas emissions as set in the EB4 demonstration path. That lets us assess the likely nature and size of the impacts of meeting the fourth emissions budget.

Our assessment assumes that the EB4 demonstration path is followed. Delays in acting to achieve the emissions reductions needed to meet the emissions budget could intensify negative impacts and delay the availability of opportunities presented by the transition to lower emissions. The greater level of negative impacts is expected because delayed action can require abrupt changes to meet the budgeted reductions, and abrupt changes have greater overall impacts.

The choice of actions taken to meet the fourth emissions budget will determine the impacts and how they are distributed across groups

The specific actions taken to achieve the fourth emissions budget, and the policies introduced to encourage them, will determine the size and speed of changes needed. These choices also affect how any changes will be experienced differently in different regions, groups of people or economic sectors – we talk about 'distribution of impacts'. The policy decisions are a future task (we will provide advice on those options for an emissions reduction plan, which the Government considers when it prepares its draft and final plans). However, considering the effects of potential actions when setting the fourth emissions budget level allows the Government to make decisions on whether the effects can be managed, and what supporting policies may be needed. We took the size, speed and distribution of impacts into account in the judgements that underlie our recommended fourth emissions budget; the Act also requires these effects to be considered by the Government when making final decisions.

A number of factors (see **Box 6.1**), some outside government control, will determine how changes actually occur to meet the fourth emissions budget, and therefore how different sectors, regions and communities will be affected.

Box 6.1: Key factors that will affect how people and communities are impacted

Setting the level of an emissions budget does not on its own have direct impacts on people. It is the choices made to achieve the budget that will determine the impacts that the budget creates. Some of these choices are made by the Government, others by individuals, businesses, industries or even the international community. Factors that may affect how the change is experienced by people include:

- **policies and signals** – the overall mix of policies (including through emissions pricing) as well as individual policy design, and other signals from the Government
- **Government choices** – the choices the Government makes about whether and how to support vulnerable groups
- **technology** – the development, pace, availability and cost of technology
- **behaviour change** – the willingness and extent of behaviour change across individuals, groups or businesses, and society
- **investment** – the extent and pace of public and private investment in enabling businesses and communities to take action
- **international context** – the influence of international policy on Aotearoa New Zealand's products, international regulation, or external shocks such as COVID-19
- **climate adaptation** – the effects of a changing climate on people and the choices around climate adaptation.

Economic impacts of meeting the fourth emissions budget

Overall assessment of the economic impacts

How the economy will change and grow between now and 2050 will depend on a wide range of factors, of which action to address climate change is just one. Our judgement, informed by the evidence we have gathered and the results of our modelling, is that the expected economic effects of meeting the fourth emissions budget in the way we have demonstrated should not be a barrier to Aotearoa New Zealand acting to reduce its greenhouse gas emissions.

Our analysis shows that if the country took the actions in the EB4 demonstration path the overall effect would be economic and social gains. This depends on making changes that reduce gross emissions, and can unlock co-benefits.

As above, we recognise that estimating changes 15 or more years into the future is difficult, and there are a range of factors that can influence how that change occurs, including successive governments' choices about policies (see **Box 6.1**).

We draw on a range of perspectives to understand the potential impacts of the fourth emissions budget

To understand the potential impacts of the fourth emissions budget we have used a range of models and approaches to make our assessment. Individually each perspective has limitations, but by combining perspectives we are able to arrive at a more comprehensive assessment of the changes involved in following the EB4 demonstration path. Our conclusions about the economic impacts are based on considering the results of these different perspectives together.

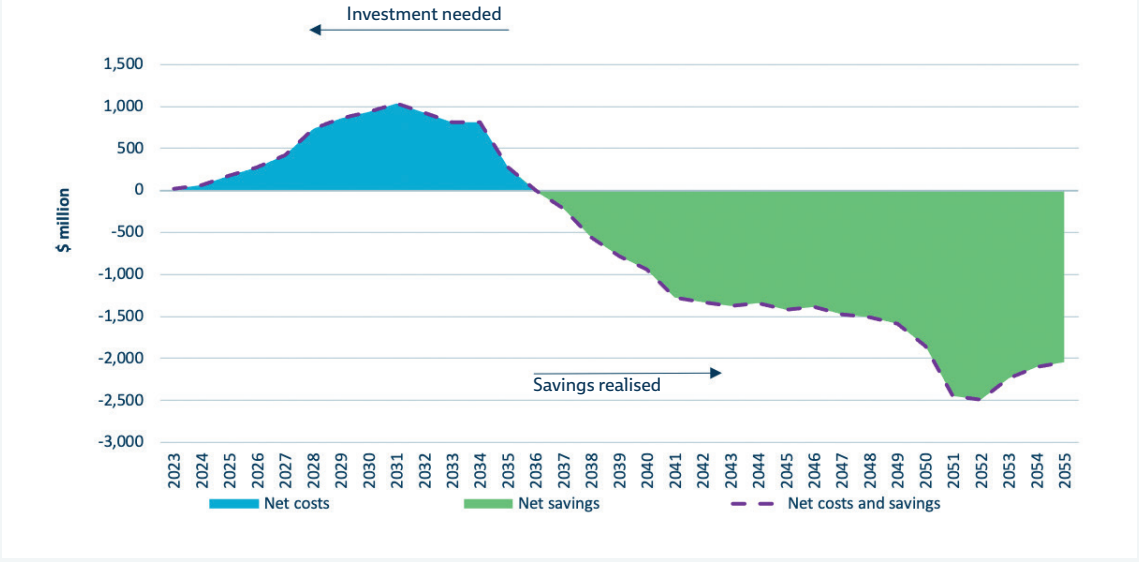
Investment in climate action will lead to large direct cost savings

We have looked at the changes in **direct financial costs** under the EB4 demonstration path relative to the reference scenario. This reflects the expected changes in investment and operating costs for technologies in key emitting sectors, including transport, energy, industry and agriculture. We have used the Energy and Emissions in New Zealand (ENZ) model to make this assessment. This analysis provides a perspective on the overall change in costs to households and businesses from adopting certain emissions reduction actions.

The ENZ model shows that, for many of the actions in the EB4 demonstration path, investments made in low emissions technologies will more than pay for themselves in the long term through fuel savings and lower maintenance costs.

Figure 6.1 shows changes in financial investments and savings from following the EB4 demonstration path. The increase in investment in the short term would lead to a payoff beyond 2036 from reduced costs of operation. Savings would come from improved efficiency, lower energy costs and lower maintenance costs of lower emissions technologies. Savings would grow to NZ$1 billion per year by the end of the fourth emissions budget period.

Figure 6.1: Projected annual change in investment and savings from fuel switching across domestic road and air transport, buildings and process heat sectors in the EB4 demonstration path compared to the reference scenario[lxvi]



Source: Commission analysis

The economy will continue to grow through the transition

We have also considered the **whole of economy** effects of following the EB4 demonstration path. This perspective helps us to see the big-picture effect of our proposals on the economy, as well as how things shift between sectors within the economy.

We have used the Computable General Equilibrium (CGE) model C-PLAN, developed for the Commission, to assess how the EB4 demonstration path might alter the projected growth of the overall economy, measured using gross domestic product (GDP).[lxvii]

Since consultation on the draft advice we have updated the model and underlying data sets it uses to include the latest available global trade data, and updated emissions data (see *Technical annex* for further explanation).

After having made the relevant updates and run the analysis, results suggest that following the EB4 demonstration path would mean the level of GDP in 2050 would be around 1% lower than if Aotearoa New Zealand follows the reference scenario.[lxviii]

lxvi This cost analysis includes estimates of future spending on electricity distribution networks.

lxvii Gross domestic product (GDP) is a measure of the size of a country's economy. While this is often interpreted as a measure of wellbeing or economic welfare, there are limits to what is included in GDP. For example, GDP does not factor in changes in the state of the environment, or changes in the quality of life from improvements to health. It is possible that some actions in the EB4 demonstration path (such as increasing walking and cycling) could increase wellbeing, but decrease GDP.

lxviii The estimated change in GDP should be considered in the context of the great uncertainty inherent in predicting the level of GDP over 25 years.

For the fourth emissions budget period we anticipate that following the EB4 demonstration path would not lead to a noticeable change in the level of GDP compared with the reference scenario. While overall the modelling suggests the budget would have a negligible impact on GDP in the period 2036–2040, we expect it to result in a different pattern of economic activity than the reference scenario – with the output of some sectors increasing and others decreasing. The distribution of these changes will also depend on the policies chosen to achieve the budget.

Action to reduce emissions will be one of many factors that determine the trajectory of economic growth, and this result does not incorporate the effect of a changing climate on growth, or benefits from actions to reduce emissions outside the market, such as improvements in human health, or the economic impact of those improved health outcomes.

There are specific limitations of C-PLAN that should also be considered:

- CGE models, including C-PLAN, assume that both capital and labour are fully utilised in the baseline, with both being optimally allocated across sectors. Therefore any scenarios that alter the pattern of economic activity are likely to result in reduced production and therefore GDP, according to the model.
- Like many CGE models, C-PLAN assumes that businesses and households are able to adjust perfectly in response to, and/or make, the changes happening in the EB4 demonstration path. While in reality, financial, behavioural or technological constraints will mean that this is a simplification, CGE models still provide useful insights.
- The model includes the main emissions reduction actions from the EB4 demonstration path, but it has not been possible to represent all of them. As a result C-PLAN reduces output in some sectors to meet the imposed emissions constraint, where in reality we expect there to be ways to reduce emissions in these sectors. This limitation is expected to result in an overestimated size of expected change in GDP.
- C-PLAN looks only at market transactions, and does not account for the non-market changes that climate actions can drive – including changes in ecosystem services, human health, or cultural values.
- None of the C-PLAN scenarios considers the expected effects of the physical impacts of climate change (such as droughts, floods, forest fires, changing weather patterns) on economic output. Experience from recent extreme weather events suggests the impact of these events could be substantial. While recovery from these events could boost economic activity in the short term, it diverts resources from other productive uses.

Box 6.2 Other approaches to estimating the wider economic effects of climate action

Other jurisdictions have modelled the impacts of emissions reductions using different types of modelling approaches built on the assumption that the economy can have unused capacity and the additional investment in decarbonisation can provide a stimulus that boosts total economic output. International studies using these macro-econometric models suggest that GDP could be boosted through climate action.[lxix]

OECD modelling from 2017 found that implementing a mix of economic and climate policy reforms could result in GDP 2.8% higher on average across G20 countries, compared to continuing existing policies.[55] Modelling for the UK Climate Change Committee using a macro-econometric model also found that increased investment, stimulating activity and employment, along with increased savings (or reduced operating costs) would lead to a potential boost to GDP of around 2% by 2035.[56]

There are wider economic benefits of the actions in the EB4 demonstration path

As discussed above, many of the wider effects of actions that reduce greenhouse gas emissions are not accounted for when assessing potential changes in GDP. Many actions to reduce emissions can have indirect 'co-benefits' – such as improving human health, supporting biodiversity, or improving other environmental systems. For some of the co-benefits we have been able to quantify the expected impacts. Many others are described qualitatively.

Burning fossil fuels produces a range of pollutants beyond carbon dioxide that have significant impacts on human health, including reduced quality-of-life and lost productivity through increased hospitalisations, childhood asthma, restricted activity days, and premature mortality. We have used the Government's published guidance[57] to quantify the benefits from improved local air quality due to reduced burning of fossil fuels in our EB4 demonstration path.

We have estimated that the reduction in transport fossil fuel demand under the EB4 demonstration path would lead to improvements in air quality valued at on average NZ$2.1 billion a year over the fourth emissions budget compared to the reference scenario.

lxix For more information see https://www.climatecommission.govt.nz/public/Evidence-21/Evidence-CH-15-How-we-earn-our-way-in-the-world.pdf pg.14–17.

There are other co-benefits from the EB4 demonstration path, but we have not been able to quantify the value of these for this advice. These include:

- better health from homes that are more energy efficient and warmer, as well as from people walking and cycling more
- improved biodiversity and resilience to the physical effects of climate change (such as flooding and land erosion in high rainfall events), through much larger planting of native forests
- improved soil and water quality from changes to farm management such as managing supplementary feed, and adjusting stocking rates and fertiliser use.

According to the Intergovernmental Panel on Climate Change, the potential for 'synergies' or benefits across other goals, including health and equity, is greater than the potential for negative impacts or trade-offs.[58]

The size of these co-benefits would depend on the specific actions taken to achieve the fourth emissions budget, including policy choices by the Government. For example, actions that focus on improving walking and cycling can bring much larger benefits than those focused on electric vehicles alone.[59]

While it is not possible to estimate a monetary value for some of the benefits, **Table 6.1** provides an indication of scale of some of these co-benefits.

Table 6.1: Non-quantified co-benefits of the EB4 demonstration path

Benefit	Action in the EB4 demonstration path	Potential scale of benefit
Energy efficiency	Improved insulation and heating – increases energy efficiency and reduces exposure to mold and allergens, as well as the risk of respiratory issues and lung cancer. In the EB4 demonstration path, we have assumed that the energy efficiency of new and existing buildings would improve over time (reducing the demand for heating by 19% for residential buildings).	Health benefits from EECA's Warmer Kiwi Homes has been found to generate at least NZ$4.36 in benefits for every NZ$1 of government investment.[60] In 2017, damp or moldy housing in Aotearoa New Zealand was estimated to lead to 6,276 hospitalisations, representing a cost of NZ$36 million.[61] Greater energy efficiency can also save costs to households.
More active transport	Access to active types of transport such as walking and cycling can improve individuals' health, including mental health.	Healthcare cost savings from switching 50% of short vehicle trips to walking and cycling have been estimated to be up to NZ$1.25 billion (across the lifetime of the New Zealand population alive in 2011).[62]
Improved biodiversity and resilience to climate change	For the fourth emissions budget we see native planting playing an important role, particularly on marginal or highly erodible land – reducing emissions while improving biodiversity and resilience to climate change.	The cost of landslides following Cyclone Gabrielle was conservatively estimated at NZ$1.5 billion, so the scale of these benefits should not be underestimated.[63] Facilitating planting on agricultural land to support more diverse or 'mosaic' landscapes can provide greater biodiversity, and more diverse income, as well as improve soil and water quality.
Soil and water quality	Changes in stocking rates, nitrogen fertiliser use, pasture management, and supplementary feed in the EB4 demonstration path would bring co-benefits for water and soil quality.	Management practices already in commercial use could potentially improve the efficiency of nitrogen use on farms. This could, in turn, potentially reduce nitrogen leaching by more than 30% and greenhouse gas emissions by more than 15%.[64]

There is a risk to export markets if Aotearoa New Zealand does not act

We have also considered what the potential implications for Aotearoa New Zealand's economy could be if it does not respond to climate change by acting to reduce greenhouse gas emissions, or if that action is considered by others to be inadequate. A major source of Aotearoa New Zealand's export earnings comes from agricultural and primary products, including meat, wool, milk and wood.

We have observed a trend towards greater transparency around emissions reporting for companies, and some jurisdictions are increasingly implementing or exploring policy that would seek to restrict market access for products which do not meet emissions standards. If Aotearoa New Zealand fails to act to reduce emissions there is a risk that access to some markets could be restricted. While it is not possible to quantify this risk, we expect that the actions included in the EB4 demonstration path would decrease the likelihood that other countries would act to restrict market access for Aotearoa New Zealand's primary products. We also consider that these actions would put exporters in a stronger position to demonstrate value from providing lower emissions products to consumers.

Impact on public spending and borrowing will depend on policy

The fourth emissions budget is also expected to affect central government taxation and spending. For example, accelerating the transition to EVs under the EB4 demonstration path is expected to result in a change in revenue collection from fuel excise duties towards road user charges. Other sources of central government revenue are expected to be affected, including Waste Levy funding.

The impacts on public spending will also be determined by the mix of policies that future governments choose to implement to achieve emissions budgets. These are choices for the government of the day.

Our analysis has not identified any concerns about the potential impacts of emissions budgets on taxation, public spending or borrowing, that are not most appropriately addressed by the government of the day. We assess the expected changes to taxation and public spending as manageable, but the Government will need to plan for these.

Considering specific effects for iwi/Māori

The Commission's role in advising the Government requires us to consider the implications of decisions about Aotearoa New Zealand's climate response, including for the Crown–Māori relationship, te ao Māori and the specific effects for iwi/Māori (see *Chapter 1: Introduction*).

This section presents our understanding of likely effects for iwi/Māori of the country following the EB4 demonstration path. It recognises the potential benefits presented by the transition to a lower emissions economy, as well as the accompanying need to increase resilience to the impacts of climate change. This is based on what we have heard through our recent consultation, as well as earlier engagement and consultations, and from research.

Through engagement, previous consultations, and Maui.Tech case studies we have heard about iwi/Māori climate leadership, expressed through intergenerational taiao strategies and grounded in tikanga and mātauranga Māori. A key element for Aotearoa New Zealand to meet the fourth emissions budget is engagement with iwi/Māori to continue climate leadership. Our analysis and engagement with communities shows this will support faster emissions reduction and help achieve an equitable transition for the benefit of all New Zealanders – as set out in our December 2023 advice to the Government on its next emissions reduction plan.[65]

We heard through submissions that hapori Māori are being disproportionately impacted by climatic weather events as they increase in frequency and severity. Climate change will have distinct and wide-reaching impacts on iwi/Māori, from threatening the unique relationship iwi/Māori have to whenua and te taiao, to the intensification of Māori health inequities. Many Māori live in communities that are exposed to climate risk and at risk of being cut off from important services if transport networks are damaged.[66] A large number of marae around the country are also exposed to climate-related risk. These impacts have implications for social, cultural and economic wellbeing.[67]

We also heard that many iwi/Māori are already helping lead the response to climate change. Māori have important roles to play in communities: as partners of the Crown; leaders of their iwi, hapū; kaitiaki of their whenua; landowners and business owners. Through our work we have heard about the many and diverse ways iwi/Māori are responding to climate change as tangata whenua, rangatira and kaitiaki, in line with their tikanga and kawa.[68]

With an asset base estimated to be worth NZ$70 billion and a projected growth rate of 5% per annum,[69] the potential economic opportunities for iwi/Māori to support the transition are also considerable.

Much of the Māori economy is based directly off the land. The sheep and beef industry makes up 51% of emissions for the Māori economy compared to 30% for the whole of the economy. The Māori economy is also proportionately more involved in dairy, construction, forestry, fishing, education, and transport.[70] Māori also have considerable interests in the tourism and leisure sectors.

We understand that te ao Māori places te taiao and mokopuna at the heart of decision-making. Our Māui.Tech case study work also highlighted how tikanga and mātauranga Māori inform business models, pathways for land-use change, and other social and cultural initiatives that reduce emissions.[71] In 2021, Stats NZ found that 70% of Māori authorities, including 75% of those in the primary industries, were very aware of the potential impacts of climate change, compared with 39% of all Aotearoa New Zealand businesses.[72]

Opportunities and risks for the Māori economy in the transition

The strong land base of iwi/Māori provides opportunities to accelerate environmental management practices based on te ao Māori, but it also exposes the Māori economy to greater risk and may reduce revenue for iwi/Māori in the fourth emissions budget period. An indication of this exposure is provided by these statistics: while contributing 6.4% of the country's GDP in 2018, the Māori economy was responsible for 11.2% of Aotearoa New Zealand's emissions, due largely to strong interests in sheep and beef.[73] Research on the emissions profile of the Māori economy found the following key areas of risk:[74]

- as Māori collectives are heavily invested in agriculture and forestry, any increasing costs or impacts on this sector may negatively impact Māori whānau
- land-use characteristics of Māori freehold land mean that these landowners may have more limited options and face challenges in terms of land-use change (see **Box 6.3**)
- a large proportion of forested Māori freehold land was planted before 1990, rendering this land ineligible for earning emissions trading units – but still liable to pay carbon credits if deforested
- Māori are disproportionately in lower paid jobs, which are more exposed to shocks in the economy
- Māori small- and medium-sized enterprises (SMEs) make up almost all of the Māori asset base for transport, construction, and manufacturing – that may require significant capital expenditure to transition (which may be a barrier).

Māori-owned businesses face diverse climate hazards, with varying exposure levels across industries and regions. Agriculture-related sectors consistently show high vulnerability, emphasising the need for adaptive strategies in the face of changing climate conditions.[75] Ensuring iwi/Māori can adapt their communities and businesses will support transitioning to a low emissions and climate-resilient economy.

We have heard that an equitable transition for Māori needs to be Māori-led, and that any transition decisions should involve Māori in a meaningful way and at a local level. In our advice to the Government on its next emissions reduction plan in 2023, we also demonstrated that investing directly in iwi/Māori and designing policies in partnership, at all levels of decision-making, was essential to managing the impacts on iwi/Māori.

Choices made about actions to meet the fourth emissions budget also present opportunities and risks for the Crown–Māori relationship. An effective relationship between iwi/Māori and the Crown and private entities is more likely to lead to effective and durable emissions reductions, avoiding unnecessary delays and costs.

Box 6.3: Complexities of Māori freehold land

Iwi/Māori have a unique relationship with their whenua; it is an integral part of who they are and how they connect to each other, to their tūpuna and to the broader ecosystem. From 1840 many Māori were dispossessed of their whenua by the government, largely through acquisition and raupatu.

There are now some common characteristics of Māori land that mean a high proportion of Māori land area is restricted or of limited use including:

- much of Māori land is made up of land titles that are small in area (around 40% of Māori land is less than a hectare)
- much is on steeper or highly erodible land – around double that of non-Māori land
- more than 50% has no management structure in place
- 1.4 million ha of land is fragmented in small parcels of land with many registered owners (approximately 27,000 titles).

Often, forestry operations on land held by Māori collectives are typically subject to long-term agreements, sometimes up to 99 years or a defined number of rotations. As these agreements end, many Māori landowners are taking on management responsibilities for their forests and making decisions for their whenua, including whether it is commercially viable to plant permanent forests.

Different policy settings – such as those under Te Ture Whenua Māori Act – have an impact on what Māori collective owners of land can do with their land, which in turn may have wider implications under Te Tiriti o Waitangi/ The Treaty of Waitangi.

The iwi/Māori workforce is changing

Historically, a higher proportion of Māori have been in lower paid jobs or in industries that are particularly vulnerable to changes in technology and economic cycles (for example, manufacturing, wholesale, retail, trade, and construction).

In more recent years, Māori employment has been diversifying and moving more into higher skilled jobs.[76] Since 2013 there has been large growth of Māori employees in administrative, support, retail, accommodation and food services, and construction and manufacturing. There have also been increases in health, education, and public administration (reflecting government spending drivers). The proportion of Māori employed in the professional, scientific, and technical services sector is also above the economy-wide average.[77]

With a younger Māori demographic compared to the rest of the population, there is an opportunity to build on these trends and support rangatahi to develop appropriate skills for the transition to a low emissions economy grounded in te ao Māori.

There is care needed to manage workforces through transition, to avoid disproportionate effects on particular groups. Māori employees have historically fared poorly in transitions, being more likely to be made redundant during recessions or finding it harder to secure re-employment. This has also been evident after sudden adjustments such as the Christchurch earthquakes, when Māori generally fared less well than other workers.[78]

Regions and communities

Changes for the agricultural and land sectors

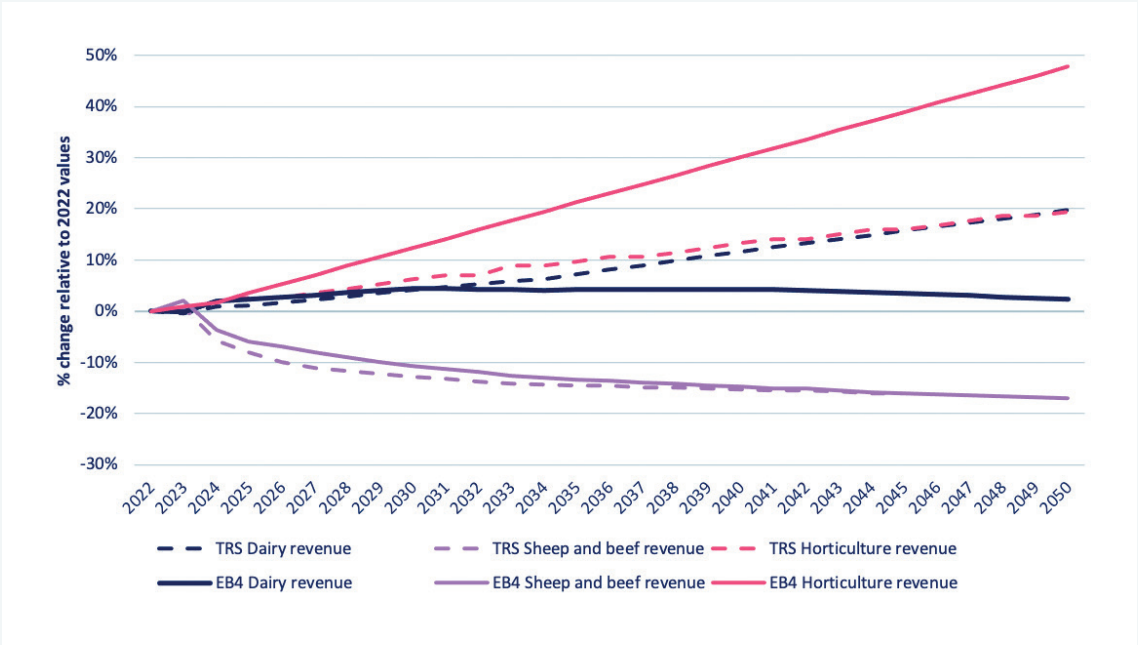
There have been substantial changes in how land is used over the last 30 years, along with significant changes in farming practices and performance. Understanding the scale of the impacts on agriculture for the fourth emissions budget should also be considered in light of the potential changes required to respond to changing consumer preferences in a lower emissions world, and the challenges of dealing with the physical impacts of climate change.

Under the EB4 demonstration path, the value of dairy output is expected to be maintained while the sector reduces emissions. As shown in **Figure 6.2**, improved practices in the dairy sector would mean that milk solid production and revenue can be maintained at least at today's levels beyond 2040, despite the EB4 demonstration path including land-use change from dairy to horticulture of 32,000 hectares by 2050.

However, compared with the reference scenario, revenue from the dairy sector would not increase relative to today.

Current and recent historical trends are expected to continue with output from sheep and beef in the EB4 demonstration path projected to continue to decline by 17% by 2050 relative to 2022 levels, despite less land-use change to forestry under the EB4 demonstration path compared to the reference scenario. In comparison, revenue from horticulture is projected to increase (see **Figure 6.2**) due to greater land-use change from dairy.

Figure 6.2: Comparison of revenue changes for sheep and beef, dairy, and horticulture to the reference scenario (TRS) relative to 2022



Source: Commission analysis

For both dairy, and sheep and beef, adopting improved farming practices and new technologies would allow emissions to be reduced by changing practices to focus on farming fewer, more productive animals. Adopting new methane-reducing technologies, as assumed in the EB4 demonstration path, is expected to come at a cost. This cost should be considered in the context of the potential consumer shifts which could increase demand for products that can demonstrate a lower emissions footprint. Maintaining access to markets may also rely on Aotearoa New Zealand's farmers being able to demonstrate they are taking actions to address greenhouse gas emissions. We also note that, without new technologies, reducing agricultural production and more land-use change would be required to reach the fourth emissions budget.

There is an opportunity to add value to the land sector

With the large size of Aotearoa New Zealand's land sector there are also opportunities to build on the traditional farming sectors, with a lower carbon, more 'circular' bioeconomy.[lxx] Research suggests there will be opportunities to grow the bioeconomy[79], including through:

- substituting fossil fuels and fossil fuel-derived plastics
- establishing new bioproduct and fibre-based exports
- adding value to forests and establishing new manufacturing processes
- creating several hundred jobs in the regions.

lxx Bioeconomy describes the parts of the economy that use renewable biological resources to produce food, products and energy. A more 'circular' bioeconomy can use waste biomass, or renewable resources, from forestry, fisheries, and agriculture as raw materials to produce other products. 'Waste' from one process becomes feedstock for another.

For example, waste wood from exotic forestry can provide a source of biomass for low-carbon liquid fuels, replacing fossil fuels for transport or other energy. Native forests also create opportunities for jobs in honey, recreation and ecotourism, and forest-based pharmaceuticals.

Incentives to reduce emissions will affect rural communities through land-use change

Given the large contribution of the land sector to Aotearoa New Zealand's emissions profile, incentives to reduce emissions will continue to affect how land is used and how it will change over time.

Over recent years, the relative profitability of forestry compared to extensively farmed sheep and beef has led to changes in land use. The EB4 demonstration path assumes less exotic forestry is needed compared to the reference scenario, but forestry will continue to play an important role. Like recent trends, exotic and native forests are likely to be established on parts of sheep and beef land, particularly areas with low economic viability (for example, erodible areas).

The impact of this land-use change on communities is difficult to predict and likely to affect different communities in different ways. Wholescale conversion of sheep and beef farmland to forestry would affect communities in the immediate area. More land converting from dairy to horticulture would also affect the nature of work in different regions, as horticulture requires more seasonal workers. More permanent or native afforestation may also generate fewer jobs than exotic production forestry, particularly if the land is left to revert rather than being planted.

Some changes in land use could in turn impact the population of rural communities and reduce expenditure in other businesses that rely on these sectors. Land-use change could also disproportionately impact iwi/Māori given Māori assets are predominantly in land and a higher proportion live in rural areas.

Less reliance on exotic forestry to offset e missions will be important to reduce these impacts. Capacity-building and advisory services for landowners focused on integrating trees or forestry onto farms rather than wholesale land-use change could also limit the impacts of afforestation.

Changes in the expected patterns of employment

Our analysis in *Ināia tonu nei* estimated that most regions would experience more jobs (rather than fewer), except for Taranaki and the West Coast (due to jobs in the oil, fossil gas, and mining sectors in these two regions). Since *Ināia tonu nei*, interest in offshore renewables and hydrogen in Taranaki has grown significantly, which may offset job losses from oil and fossil gas, should these industries develop.

For the fourth emissions budget, employment is likely to face similar trends as outlined in *Ināia tonu nei*, as the path results in broadly the same pattern of changes across sectors. The high-level trends in employment expected for the fourth emissions budget are shown in **Box 6.4**.

Changing employment would affect some groups more than others

For the most part, the changes in the patterns of employment that are predicted are expected to be gradual. There will be more opportunities for workers to naturally transition out of sectors through normal turn-over or retirement than if there are expected to be abrupt changes in a sector. For instance, some sectors may be able to adjust over time by reducing the number of new workers being hired rather than workers losing their jobs.

Younger workers can be expected to factor the long-term prospects of a sector into their career choices.

There are also significant shifts in the patterns of employment expected between sectors over the next 15 years, as some sectors grow and others contract. These changes are expected for a number of reasons not connected to climate action.

Box 6.4: How employment in different sectors may be affected

In the EB4 demonstration path, we expect the following trends in the pattern of employment to occur:

- Fewer jobs in coal mining, oil and fossil gas, and the services that support them, particularly affecting Taranaki and the West Coast where most of these jobs are located.
- More jobs in renewable electricity – workers will be needed quickly as capacity grows and transmission and distribution infrastructure expands.
- Fewer motor mechanics will be needed as people shift to more active and public transport, and transition to electric vehicles that require less maintenance.
- More jobs in energy efficiency, for example research by BERL and the Green Building Council found that moving to building low emissions buildings only from 2025 onwards could support an additional 46,000 FTE between 2025 and 2050, as well as contributing an additional NZ$147 billion to GDP.[80]
- More jobs in the waste sector – estimates indicate 2–4 jobs could be created in resource recovery for every job in landfilling.[81]
- Changing jobs in the agriculture sector.
- New jobs in agriculture advising farmers how to improve farm management practices as well as more research and development into new methane-reducing technologies.
- Fewer jobs in sheep and beef as more land-use change away from sheep and beef occurs.
- More jobs in horticulture requiring
- higher numbers of workers, as horticulture is generally more labour intensive, but seasonal.
- More jobs in forestry, including native forests, where there may be new opportunities for jobs in honey, recreation and ecotourism, and forest-based pharmaceuticals.
- More jobs in bioeconomy, for example new jobs in recovering forest and wood waste, or wood and biofuel processing.
- Job uncertainty in carbon intensive industries that are unable to reduce emissions or fully decarbonise effectively, for example in steel, aluminium, cement, methanol, and fertiliser/lime industries.
- Potential for new jobs in alternative fuels or other new sectors, depending on how they emerge.

Analysis by the Commission for *Ināia tonu nei* also found that there would be more impacts on some groups of workers than others. Specifically:

- As Māori tend to be employed more in higher emissions industries, like sheep and beef, and lower-skilled jobs, Māori may be more exposed to workforce changes.
- Pacific people currently experience higher unemployment and earn less, but our analysis estimated they could experience more job gains.
- Young people are likely to see net job gain as a result of recommended emissions budgets, while those workers over the age of 45 would be more affected by job loss.
- Men may be more affected by the transition than women. This is because the industries that are most affected by the transition tend to employ more men. However, there has been evidence historically that women are more negatively affected during economic change.
- Any changes to jobs could have disproportionate impacts on disabled people. This is because disabled people are more likely to face poor employment outcomes, as they are less likely to be in work or education, and are more likely to be unemployed, underutilised, and earn less than people who don't have a disability.

A study commissioned by the Ministry for Business, Innovation and Employment (MBIE) looked at the impacts of economic transitions on firms, workers and regions.[82] The findings of this report demonstrated the importance of a transition that targets both those who bear the greatest costs and those who are least able to respond by themselves. Comparing the three case studies of climate change, technology change, and the 1980s reforms, the study found that:

- the impacts of past transitions have not fallen equitably across the population, and the costs of adjusting can fall heavily on groups such as Māori businesses and employees, small businesses in exposed industries, and regions of Aotearoa New Zealand with 'tight' labour markets
- economic transitions can drive economic displacement, change the mix of skills in demand, increase costs of operating for firms and affect household wellbeing.

Improving skills will be important to reduce employment impacts

While there is evidence from international studies that emissions-reducing sectors tend to create more job opportunities than are lost in fossil fuel sectors,[83] differences in type of work and skills can mean that work from one sector is not easily transferrable to another.

In its report *Technological Change and the Future of Work*,[84] the New Zealand Productivity Commission highlighted that Aotearoa New Zealand generally has a flexible labour market that has historically adapted well to economic change. Good flexibility, however, requires workforce training, as well as support for individuals and communities. For example, to build new renewable energy generation and improve transmission over the coming decades, Transpower estimates that thousands more highly skilled workers will be needed in the electricity sector by 2035 to meet increasing electricity demand.[85] Many of these jobs will be outside the main centres, particularly in building new generation and distribution lines. Many of the workers in the oil and fossil gas sector are highly skilled – engineering, earth sciences, surveying and logistics.

The workforce changes in higher emitting sectors are expected to occur gradually, as some workers will continue to be needed to manage, safely decommission, and phase out existing infrastructure. Additional workforce in the renewable energy sector is likely to be needed in the short term, which may pose some constraints to this sector.

The Commission's *Advice on the direction of policy for the Government's second emissions reduction plan* outlined the importance of making the education system more flexible to enable mid-career professionals to re-train and address barriers that restrict some New Zealanders from accessing education, including iwi/Māori, Pacific people, and low-income groups.

Households and whānau

Changes to meet the fourth emissions budget across the economy will have flow-on effects to households. Exactly how changes will be felt for households can be challenging to predict.

For those able, taking up lower carbon technology can lower costs and bring wider benefits

Households that can improve the energy efficiency of their homes, such as by installing insulation or double glazing, will benefit from lower electricity bills and warmer, drier homes. Efficiency improvements can also reduce electricity use at peak times, in the mornings, evenings, and in winter. Reduced demand at peak times helps the entire electricity system as there is less of a need to build additional generation and upgrade electricity lines, reducing costs for all households.

During consultation, we heard that rooftop solar electricity generation has become increasingly attractive for households and should play a bigger role than we have modelled. We have tested significantly faster rooftop solar uptake rates through sensitivity analysis and found the difference to energy sector emissions is minor. This is because, in the modelling, greater rooftop solar reduces the need for other non-fossil generation types (fossil generation generally being needed only for peaking, to which rooftop solar makes little to no contribution).[lxxi]

Rooftop solar could however, make a difference to household energy bills, as well as system level costs. In other words, a household making an upfront investment in rooftop solar (financed or otherwise) could enjoy reduced energy bills as a result, while also reducing the need for investment in grid scale renewables.

lxxi We also note that sources such as EECA's 2024 report ***Electrifying Aotearoa: The consumer perspective***, and MBIE's 2024 Electricity Demand and Generation Scenarios modelling, are relatively consistent with the rooftop solar uptake rates we modelled in our draft advice.

Home batteries are another technology that could help households reduce electricity bills, especially if paired with rooftop solar. Home batteries have the additional advantage of helping to reduce peak electricity demand, therefore limiting the need for network investment and the need for higher-cost flexible thermal generation. This would help minimise whole-of-system costs, and therefore power bills, for all electricity consumers.

As the price of electric vehicles (EVs) reduces over time as is expected, there would also be a saving to households from lower initial purchase costs. Commission analysis found that households that replace their internal combustion engine vehicle (ICE) with an EV could save more than $2,300 a year by 2040 in purchase and running costs, in part due to the purchase price of EVs being 15% lower than an ICE vehicle.

Even today, households that switch to an EV can expect to enjoy lower overall energy bills, due to the additional cost of electricity being more than offset by savings in petrol and diesel.[lxxii]

Actions in transport that specifically increase access to public transport, safer walking and cycling, and more use of car sharing or pooling schemes (as opposed to individual car ownership), can help to meet the fourth emissions budget. Public transport can improve access to job and education opportunities for individuals who do not own private vehicles, enhancing economic opportunities for a broader segment of the population.

Electricity prices are unlikely to significantly change due to meeting the fourth emissions budget

While we expect electrification to reduce overall household energy bills (as noted in the section above, as well as in Box 6.5 below), household electricity bills are expected to rise over time due to additional electricity consumption as households switch to electric heating, cooking, and transportation, as well as increasing retail electricity prices. While we expect electricity bills to rise in both the reference scenario and the EB4 demonstration path, the rise will be greater in the latter due to much greater use of electricity.

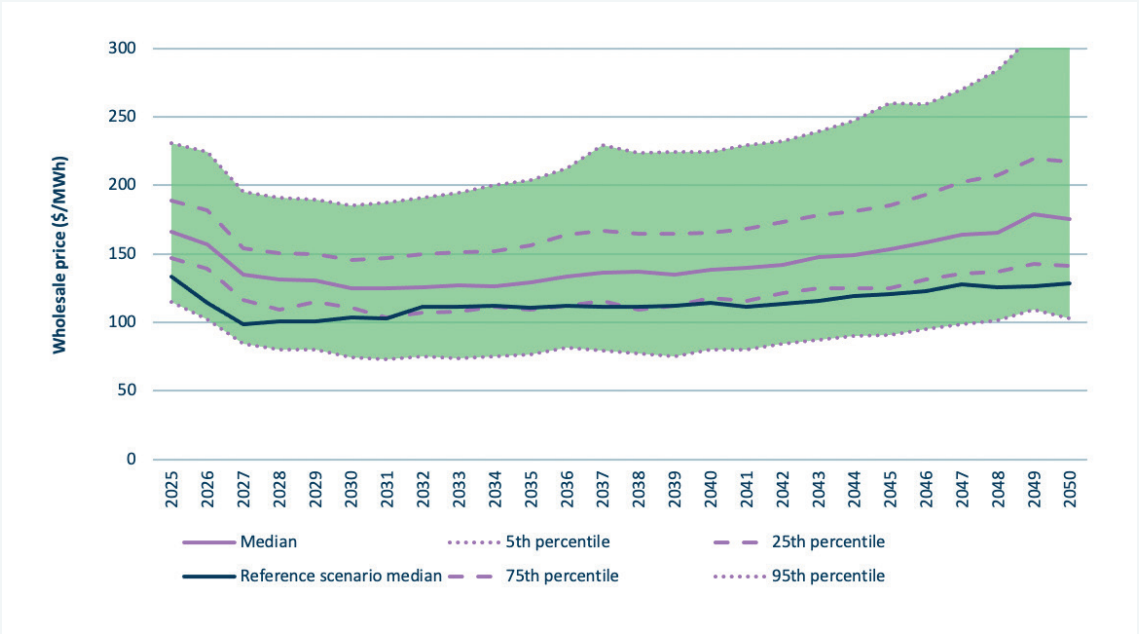
Retail electricity prices are driven by several factors, including wholesale electricity prices, the cost of transmission and distribution, and retailer costs.

Wholesale prices, which broadly reflect the cost of generating electricity (and to a lesser extent transmitting it to different locations around the country), as well as the balance between supply and demand, are one determinant of the retail electricity price paid by households. As indicated in **Figure 6.3**, modelling suggests that by taking action to meet our proposed emissions budget, wholesale electricity prices are likely to be slightly higher than in the reference scenario, as a result of electricity demand being higher in our demonstration path.[lxxiii]

lxxii In this context, the phrase 'household energy bill' refers to the total amount of money directly spent by a household on energy. This includes electricity bills and spending on solid or liquid fuels for household transportation or use in or around the home.

lxxiii We commissioned modelling work by EnergyLink to investigate wholesale electricity price paths under different scenarios – the wholesale price being that at which retailers buy the electricity. Wholesale prices change depending on changes in supply, demand, or environmental factors such as river levels for hydro generation. When electricity retailers determine how to pass costs on to consumers, they often do this in a way that removes the day-to-day, month-to-month, and year-to-year variability of wholesale prices. This modelling assumes a continuation of the current market structure for pricing.

Figure 6.3: Wholesale electricity price range under the EB4 demonstration path with median price under the reference scenario overlaid



Source: EnergyLink modelling

For both the EB4 demonstration path and the reference scenario, wholesale prices remain elevated in the near term, reflecting an expected continuation of recent market conditions of tight levels of electricity supply compared to demand. Over the next few years, the modelling suggests that a rapid build out of wind, solar and geothermal generation will improve the supply / demand balance and displace an increasing amount of higher cost fossil-fuelled generation. This will help to reduce the average wholesale price in both scenarios.

Beyond the late 2020s, as electricity demand continues to rise, more new renewables are expected to be built. Since the most attractive projects are built first, further addition of generation gradually becomes more expensive, resulting in a gradual increase in wholesale prices longer term. The EB4 demonstration path, with higher electricity demand, requires more new generation to be built, and hence higher prices than the reference scenario over the modelled period.

Additionally, the modelling shows that wholesale prices will remain highly sensitive to inflow levels into the hydro generation systems. This is illustrated by the wide price range shown between the percentiles in **Figure 6.3**.[lxxiv]

However, wholesale prices are only one factor influencing electricity consumers' bills. Bills could be significantly impacted by the direct investment costs to upgrade transmission and distribution infrastructure to meet increasing demand. The level of costs recovered from consumers, including households, is currently regulated under Part 4 of the Commerce Act 1986.

Under the EB4 demonstration path, we assume greater use of demand side response, where electricity consumers respond to pricing signals by switching off some of their demand, or shifting their usage from peak to off-peak periods. This can reduce the need to build additional generation and network capacity to meet peaks in demand, helping to minimise system-level costs. As such, we expect any increase in transmission and distribution costs in our demonstration path, over and above the expected increase in the reference scenario, to be insignificant.

The costs of the gas network will be shared across a smaller number of customers

Households that use fossil gas for heating and cooking are likely to see an increase in their fossil gas bills. As households switch away from fossil gas, the cost of maintaining the gas distribution network will need to be recovered from a smaller number of customers. For those households that continue to use fossil gas, the average bill in 2040 is expected to increase by up to NZ$740 a year under the EB4 demonstration path due to higher emissions prices, compared to the reference scenario. It is difficult to predict exactly what will happen, as the speed at which households switch away from fossil gas will affect the prices for those who remain, and therefore their incentive to switch too.

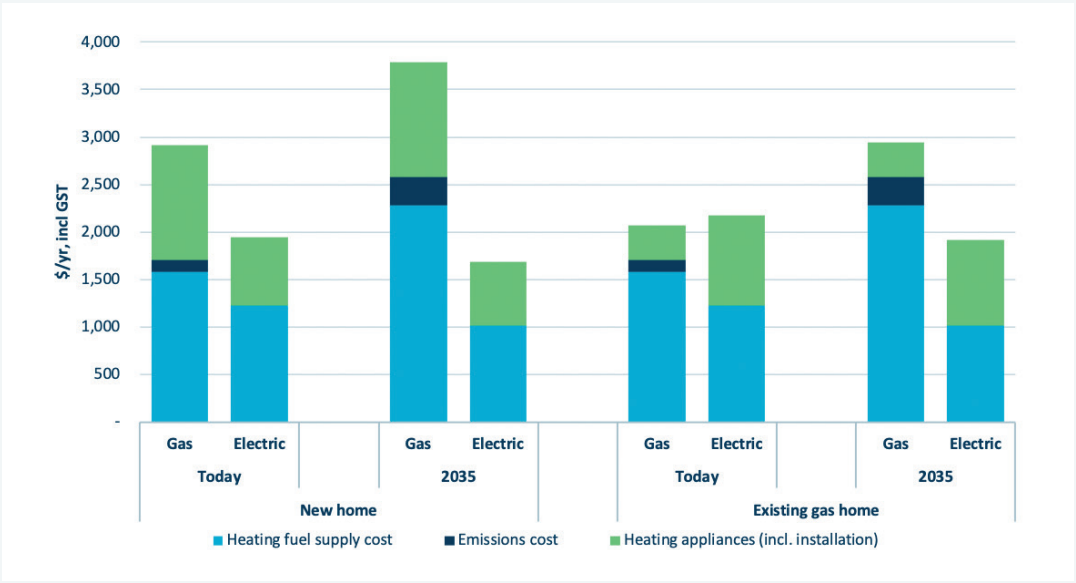
Higher fossil gas prices mean that, over time, many households would benefit from replacing fossil gas appliances with electric ones. Replacing appliances at the end of their life, and discouraging new fossil gas appliances from being installed, would help to reduce the cost of this change for households. Other costs associated with this change include removing fossil gas piping into homes, additional wiring, changes to electricity meter boards, and the associated building work.

lxxiv The wholesale price paths shown in Figure 6.3 are not a forecast, rather, they reflect the theoretical outcome of an efficient market in which the commissioning of new generation is optimally timed such that supply and demand are effectively balanced. In such a scenario, generators make just enough revenue to provide a reasonable return on investment. This does not necessarily reflect what might actually happen and illustrates the importance of ensuring appropriate market settings are in place.

Box 6.5: Impact on household space and water heating costs of switching away from fossil gas to electricity

Figure 6.4 shows the costs of space and water heating for an existing home today and in 2035, for a household continuing to use fossil gas, or choosing to switch to electricity.[lxxv] Currently, households already using fossil gas would increase overall costs by switching to electricity for space and water heating. Although switching would reduce the fuel costs a household faces, it would increase overall costs as there are costs to buying a heat pump and removing the fossil gas appliance that need to be factored in. However, by 2035 the higher price of fossil gas is expected to allow households that switch to electricity for space and water heating to save around NZ$670/year (after factoring in the costs of buying a heat pump and removing fossil gas appliances).

Figure 6.4: Potential impact on household energy bills of switching from gas to electricity for space and water heating



Source: Commission analysis

Notes: In this chart, the 'Heating appliances' component includes operational and maintenance costs associated with running heating appliances, as well as capital costs incurred when replacing appliances. The capital component includes 'make-good costs', such as building work for retrofit situations. The 'heating appliances' component is annualised over the lifetime of the appliance. 'Emissions cost' refers to the proportion of the fuel supply cost incurred due to the presence of emissions pricing. 'Heating fuel supply cost' refers to the proportion of a fossil gas or electricity bill which is incurred due to the use of energy for heating.

lxxv For comparison, the figure also presents the cost of choosing to install gas or electric space and water heating for a new home, which shows that it is already cheaper for households to install electric space and water heating than to install and use fossil gas. By 2035, the difference is even greater with a home that installs fossil gas paying an additional NZ$2,095/year compared with one that installs a heat pump.

Petrol and diesel prices are higher than the reference scenario

Improving fuel efficiency, a shift to EVs and more public transport, walking, and cycling are all important in reducing emissions from transport. Commission modelling indicates that petrol prices could increase by up to 40 cents per litre in 2040 due to higher emissions prices under the EB4 demonstration path. This is 13% (33 cents per litre) higher than the reference scenario in the EB4 demonstration path. The average household using petrol or diesel vehicles may expect to see transport fuel costs increase over time, but overall costs for transport will depend on the distance travelled and the efficiency of the vehicle. Shifting some trips to walking, cycling, or public transport could offset some of the increased transport fuel costs. 'Active transport' like walking and cycling brings further benefits to health through increased mental wellbeing and physical fitness, and reduced risk of cardiovascular disease, overweight, type 2 diabetes and some cancers, and all-cause mortality. Higher petrol and diesel prices are also expected to encourage households that can afford it to purchase more efficient vehicles or switch to electric vehicles.

Some households or whānau will be more affected than others

People on lower incomes may be more in need of energy efficiency and cost saving measures but also less able to afford them. Government support targeted to those people facing cost or other barriers during the low emissions transition will be important to manage impacts.

A recent report by the Energy Hardship Panel found that 110,000 households in Aotearoa New Zealand could not afford to keep their homes adequately warm in 2022. In 2017, damp or mouldy housing was estimated to have led to 6,276 hospitalisations, representing a cost of NZ$36 million.[86]

The report also shows Māori, Pacific people, renters, and low-income households were far more likely to experience energy hardship. These groups are more likely to live in older, poorly insulated homes, where cost savings due to improved energy efficiency would make the biggest difference.

Current transport systems that are reliant on ICE vehicles can lead to health inequities. Generally, people from lower socio-economic groups are less able to afford converting to EVs and may also experience disproportionate harm from noise exposure, air pollution, physical inactivity, injury and climate change.[87]

Other barriers or impacts for some households, whānau or communities include:

- Low-income households may be more exposed to higher emissions prices as they tend to spend a larger share of their disposable income on food and fuel.
- Renters may be disproportionately affected as landlords do not have the same incentive to install energy efficient appliances or measures as they would not benefit from the savings in running costs.
- Switching to EVs may also be challenging for those who cannot charge an EV at home, for example people living in apartments.
- Women are less likely to cycle due to safety concerns.[88]
- Smaller remote communities may be exposed to higher electricity prices, which can vary as much as 40% between regions.[89]
- Smaller remote communities may also have less access to public transport, and be more reliant on fossil fuels.

Policy that targets most affected households brings the greatest benefits

Targeted climate policy provides an opportunity to address inequality and bring a greater scale of benefits such as warm and healthy homes, or cost savings for those that most need it, alongside reducing emissions.

A recent study found that reducing transport emissions may help reduce health inequities between Māori and non-Māori if policies are implemented equitably, particularly where greater walking and cycling is involved. When assessing the health benefits of actions on transport for our technology and behaviour change scenarios in *Ināia tonu nei*, this study found that health gains for Māori were 20-30% larger than for non-Māori.[90]

A transition that supports New Zealanders

The changing climate will exacerbate impacts on vulnerable sectors and communities

The combined effects of adapting to climate change and reducing emissions will influence the choices and impacts for sectors and communities.

Many sectors and communities that are vulnerable to climate change are also likely to be significantly affected by the need for emissions reductions, such as agriculture, forestry, fisheries, tourism, and energy and transport networks. There may be less availability of water for irrigation or feed for stock, for example, placing further pressure on the land sector and reducing land-use choices in certain areas. More exotic forestry may also increase the vulnerability of regions to climate events, as was the case with Cyclone Gabrielle.

Critical infrastructure, including built assets, stormwater and wastewater, transport links (for example, roads, railways, airports) and electricity (transmission lines, structures, sites), is also at risk of severe weather events – with potentially high emissions rebuilds.

The impacts of a changing climate are likely to have a disproportionate impact on iwi/Māori due to:

- increased risk of displacement from tūrangawaewae vulnerable to climate change, with many marae and papakāinga located coastally
- the high proportion of business interests in the primary sector
- potentially restricted access to taonga species that are vulnerable to impacts
- disrupted transfer of customary practices and mātauranga Māori to future generations.[91]

Young people will be more exposed to the effects of climate change in their lifetime. Delaying action on climate change has the potential to have a greater impact on younger people as it will mean higher costs later.

Acting to reduce emissions and adapting to climate change will be crucial together, to ensure one goal does not undermine the other and that inequities are not exacerbated.

Government policy will be crucial to addressing inequities

By clearly signalling its transition plans, the Government can help to provide certainty and time for sectors and communities to plan and change.

Clear and stable policies, consistent with the purpose of the Act, along with investment and support targeted at those who will face the most costs will also be important. Failing to address fairness and equity could risk resistance to action on climate action generally, and particularly from those who will lose the most.[92]

As shown in this chapter, iwi/Māori may potentially be more affected than others by the fourth emissions budget. Investing directly in iwi/Māori and working in partnership is important not only to address these inequalities and uphold Te Tiriti/The Treaty, but also for accelerating emissions reductions for the benefit of all New Zealanders. Supporting communities and enabling young people to participate in the transition to a low emissions future can positively impact mental health through an increased sense of control, hopefulness, and resilience.

Meeting the fourth emissions budget can be economically affordable and socially acceptable if it is well-signalled, well-paced and planned together with communities. Society is likely to benefit from associated improvements to health and wellbeing. Balancing the pace of change will be important to ensure inequities are not created or exacerbated in the short term, while also ensuring the costs don't fall inequitably to future generations. Our draft advice on the fourth emissions budget seeks to find this balance.

Te reo Māori glossary

Kupu/rerenga kupu Māori
English contextual translation

hapori Māori Māori communities

hapū kinship group comprised of whānau who share a common ancestry

iwi extended kinship group of whānau and hapū who share a common ancestry and are associated with a distinct territory

kaitiaki guardians, stewards, trustees

kaupapa Māori issues and topics that have a specific focus on the Māori world

kawa protocols, practices

mana whenua authority over land or a specific territory

marae the open area in front of the wharenui, where formal greetings and discussions take place; often used to include the complex of buildings around the marae

mātauranga Māori Māori knowledge, the body of knowledge originating from Māori ancestors, including the Māori world view and perspectives, Māori creativity, and cultural practices

mokopuna grandchildren

rangatahi youth

rangatira chief, chiefly, noble

raupatu to take by force, often used in the context of land confiscations

tangata whenua people born of the whenua – people of the land where their ancestors have lived

taonga treasure, anything prized: applied to anything considered to be of value including socially or culturally valuable objects, resource, phenomena, ideas, and techniques – children and future generations may also be regarded as taonga

te taiao the natural world, the environment

tikanga correct procedure, custom, habit, lore

tūpuna ancestors

tūrangawaewae a place to stand – it denotes whakapapa connections of a person to a particular place

whakaaro thought, opinion, idea, understanding

whānau family

whenua land

Wāhanga 7 | Chapter 7

Ngā panonitanga ki te tuatahi, te tuarua me te tuatoru o ngā tahua tukuwaro
Recommended changes to the first, second and third emissions budgets

As part of its decisions on setting the fourth emissions budget, the Government has the option of revising the set emissions budgets to ensure they remain both ambitious and technically and economically achievable.

We recommend adjustments to the first, second and third emissions budgets due to changes in how New Zealand's Greenhouse Gas Inventory calculates and reports emissions, and the impact of higher rates of forestry planting than projected.

Under the Climate Change Response Act 2002 (the Act), as part of our advice to the Government on the setting of the fourth emissions budget, we may also provide advice on whether any revisions should be made to the first (2022–2025), second (2026–2030), and third (2031–2035) emissions budgets.

Reviewing set emissions budgets every five years helps ensure that they are flexible to changing circumstance and that they remain ambitious, and technically and economically achievable over time.

We may only advise a change to emissions budgets if we find evidence that specific circumstances have changed since the budgets were originally set. There are two categories of change we are required to consider in this analysis.

- **Methodological change**: New Zealand's Greenhouse Gas Inventory (GHG Inventory) is released annually. With each new release, the GHG Inventory may include adjustments to the way Aotearoa New Zealand's greenhouse gas emissions are calculated and reported. Whenever there are changes to the GHG Inventory's methodology or underlying data, these adjustments are applied retrospectively to all previous inventory reports, as well as the most recent release. These adjustments can change Aotearoa New Zealand's reported level of emissions, and therefore have direct implications for whether current and future emissions budgets can be met.
- **Significant change:** Emissions budgets are set based on specific considerations, outlined in section 5ZC of the Act (see **Box 7.1**). If these conditions have changed significantly since the budget was set, that can affect what is achievable in an emissions budget period. Changed circumstances have to be judged significant for an existing budget to be revised; changes can include matters raised in consultation.

It is the Minister's decision whether to revise an emissions budget. For the current emissions budget period (which for this advice is the first emissions budget for 2022–2025), the Minister must not revise the emissions budget, under s5ZE of the Act, unless the circumstances are exceptional.

Our analysis has shown that methodological changes have occurred since the budgets were originally set and we recommend that methodological changes are incorporated into revisions for all emissions budgets as a matter of course. Methodological changes in 2024 impacted the first and second budget periods, but not the third. We have assessed that the impacts of higher rates of recent forestry planting are a significant change in the second and third emissions budgets.

This chapter provides our advice and recommendations for revisions to the first, second and third emissions budgets. It outlines the factors we have considered in our analysis, including the impact of the methodological and significant changes we have identified in our work and through feedback from consultation.

Changes from the draft version of this chapter

Our draft advice proposed changes to the first, second and third emissions budgets under the requirements set under the Act. In response to feedback on those proposals, and in light of new data, we have revised our recommended changes to set budgets.

We found *methodological improvements* from the 2024 edition of New Zealand's Greenhouse Gas Inventory (GHG Inventory) have an effect on the first and second emissions budgets – but not on the third emissions budget. In our draft advice we had proposed revision of all three set budgets.

Our final advice confirms our assessment that the recent higher rates of exotic afforestation are a *significant change*, affecting the second and third emissions budgets. Our re-analysis, using the extra year of data that became available after publication of our draft advice, shows the impact on the second and third budgets is greater than we originally estimated.

This chapter presents updated modelling and interpretation of our analysis, as well as our final recommendations for changes to set budgets.

In response to feedback, we considered new areas in our significant change analysis, but these changes did not meet the threshold for significance. These included the greater potential of carbon capture and storage, decline in fossil gas reserves and supply, and anticipated lower afforestation rates in future years.

Methodological change

Changes to how emissions budgets are calculated mean emissions budgets need to change

Why account for methodological changes?

Methodological consistency is important. Our models, utilising the data provided by the GHG Inventory, are used to inform projections of future emission paths and emissions budgets. Methodological updates to the GHG Inventory can lead to an increase or decrease in emissions levels, without any changes in mitigation actions. In some cases, these changes may look like large emissions reductions or increases, but these changes represent a change in how the emissions are measured, not a real-world increase or decrease in emissions.

The ability under the Act to review and, if appropriate, revise set emissions budgets because of methodological change means that progress can be more accurately monitored, and ambition on emissions reduction can be maintained over time. If set emissions budgets could not be revised, changes to the GHG Inventory methodology could lead to unexpected windfall gains or losses for a budget period. A notable example of a methodological change was the reallocation of liquid fuel emissions from road transport to recreational marine usage in the residential energy sector. The impact of this change on the first emissions budget was a decrease of approximately 4 $MtCO_2e$ in the transport sector, which was partially offset by an increase in emissions in the residential energy sector.

How we have assessed the impacts of methodological changes on set emissions budgets

For this advice, we looked at methodological changes that have occurred since the first, second and third emissions budgets were set by the Government in 2022, including the latest GHG Inventory update in 2024.[93]

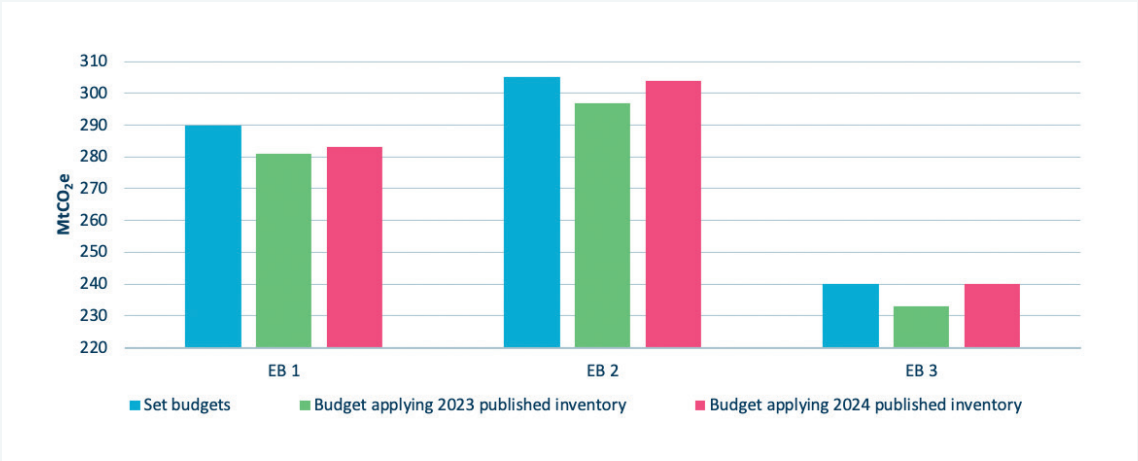
To determine the impact of methodological changes on emissions budgets, we have taken data from the 2024 update to the GHG Inventory for the period between 1990 and 2019, and compared this with our previous modelling on emissions budgets we did for *Ināia tonu nei* covering the same period.[94] This was so we could isolate the impacts due to methodological changes from other changes, such as more recent data or updated emissions projections. This allowed us to see what the emissions budgets would have been at the point in time when the set budgets were established, if the updated GHG Inventory methodologies had been used.

There is a *de facto* minimum threshold that applies since emissions budgets are reported to the nearest 1 $MtCO_2e$ across a budget period. Changes that in aggregate come to less than ±0.5 $MtCO_2e$ across a budget period would not result in us recommending a change to the emissions budgets.

What our modelling shows

Our analysis shows that the methodological changes to the GHG Inventory since 2022 would have had an impact on the level of the emissions budgets. Methodological improvements aligning with the 2024 publication of the GHG Inventory leads to the conclusion that the first two emissions budgets would have been set at lower levels. The impact of the methodological changes from the GHG Inventory published in 2024 on the set budgets, along with the impact of methodological changes from the GHG Inventory published in 2023 that was used in our draft advice, is shown below in **Figure 7.1**.

Figure 7.1: Impact on emissions budgets when applying methodological improvements to the GHG Inventories published in 2023 and 2024 ($MtCO_2e$)



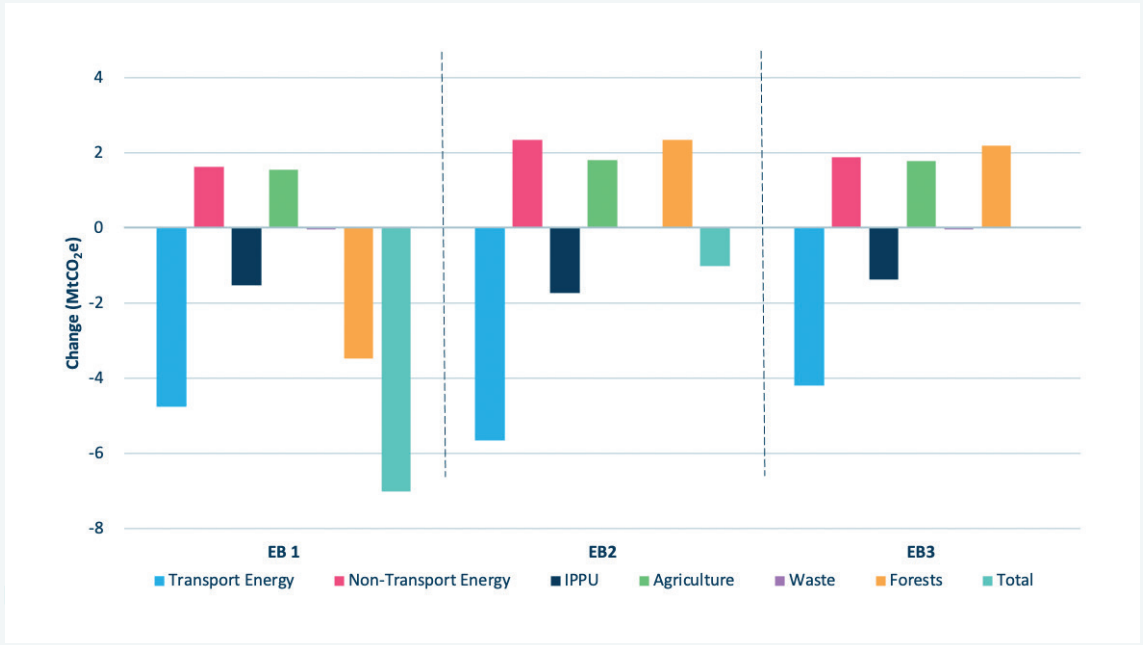
Source: Commission analysis

Some of the methodological changes that had the most impact on this overall change, for each sector, were:

- In transport, there were changes to historical estimates of average liquid fuel efficiencies of vehicles.
- In non-transport energy, there were revised estimates of fugitive emissions from fossil gas distribution and the energy content of coal (gross calorific value) was updated.
- In the industrial processes and product use (IPPU) category, there was a re-estimation of stocks of hydrofluorocarbons (HFCs) held by importers and users.
- In the agricultural category, non-pasture feed was added into the GHG Inventory, there was a revision to the fraction of nitrogen applied to agricultural land that is lost through leaching, improvements to beef cattle population and liveweight, and changes were made to the accounting method for agricultural use of lime.
- Within forestry, there were multiple method changes to increase accuracy of planted forest estimates, improvements to harvest/deforestation data, changes to loss and gain of biomass and soil carbon, and carbon yields.

One methodological improvement resulted in a redistribution of emissions across sectors but has had only a small net effect. A proportion of emissions from petrol and diesel in the transport category were reallocated to the residential sector (categorised as non-transport energy), which includes fuel used around the home and for recreational activities like boating. **Figure 7.2** below summarises the impact of methodological changes by sector across the first three emissions budget periods, with the total rounded to the nearest whole $MtCO_2e$.

Figure 7.2: Impact on emissions budgets by sector of methodological improvements to the GHG Inventory



Source: Commission analysis

Significant change

A significant change is one that is notable, important, and consequential

Considerations when assessing whether a change is significant

Emissions budgets are set based on specific considerations in the Act. Over time, these considerations may undergo significant change, which can impact the achievability of emissions budgets, as well as the actions to reduce emissions in Aotearoa New Zealand.

He Pou a Rangi Climate Change Commission (the Commission) may recommend that set budgets be revised if there has been one or more significant changes that have affected those considerations on which the emissions budget was based (see **Box 7.1**).

In order to determine whether a change is 'significant', we need to define the term. For this advice, significant is defined as something that is notable, important and consequential.[95]

Box 7.1: List of considerations that are potentially significant

When considering significant changes, the Commission must have regard to changes that have occurred in the considerations used for setting the emissions budgets. These considerations include:

- key opportunities for emissions reductions and removals
- the principal risks and uncertainties
- projections in the emission and removal of greenhouse gases
- domestic and international scientific advice
- existing technology and anticipated technological developments
- what is technically and economically achievable
- impact of actions to achieve budgets and the 2050 target
- distribution of impacts for regions, communities and between generations
- economic circumstances
- the impact of land-use change on communities
- results of public consultation
- responses to climate change taken by other signatories to the Paris Agreement
- Aotearoa New Zealand's relevant obligations under international agreements.

For significant changes we have applied the minimum threshold differently for the current emissions budget (2022–2025) compared to future budgets. This was due to the proximity to the end of the budget period, and the nature of a significant change compared to a methodological change.

Under the Act, the Minister of Climate Change can only revise the current budget if the circumstances are exceptional.[96] This does not preclude the Commission from recommending a significant change to the current budget, as the decision on whether it is exceptional is for the Minister of Climate Change to make.

We have developed a framework for assessing significant change

This framework is designed to meet our statutory requirements when evaluating significant changes.

Using a framework ensures that we are systematically and consistently assessing whether changes are significant, and that the approach is transparent. We are only assessing changes that:

- were not known when the budget was originally set
- are not due to a methodological improvement, since this is addressed separately
- are not due to a change to the 2050 target, since this, in its own right, would induce revisions of emissions budgets to be made
- affect one or more of the matters listed in the Act (see **Box 7.1**).

There are potentially many changes that occur over time. For changes that meet the criteria above, the significant change framework can be applied. The framework consists of two steps:

- *Test of significance* – an assessment against criteria that provides more detail to our definition of significance (i.e. notable, important and consequential) (**Table 7.1**)
- *Recommendation on budget changes* – an assessment of the cumulative impacts of significant changes and our recommendations based on consistency with the purpose of the Act.

The criteria in **Table 7.1** are applied to an identified change. One or more of the criteria should be met for the change to be considered significant. Some of the considerations in the Act may require modelling to evaluate whether impacts have changed.

Table 7.1: Criteria used for testing whether a change should be considered significant

Criteria applied	Reasoning
Material impact: How does the change affect the level of emissions reductions possible?	To be notable the change should be large enough to materially impact the level of an emissions budget.
Permanence: Is the impact of the change permanent, or could it be reversed?	The change should likely be permanent for the period of the set emissions budgets and the impact of the change should propagate through multiple budget periods. Some change may simply bring an existing action to reduce emissions forward in time to an earlier budget period. However, this is unlikely to represent a change in the emissions budgets as it represents an alternative path that the Government may take, but that has already been factored in.
Likelihood: What is the likelihood that the impact on budgets will be realised?	Changes have an impact on budgets occurring several years into the future. There may be uncertainties as to the magnitude of the impact and the timescale over which an action to reduce emissions might be implemented. If the assumption on which the change is based is uncertain, this could influence the likelihood of it occurring.
Reason for change: Has the change altered the assessment of what is feasible in the budget period?	The change should impact the feasibility of what is achievable in the budget period to be considered significant. For example, an alternative technology may be a circumstance that has changed, but if we have already considered its effects, it just represents an alternative path that the Government may take and is not a significant change.

The second step in the framework is to evaluate how the application of the criteria affects the emissions budgets. A recommendation to change an emissions budget is based on the cumulative impact of all the significant changes. This means that even if two significant changes were identified, if they were opposite and equal in magnitude, they would cancel each other out, and there would be no need to change the emissions budge. As well as assessing the cumulative impacts of changes, this step also considers the purpose of emissions budgets under the Act. Emissions budgets are required to provide a means to meet the 2050 target and contribute to the global effort under the Paris Agreement to limit the global average temperature increase to 1.5°C. Under the Act, emissions budgets should also provide predictability for those affected.

The framework is discussed in more detail in the *Technical annex* published on our website.

Box 7.2: Equal consideration regarding the direction of change

Recommendations on changes to emissions budgets will depend on the cumulative impacts of the significant changes identified. The significant changes may have the effect of loosening or tightening those budgets, whilst any budget changes should remain consistent with the purpose of emissions budgets under the Act. The purpose of budgets includes:

- to continue providing a path to meeting the 2050 target
- contributing to the global effort under the Paris Agreement to limit global average temperature increase to 1.5°C
- providing predictability for those affected, including households, business and investors.

The purpose of the emissions budgets can be achieved regardless of whether the change increases or decreases emissions. A stable emissions budget would be favoured if we follow the principle of predictability, or one with a limited number of changes.

If a change occurred that results in an increase in an emissions budget we may still consider it aligned with meeting the 2050 target, as long as later budgets remain on track. To align with the purpose of the Act to maintain the global effort required to limit temperature rise to 1.5°C, an increase in an emissions budget may need a steeper correction in a later budget, so that cumulative emissions remain unchanged.

Finally, a change that tightens an emissions budget may also be consistent with the purpose of the budgets. It would represent a path aligned with meeting the 2050 target as well as contributing to the global effort to limit temperature rise to 1.5°C.

In meeting the purpose of the Act, an emissions budget may equally be revised up as down as a result of a significant change.

Our analysis is that higher afforestation rates are the only significant change

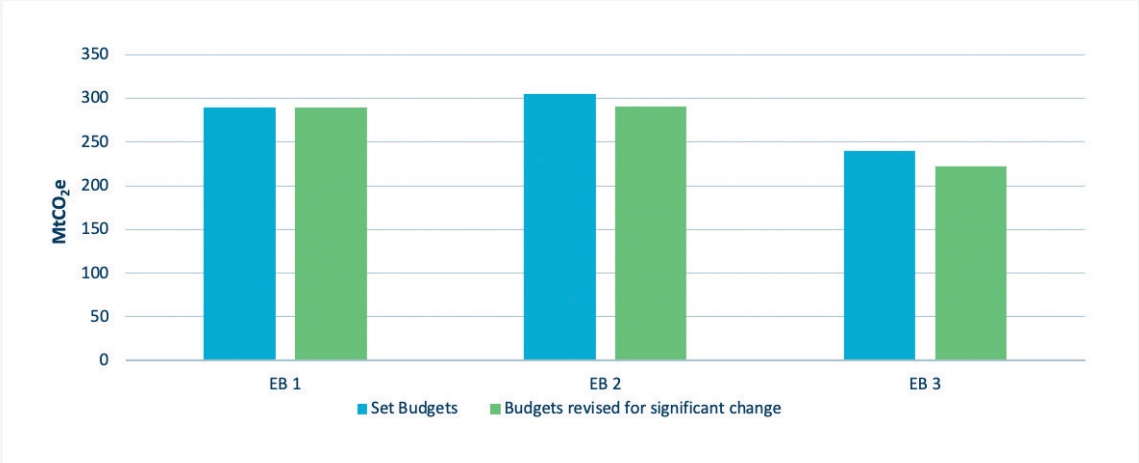
Afforestation rates of exotic forests over the last four years are higher than were predicted when the first three emissions budgets were set, and we consider this to be a significant change. We incorporated into our model these figures – observed higher afforestation rates (2020 to 2022), estimated (2023), and anticipated (2024) – to assess the impacts on the first three emissions budgets. Our assessment makes no further changes to afforestation rates (from 2025 to 2050) modelled for the set budgets.

Our assessment of significance was based on the criteria from **Table 7.1**.

- **Material impact** – The change is material for the second and third emissions budgets. For the first emissions budget we did not consider the estimated change of 1 $MtCO_2e$ to be material. The difference between what was projected for afforestation in the set budgets and afforestation observed (2020, 2021, 2022), estimated (2023) and anticipated (2024) results in substantial changes of – 14 $MtCO_2e$ in the second emissions budget, and – 18 $MtCO_2e$ in the third emissions budget.
- **Permanence** – There is a high degree of confidence that this change is permanent for the duration of the emissions budgets through to 2050. The impacts of this change are unlikely to be reversed in this time through deforestation.
- **Likelihood** – The higher-than-anticipated afforestation will produce ongoing additional removals of carbon through to 2050. Although the projected afforestation rate is uncertain, the actual afforestation that has occurred is highly likely to achieve sustained removals of CO_2.
- **Reason for change** – If the budgets remain the same, the higher amount of afforestation in recent years will contribute more carbon removals, thus supplanting some gross emissions reductions. If the first three emissions budgets can be met without reducing gross emissions, then subsequent emissions budgets will, at worst, be unachievable and, at best, only achieved through higher-cost action later. The level of ambition for gross emissions reductions should be maintained along with the actions necessary to ensure future budgets can be met. What we now consider feasible is greater overall reductions occurring in the second and third emissions budgets.

We modelled the impact of recent exotic afforestation on emissions budgets, as shown in **Figure 7.3**. Since our draft advice an extra year of data became available. Our re-analysis shows the impact on the second and third budgets is greater reduction than we previously estimated. A more pronounced reduction in the second and third emissions budgets is seen in **Figure 7.3** when compared to the first emissions budget.

Figure 7.3: Impact on emissions budgets of higher afforestation levels



Source: Commission analysis

We considered a range of other changes in our analysis that were not assessed to be significant

We evaluated a number of changes using the above framework. No other change was deemed to be significant at this time, and an explanation for this is provided in **Table 7.2**. Further details are available in the *Technical annex* published on our website.

Table 7.2: Changes evaluated for significance using the framework

Changes evaluated but not deemed to be significant	
Change item	**Justification**
Transport	
EV uptake rate higher than predicted	From 2021, a suite of policies were introduced to incentivise the uptake of low emissions vehicles. This policy response was intended to achieve an action assumed in the emissions budgets, and therefore has not changed our assessment of what was feasible. Uptake projections are inherently uncertain, and the rates could be different in the second and third emissions budgets. Changes to government policy may alter the projection of EV uptake in the future.
Change in vehicle kilometres travelled (VKT) projections	VKT forms the basis of emissions estimates in the ENZ model, which is used to derive the level of emissions budgets. Light vehicle VKT is now estimated to be lower than that projected under *Ināia tonu nei* through to the third emissions budget. For heavy vehicles, the VKT projections have increased but have a smaller total VKT than light vehicles. These projections linked to demand can be harder to accurately predict than single discrete events, such as an industrial process change. This makes it an uncertain change that may not be permanent, and therefore was determined to not represent a significant change.
Biofuels mandate	Biofuels are part of the *Ināia tonu nei* demonstration path and the Government's emissions reduction plan and are a realistic action to reduce emissions for hard-to-abate sectors such as heavy freight and aviation. The biofuels mandate is a specific policy used to incentivise uptake. Although this policy has been discontinued it does not mean alternative mechanisms will not emerge, or that alternative paths cannot be identified.

Changes evaluated but not deemed to be significant	
Change item	**Justification**
Energy and industry	
NZ Steel electric arc furnace (EAF) funded	The EAF is a change in technology that will reduce carbon emissions that was not considered in *Ināia tonu nei*. The EAF is considered one of the main initiatives for the Government to meet its second and third emissions budget targets. It is a policy response to the emissions budgets being in place. The EAF is not representative of a new technological breakthrough for the industry but represents a different path for decarbonisation that the Government could take.
Fonterra receiving GIDI funding to reduce process heat	This initiative is a policy response by the Government as a means to achieve emissions budget reductions. Although this particular initiative was not modelled in *Ināia tonu nei*, the move away from coal for process heat was considered at the time (albeit at a later date). Our understanding of what is feasible is unchanged, and it should not represent a significant change.
Heat pumps that can deliver heat >100°C	This is an emerging technology which has continued to develop since *Ināia tonu nei* was published. It is likely to be an option for electrification of process heat within the second emissions budget period. The GIDI funding recently awarded to Fonterra to reduce coal use in process heat, in part, addresses the same emissions source. This represents an alternative decarbonisation path the Government could take. There is not sufficient justification to represent a significant change.
Carbon capture and storage now has greater potential	Prospects for CCS technology have improved since the publishing of *Ināia tonu nei*. The EB4 demonstration path includes CCS for geothermal electricity generation, whilst it was not included in the paths used for setting the first three emissions budgets. This technology represents an alternative path to decarbonising electricity generation, so it is not considered a significant change. The other opportunity for CCS, applied to fossil gas production, is being actively evaluated by government. However, it is not a mitigation necessary for the EB4 demonstration path, and impacts on emissions budget levels are uncertain.
Fossil gas reserves and supply have declined	Domestic fossil gas reserves have declined at a faster rate than was anticipated in *Ināia tonu nei*. We anticipate a role for fossil gas through the energy transition. While a change has clearly occurred, with the situation still unfolding, our assessment is that it does not meet the criteria for being significant. At this stage there is still a high level of uncertainty for how this change may develop and the possible extent of implications for meeting emissions budgets.

Changes evaluated but not deemed to be significant	
Change item	**Justification**
Agriculture and land use	
Methane Inhibitor 3-NOP	The likelihood that a methane inhibitor will be available in Aotearoa New Zealand by the second emissions budget period (2025–2030) has increased since the set budgets. However, there is no change yet to the knowledge of how effectively they could reduce emissions, barriers that may exist, or the costs to implement across Aotearoa New Zealand. The uncertainties remain too large to recommend this as a significant change.
Lower afforestation rates anticipated over next few years	Submissions arising from the public consultation identified that in the next few years afforestation rates are predicted to fall substantially. The government projections for afforestation through to 2050 have also changed. The projected afforestation for 2025 to 2050 remains highly uncertain, and for this reason, is not deemed significant.
Implication of land-use changes on communities	Since *Ināia tonu nei* was published, the rate of afforestation has increased faster than was predicted. How this progresses in the next few years could dictate the impacts on communities. There is a limited body of literature addressing the potential social impacts of future land-use changes,[97,98] which was available at the time the budgets were set. No further climate policies have been announced or introduced that are likely to significantly influence land-use change and impact rural communities.

Collective impacts of changes on the first three emissions budgets

Our analysis in this advice has shown methodological and significant changes to the first three emissions budgets have occurred. The impact across the three emissions budget periods is illustrated in **Table 7.3**. Under the Act we are required to provide emissions budget recommendations that include all greenhouse gases expressed as a net quantity of CO_2e.

Table 7.3: Impact of methodological and significant changes on set budgets

	First emissions budget (2022–2025)	Second emissions budget (2026–2030)	Third emissions budget (2031–2035)
Set budgets (Total net emissions)	290 $MtCO_2e$	305 $MtCO_2e$	240 $MtCO_2e$
Difference due to methodological changes	-7 $MtCO_2e$	-1 $MtCO_2e$	-0 $MtCO_2e$
Difference due to significant changes	0 $MtCO_2e$	-14 $MtCO_2e$	-18 $MtCO_2e$
Recommended budgets (Total net emissions)	283 $MtCO_2e$	290 $MtCO_2e$	222 $MtCO_2e$
Annual average	70.8 $MtCO_2e$/yr	58.0 $MtCO_2e$/yr	44.4 $MtCO_2e$/yr

Source: Commission analysis

Recommendation

Recommendation 5 – Revisions to the set emissions budgets

We recommend that the Government revise the first, second and third emissions budgets as outlined in the table* below:

	First emissions budget (2022–2025)	Second emissions budget (2026–2030)	Third emissions budget (2031–2035)
Set budgets (total net emissions)	290 $MtCO_2e$	305 $MtCO_2e$	240 $MtCO_2e$
Difference due to methodological changes	-7 $MtCO_2e$	-1 $MtCO_2e$	0 $MtCO_2e$
Difference due to significant changes	0 $MtCO_2e$	-14 $MtCO_2e$	-18 $MtCO_2e$
Recommended budgets (total net emissions)	283 $MtCO_2e$	290 $MtCO_2e$	222 $MtCO_2e$
Annual average	70.8 $MtCO_2e$/yr	58.0 $MtCO_2e$/yr	44.4 $MtCO_2e$/yr

*All values listed in $MtCO_2e$ are calculated using the IPCC AR5 GWP_{100} values.

Wāhanga 8 | Chapter 8

Te Tātainga o ngā kauneke kei ngā tahua tukuwaro me te ahunga 2050
Measuring progress towards emissions budgets and the 2050 target

The methods used to calculate and report the amount of greenhouse gases emitted or removed from the atmosphere over time towards the target are a critical component of effective climate policy.

Emissions accounting rules are those that govern how greenhouse gas emissions are measured and calculated in Aotearoa New Zealand. They are important for informing climate policy and monitoring and reporting progress against emissions budgets and the 2050 target.

Under the Climate Change Response Act 2002 (the Act), any time He Pou a Rangi Climate Change Commission (the Commission) provides advice on emissions budgets, we must also advise on the rules that will be used to measure progress towards meeting those budgets and the 2050 target. We first advised on these rules in our 2021 report *Ināia tonu nei*, in which we provided advice to the Government on setting the first three emissions budgets.[99] When the Government set the first three emissions budgets in May 2022, it adopted emissions accounting rules largely in line with our advice.

We note the current rules use production accounting with a modified activity-based framework for land emissions for measuring emissions reductions. There remain areas where the Government has yet to clarify how its rules will work, including particulars of rules applying to forestry and rules for non-forestry removals. The operation of these rules could materially affect the ambition of future emissions budgets. We will continue to monitor developments, as information becomes available.

This chapter provides advice for how the Government can set additional rules to better manage the levels of carbon dioxide removals by forests included in emissions budgets, as well as account for non-forestry carbon dioxide removals.

We also advise the Government to publish a rigorous and transparent analysis and report of the methods chosen (e.g. averaging and forest reference level) and alternatives considered, including an assessment of their robustness, integrity, challenges, and drawbacks.

Changes from the draft version of this chapter

We have not substantively changed this chapter in response to consultation. Our recommendation on what the Government should consider when developing accounting methodologies for additional emissions sources or sinks is unchanged. In response to specific feedback, we strengthened our advice to Government to complete and publish rigorous and transparent analysis of the options considered and decisions made about accounting rules.

Greenhouse gas emissions accounting

Robust and accurate emissions accounting is essential for:

- setting emissions budgets and target components
- monitoring and evaluating progress towards meeting budgets and target components
- judging compliance at the end of a budget period.

In the Commission's first advice, *Ināia tonu nei*, we introduced six principles for what emissions accounting should do, which remain relevant. These principles are based on the requirements of Article 4.13 of the Paris Agreement that, in accounting for emissions, parties shall "... promote environmental integrity, transparency, accuracy, completeness, comparability and consistency, and ensure the avoidance of double counting...". We said that emissions accounting should:

- seek to cover all material human-caused emissions sources and sinks
- be grounded in robust science and evidence
- send a clear signal for climate action
- be accurate and reduce uncertainty as far as practicable
- be transparent, practical, and acceptable
- be consistent and maintain the integrity of the 2050 target.

A key purpose of the emissions reduction targets that countries set themselves is to drive actions to reduce human impacts on the climate. The accounting methods for these targets need to deliver useful data to inform emissions reduction efforts and priorities. This link between policy and driving change is why target accounting may differ from the methods used for reporting emissions in Aotearoa New Zealand's greenhouse gas inventories.

Accounting approaches and methodologies should allow continuous improvement toward more robust measuring and reporting of emissions. Changes in methodologies should not be a mechanism to achieve targets more quickly.

Roles and responsibilities

The Commission is required to advise on the rules that will apply to measure progress towards emissions budgets and the 2050 target, as part of its five-yearly advice on emissions budgets (section 5ZA(1)(b) of the Act). The Government must then establish the accounting rules as part of setting each emissions budget.

The Commission has a role to monitor the Government's progress in delivering its emissions reduction plans and in reaching the emission budgets. Starting in 2024, the Commission reports on progress annually,[100] and these monitoring reports must use the rules adopted by the Government when the emission budgets were set.

Changing the accounting rules can change the ambition of the target

The ambition of a target or budget depends both on its level and on the rules used to measure progress towards it. If there are significant accounting changes that depart from those that were used to set the emissions budget, that could have the effect of changing the ambition of the budget – making it either easier or harder to achieve. This is why methodological consistency is important between setting budgets and meeting them.

Ensuring methodological consistency is one of the requirements of the Paris Rulebook for meeting nationally determined contributions (NDCs).[101] Similarly the Act (in section 5ZJ(2)) requires that the Commission monitor progress towards emission budgets using the rules adopted when the budgets were set. Any changes to accounting rules should be retrospectively applied to ensure consistent methods are used to both set and meet an emissions budget.

Our previous advice

We provided advice on accounting in *Ināia tonu nei*

In *Ināia tonu nei*, we applied the accounting principles above to assess the main choices for emissions accounting, and made recommendations for how the Government should proceed on several accounting issues:

- whether to use production- or consumption-based emissions estimates
- how to account for emissions from the land sector
- voluntary offsetting
- methodological inventory updates.

In *Ināia tonu nei*, we identified two options for approaches to accounting for emissions: production and consumption approaches. The production approach records emissions at the point where human activity causes their release to the atmosphere. It includes all emissions occurring within a territorial boundary. The consumption approach focuses instead on the use of goods and services and the emissions embodied in the entire supply chain required to produce the good or service – no matter where that emission occurred.[102]

We recommended that the Government calculate and report emissions on a production basis rather than a consumption basis. Consumption-based emissions estimates for Aotearoa New Zealand were (and remain today) at the early stages of development, making them unsuitable as a basis for measuring progress against emissions budgets and the 2050 target. In contrast, production-based estimates of emissions have been produced annually for more than 25 years and have improved in their rigour and completeness over that time. However, we recommended the Government continue to produce and improve consumption-based estimates as a complementary tool.

Methodologies to estimate emissions are based on guidance developed by the IPCC. For the energy, agriculture, industry, and waste sectors, there is largely one set of agreed methodologies on how to estimate emissions via the IPCC 2006 guidelines.[103] Accounting for emissions and removals from the land sector is more complex, and there is a wider set of methodologies available. A large amount of land in Aotearoa New Zealand is used for forestry, so the rules for measuring and accounting for its impact can have a large effect on total emissions. This is why much of our rules advice focuses on how to account for land sector emissions and removals.

For land emissions, we recommended the Government use a modified activity-based approach for accounting, rather than a land-based approach. An activity-based approach accounts for particular activities – in this case afforestation, reforestation, and deforestation – in order to filter out the effect of land-use decisions made before the base year. This approach was adopted by the international community for the Kyoto Protocol. Aotearoa New Zealand modified the methodology (via averaging)[lxxvi] to focus on the component of forestry removals that are additional and permanent.

We found that this approach would focus on the impacts of decisions made now and into the future, rather than rewarding or penalising decisions made in the past. We also noted it would align with the approach used for Aotearoa New Zealand's NDC under the Paris Agreement.

Our recommendations were that the Government calculate and report Aotearoa New Zealand's emissions by:

- using a 1990 base year and 'averaging' for post-1989 forests, aligning emissions budget accounting with the approach for the NDC
- including the land areas corresponding to afforestation, reforestation, and deforestation, as confirmed for the first NDC
- excluding forest management, despite its inclusion in NDC accounting. This was because the Government had not yet set the reference level, so we had not been able to assess how the inherent challenges and uncertainties were handled
- including harvested wood products (HWPs) from post-1989 forest carbon stocks, but not from pre-1990 forests, as they are a forest management activity, which we recommended to be excluded
- including a natural disturbances provision to allow for managing the risks of extreme natural events that could radically affect land emissions and removals and aligning it with the first NDC and the 2013 IPCC Kyoto Protocol Supplement.

We also recommended the Government undertake further work to improve emissions estimates and broaden the options available for emissions accounting in the future by:

- continuing to produce annual reports on national consumption estimates
- developing appropriate methods to reflect changes in carbon dioxide stored in above-ground biomass and harvested wood products due to increased use of biomass for energy
- developing methods for tracking emissions and removals by sources and sinks not yet included in the country's domestic or international target accounting, with prioritisation given to development of methods to account for carbon in organic soils (such as peat) and biomass (such as small lots of trees and regenerating vegetation)
- examining the feasibility of using the land-based approach in accounting for the target and emissions budgets for sources and sinks other than production forests, while also managing the uncertainty and emissions fluctuations from the harvest cycles of production forests
- developing sound and transparent practices for accounting for domestic voluntary mitigation and offsetting claims, in relation to the New Zealand Emissions Trading Scheme (NZ ETS), emissions budgets, and NDC.

lxxvi New Zealand's accounting approach was communicated to the UNFCCC in October 2016 on ratification of the Paris Agreement; New Zealand's international accounting after 2021 will adopt the modified version of the current Kyoto Protocol rules.

The Government set the first rules for emissions accounting in 2022

When the Government set the first, second, and third emissions budgets in May 2022, it put in place its approach to measuring progress towards meeting those budgets and the 2050 target, largely in line with our advice.

The current rules use:

- production-based accounting, calculated and reported annually by New Zealand's Greenhouse Gas Inventory (GHG Inventory)
- a modified activity-based approach for accounting for land emissions in line with accounting for Aotearoa New Zealand's NDC.

However, the Government's rules diverged from our advice in two areas.

Forest management was included

In *Ināia tonu nei*, we advised that forest management be excluded from accounting. The Government decided it will include forest management activities in accounting towards budgets and the 2050 target.

The Government is developing a reference level for accounting for pre-1990 forests under forest management, which had previously been expected to be completed by the end of 2023. This would have enabled emissions from pre-1990 forest management activities to be included in the rules for the first emissions budget, in line with accounting for Aotearoa New Zealand's first NDC. However, this is now scheduled to be completed and published in the Government's Biennial Transparency Report, due at the end of 2024.

Natural disturbances provision was not included

The Government disagreed with our advice regarding including natural disturbances within accounting; instead, the Government said it would reconsider this issue when accounting for pre-1990 forest management.

The primary reason cited by the Government for its decision was the lack of evidence that would enable this provision to be implemented. In particular, it reported there was little, if any, evidence for assessing the background level of natural disturbance occurring in a newly established forest, to which modified activity-based accounting is applied.

However, the Government did see the natural disturbances provision as relevant for existing pre-1990 forests, where evidence is available to calculate a background level against which the provision to exclude emissions from natural disturbances can be applied.

The Government is considering additional sources and sinks

Since the first emissions reduction plan, the Government has made high-level announcements

In *Ināia tonu nei*, we advised that the Government needed to do further work to develop methods for tracking emissions and removals by sources and sinks not yet included in the country's domestic or international target accounting. We recommended the Government prioritise the development of methods to account for carbon in organic soils (such as peat) and biomass (such as small lots of trees and regenerating vegetation).

In July 2023, the Government announced the development of a Carbon Removals Strategy, intended to be included in the second emissions reduction plan. The strategy was expected to consider how a broader portfolio of carbon dioxide removal activities can be used to meet emissions budgets and the NDC under the Paris Agreement. The Government included non-forestry removals in its consultation on the second emissions reduction plan in mid-2024, with the intent to enable and recognise other types of carbon removal activities, both nature-based and engineered solutions. The second emissions reduction plan is due to be published by the end of 2024.

We cannot assess impacts on budgets and the 2050 target at this time

In *Ināia tonu nei*, we advised that expanding target accounting beyond the scope used to set the existing target would be cause for a review of the 2050 target to ensure its integrity. This is important to prevent undermining the ambition of Aotearoa New Zealand's climate commitments. We said this was most appropriately considered in 2024 when reviewing the 2050 target.

The Government has not made enough progress for us to do this. While high-level announcements have been made, significant technical work would need to happen for these additional sources and sinks to be included in budgets and target accounting. To date, we have not seen evidence of this work and cannot comment on the process or integrity of analysis.

The next formal opportunity for us to consider whether budgets need to be revised will be in 2028/2029 when we give advice on the fifth emissions budget. If the Government includes any additional sources and sinks into budgets and target accounting before that time, we will be able to consider this as part of our annual monitoring function. Identifying changes to accounting will allow us to understand the impact of additional sources and sinks on meeting emissions budgets.

Our approach for this advice

Our recommendation in this advice builds on our previous advice

In preparing advice on the fourth emissions budget, we have looked at whether the Government has updated any of its approaches to accounting since the Government set budgets and rules to measure progress.

The Government has not yet published developments to its accounting approach to permit a review ensuring they are fit for purpose. Our previous recommendations to the Government to undertake further work to improve emissions estimates and broaden the options available for emissions accounting in the future are therefore still relevant. The recommendation in this advice is intended to build on our previous advice.

This advice focuses on setting expectations for further work

Since the Government is currently developing a forest reference level and progressing work on expanding accounting to additional sources and sinks, our further advice focuses on setting expectations for what we expect to see as this work progresses. We advise the Government to publish a rigorous and transparent analysis and report of the methods chosen (e.g., averaging and forest reference level) and alternatives considered, including an assessment of their robustness, integrity, challenges, and drawbacks.

We have used the accounting principles we developed for *Ināia tonu nei* as a basis for how the Government should be considering accounting issues and challenges when making further decisions on these areas. The following sections outline these issues.

Forest management

Forest management will be counted towards emissions budgets and the 2050 target

Forest management is included in the approach to NDC accounting. The Government is currently developing a forest reference level for the NDC period 2020–2030. This will also be used for budgets and target accounting.

Box 7.1 Setting a reference level for forest management

As stated in *Ināia tonu nei*, forest management is the part of the NDC accounting system through which the impact of management practices on carbon stocks affecting pre-1990 forests is counted.

It involves setting a reference level based on a future projection of what emissions and removals in pre-1990 forests would be with no change in management. The impacts of changes in management practices on a long-term basis can potentially be measured by monitoring progress against this reference level.

Theoretically, this approach can be used to recognise the effect of human interventions that increase carbon stocks in pre-1900 forests, such as extending harvest lengths in production forests or undertaking pest control. In practice this is difficult to implement, given the national-scale measurement and monitoring systems.

Using counterfactual projections in this way has inherent accuracy and uncertainty challenges, with high risks of both under- and over-estimation. Foresters have choices about how and when to harvest and replant their forests. It can be difficult to discern actual changes to management practices from forecasting errors.

Recent history shows there are challenges to this approach

Under previous Kyoto Protocol Rules (prior to the Paris Agreement and establishment of NDCs), it was mandatory for countries to include forest management in accounting. In Aotearoa New Zealand's reporting against the 2020 emissions reduction target (covering the 2013–2020 period), the GHG Inventory showed a high amount of net removals (123 $MtCO_2e$) from forest management.

The net removal appears to have been the result of lower harvesting rates of pre-1990 production forest than projected when the reference level was set. Issues with accuracy of estimates for intended harvesting rates of pre-1990 forests are largely due to the skewed profile of the country's forests driving variable harvest rates, as well as inconsistency of different forest statistics. This means that the removals accounted for may not actually be 'additional' to what was planned. Delayed (rather than avoided) harvesting would just result in these emissions occurring further down the track.

The implications of this on Aotearoa New Zealand's target were limited (to 18.7 $MtCO_2e$ net removals[104]) due to Kyoto Protocol rules restricting the amount of forest management contributions that could count towards the target. At time of writing, the Government has not yet indicated whether it intends to put limits in place for the current NDC.

While changes in forest management of production forests were recorded, none were recorded for forest management of the country's 7.7 million hectares[lxxvii] of pre-1990 native forests Aotearoa New Zealand's native forests are generally not harvested,[lxxviii] and effects from activities – such as pest control – are challenging to accurately attribute with current monitoring techniques. Detailed research could help overcome these barriers, but with present methods, thousands of forest monitoring plots would be required (at significant cost) to provide accurate enough information for accounting purposes.[105]

Land area under forest management will increase over time

The averaging approach replaces the stock change approach to account for carbon dioxide removals from forestry. Under the averaging approach, an additionality test applies to the specific removals in each newly planted forest. Only removals from the forest's long-term average carbon stock (approximately the first 20 years of growth in production forests, depending on forest type) are considered additional and count towards the target. After that time, the forest transitions to the forest management category, and cyclical emissions and removals from expected harvest and growth are no longer included in accounting emissions so long as the land remains in forestry. Sometimes the forest will store more carbon dioxide than has been credited and sometimes it will store less, depending on where it is in a production cycle, but these fluctuations should average out over the long term.

This approach evolves the distinction from pre-1990 and post-1989 forest land to newly planted forest versus land under forest management. As more and more post-1989 forest ages, it will transition into the forest management category. This means that any discrepancies between projected emissions and removals and actual activity from land under forest management will affect larger and larger areas of land over time, with correspondingly bigger impacts on the emissions budgets and the 2050 target. This is another reason to be cautious about crediting forest management under emissions budgets using counterfactual projections.

Methodologies will need to be improved

With its intention to include forest management activities in budgets and 2050 target accounting, the Government will need to improve its methodologies to better align with the principles the Commission has set out to guide accounting and ensure integrity of Aotearoa New Zealand's climate ambition.

The Government will need to consider how it develops an appropriate evidence base to measure and monitor forest management activities. This should include a plan for how it will improve estimates around intended pre-1990 production forest harvesting.

lxxvii 2024 edition of the GHG Inventory

lxxviii Noting that indigenous forest is deforested each year: for example, net deforestation was approximately 500 ha in 2020, the most recent year for which measurements are available, according to the 2024 edition of the GHG Inventory.

Adopting strong criteria around additionality and permanence (durability) will be important to ensure removals can be considered genuine (see below section for more detail on recommended criteria for carbon removals).

As Aotearoa New Zealand's history with Kyoto Protocol accounting shows, the inclusion of forest management creates risks of generating credits or debits that are not the result of genuine management practice change affecting long-term emissions trajectories.

The Government should consider immediate needs for managing the inherent accuracy and uncertainty risks of including forest management as part of a wider plan for how it will manage risks across all carbon dioxide removal activities.

Expanding accounting to include additional sources and sinks

Other sources of land emissions and removals not yet included in accounting

In *Ināia tonu nei*, the Commission provided advice about investigating the options for a wider portfolio of carbon dioxide removal activities. Inclusion of these activities is in line with our principle that accounting should aim to cover all human caused sources and sinks of emissions.

Large sources of land emissions and removals not yet part of accounting are emissions from organic soils (mostly drained wetlands) and removals from vegetation biomass (mostly improved pasture and small lots of trees) on grasslands.

Criteria should underpin removals to ensure integrity

We think it is important that including non-forestry removals is not used to weaken emissions budgets and the 2050 target. In our advice to the Government on the direction of policy for the second emissions reduction plan, we recommended that the Government adopts the principles of additionality and permanence (durability) and includes them as criteria for any recognised removal activities, along with other key characteristics including removal capacity, measurability, cost, and acceptability. Additionality, permanence and measurability are key criteria for the environmental integrity of removals.[106] Removal capacity, cost and acceptability are important for the wider impacts of removals and their role in Aotearoa New Zealand's transition to a low emissions economy. We have provided further detail on these criteria below.

Additionality

As defined in our advice to the Government regarding its second emissions reduction plan, additionality is the concept that an activity only contributes to carbon dioxide removal if it is extra to the status quo or business as usual. This was the reason for setting 1990 as the baseline year for carbon storage in forests in Aotearoa New Zealand. The adoption of averaging has superseded the 1990 boundary by applying a stricter additionality test for new forestry.

Strict additionality tests will be needed to ensure any removals included are a result of genuine climate change mitigation efforts and not a way to gain removal credits for activity that would have happened otherwise. These tests should consider whether the removals have happened as a result of policy that has been implemented for climate change. These tests may be different across activities depending on the baseline year.

Permanence (durability)

As defined in our advice to the Government regarding the second emissions reduction plan, permanence indicates how long carbon dioxide is expected to be stored; it is also referred to as the durability of carbon dioxide removal. Carbon capture through land and coastal vegetation, soils, and sediment has storage timescales of decades to centuries. Processes involving marine sediments have timelines of centuries to millennia, and engineering processes involving geological formations and minerals even longer.

As these removals are subject to changes in management practices and climate impacts, there is a risk of reversal. The Government should consider how it may govern and enforce permanence of removals.

Other characteristics to include

Alongside permanence and additionality, other criteria that should be included are:

- **removal capacity** – the amount of emissions that can be sequestered by the carbon sink
- **measurability** – the ability to measure removals and storage, including whether established methods exist and how well demonstrated they are to date
- **cost** – the costs associated with developing evidence bases and ongoing monitoring and reporting of emissions associated with each activity
- **acceptability** – consideration of the values associated with activities, including the social licence and international recognition of activities.

Nature-based carbon dioxide removals should also go hand in hand with ecological restoration and attending to the biodiversity crisis.

Long-term planning and commitment are required

It is important that the Government sends long-term signals. Inclusion of these activities in accounting will require long-term time commitment and resources to ensure there are appropriate evidence bases and long-term monitoring and evaluation assessments. This will need to be planned for and funded.

Evidence bases of emissions and removals associated with non-forestry removals, and changes in management practices, are still in development. This makes accurately estimating the potential and enduring contribution from non-forest land uses to the target challenging. The emissions and removals from land uses also vary from site to site and project to project, so management outcomes can have high uncertainty at the national scale.

The Government should develop a phased approach over the long term to allow time for developing and improving data sets and setting up long-term monitoring and evaluation across different sources, sinks, and management practices. Some sources and sinks will be more important to prioritise due to their emissions intensity and/or removal capacity (for example, peat and small stands of trees/regenerating vegetation). Prioritisation for removals should be guided by the accounting principles and criteria set out above. This should then inform the policies needed to incentivise action.

Risks and uncertainties need to be managed

As with forest management, inclusion of non-forest carbon removal activities creates risks of generating credits or debits that are not the result of genuine practice change. Both under- and over-estimates will affect long-term emissions trajectories. Potentially, it could also be used to strategically generate removal credits that do not reflect genuine additional removals, especially if policies are developed to incentivise them.

The Government will need to plan for how to manage these uncertainties and risks. This plan should:

- include limits and constraints on the amount of removals that can be used to account towards the emissions budgets and 2050 target consistent with Aotearoa New Zealand's climate ambition
- cover both forest and non-forest removals (recognising there may be more immediate needs for managing risks associated with forest management)
- be consistent with wider work by the Government clearly communicating the role of removals from forestry out to 2050, as advised in *2023 Advice on the direction of policy for the Government's second emissions reduction plan*.

Recommendations

We are making a recommendation for the Government's work on including additional (non-forest) carbon dioxide removals.

We are not making any further recommendations on the Government's approach to accounting or forest management since no further information has been available. As noted, we advise the Government to publish a rigorous and transparent analysis of the methods chosen.

Recommendation 6 – Rules to measure progress

We recommend that, as the Government considers whether to include any new sources of emissions or carbon dioxide removals in its accounting for emissions budgets, it:

a. adopts the principles of additionality and permanence (durability) and includes them as criteria for any recognised carbon removal activities, along with other key characteristics including removal capacity, measurability, cost, and acceptability
b. develops and implements a long-term plan for measuring and monitoring additional sources, sinks, and changes in management activities, including how the plan will be funded
c. develops and implements a plan for how the Government will manage accuracy and uncertainty risks, limiting the risk that over- or under-estimation will impact long-term emissions trajectories and associated emissions reduction efforts.

Piringa 1: He iringa kupu
Appendix 1: Technical glossary

Note: there are te reo Māori glossaries provided at the end of Chapters 2 and 6, which provide English contextual translation of kupu Māori used in that chapter.

additionality	A term used to describe what an action or intervention has accomplished, compared to doing nothing. Emissions reductions or removals can be considered additional if they would not have occurred under business-as-usual conditions and without the policy or activity in question. The details of how additionality is evaluated can vary depend on the context. For example, in most carbon markets a project or activity is only judged additional if it would not have occurred without the revenue from earning units in that market. In contrast, in the system used for accounting greenhouse gas emissions against New Zealand's emissions reduction targets, based on the rules established under the Kyoto Protocol, carbon dioxide removals by any forest planted after 1989 are deemed to be additional, irrespective of whether they were driven by a specific policy intervention aiming to enhance sequestration by forests.
afforestation	The conversion of land from another use, such as pasture for grazing, to forest.
alternative fuels	Liquid fuels derived from sources other than petroleum or diesel.
anaerobic digestion	Anaerobic digestion is a natural process where micro-organisms break down organic waste such as food scraps. This produces two resources; biogas (primarily methane and carbon dioxide, produced from organic materials like animal waste and food scraps) and digestate. Digestate is a nutrient rich substance which is being used by farmers as a fertiliser. Biogas can be used in place of fossil gas in heating and electricity generation.
biofuels	Biofuels are renewable fuels made from biomass, such as ethanol, biodiesel, and renewable hydrocarbons.
biogenic methane	All methane greenhouse gases produced from the agriculture and waste sectors (as reported in New Zealand's Greenhouse Gas Inventory).

biomass	Biomass is organic material from living sources – such as wood and wood waste, crops or animal manure – that can be used as an energy source.
carbon capture and reinjection	The process where carbon dioxide that naturally occurs in geothermal fields is reinjected back underground.
carbon capture and storage (CCS)	Refers to a suite of technologies that capture carbon dioxide emissions from an industrial or energy-related point source for permanent storage in a biological or geological reservoir. A subset of carbon capture and storage is direct air carbon capture and storage (DACS). This is a technology that removes CO_2 from the atmosphere using electricity and stores it underground or uses it for other purposes.
carbon dioxide removal (CDR) techniques	Over 99% of current CDR is from conventional methods including afforestation. Novel methods (non-conventional) include techniques such as biochar, bioenergy with carbon capture and storage, and direct air capture with carbon capture and storage.
Climate Change Response Act 2002	The Act that establishes the Climate Change Commission and contains the framework for the 2050 emissions reduction target and emissions budgets. It also provides a legal framework to enable Aotearoa New Zealand to meet its international obligations under the United Nations Framework Convention on Climate Change, the Kyoto Protocol and the Paris Agreement; and provides for the implementation of the New Zealand Emissions Trading Scheme (NZ ETS) and the synthetic greenhouse gas levy.
CO_2e	Carbon dioxide equivalent. This is a way to describe different greenhouse gases on a common scale. It relates the warming effect of emissions of a particular gas to that of carbon dioxide, over a specified period of time. It is calculated by multiplying the quantity of that greenhouse gas by the relevant global warming potential (GWP). The current values used are the 100-year GWPs from the Intergovernmental Panel on Climate Change (IPCC) 5th assessment report (AR5), which are shown in short form as GWP_{100}.
decarbonise	To reduce the levels of carbon emissions (such as carbon dioxide) caused by or involved in something, such as an activity or process.
deforestation	The conversion of forest land to another use such as grazing. In greenhouse gas emissions accounting and policy relevant to Aotearoa New Zealand, deforestation is defined as clearing forest and not replanting within four years. It does not include harvesting where a forest is replanted.

domestic voluntary mitigation	Reducing emissions and increasing removals of greenhouse gases beyond government requirements (including requirements in the New Zealand Emissions Trading Scheme).
emissions	Greenhouse gases released into the atmosphere. The Climate Change Response Act 2002 covers the following greenhouse gases: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride.
emissions budget	The cumulative amount of greenhouse gases that can be emitted over a certain period. In the Climate Change Response Act 2002, emissions budgets are the total amount of all greenhouse gases (expressed as a net amount of carbon dioxide equivalent or CO_2e) that can be released over a five-year period (or four years in the case of the first emissions budget covering 2022–2025).
emissions intensity	The ratio of greenhouse gas emissions to a unit of activity or output. This could be emissions per unit of economic output, such as GDP, to give a measure across an entire economy, or relative to other variables such as per kilometres travelled for modes of transport, or per unit of revenue or of a good produced in firms' production processes, such as per litre of milk solids. Measures of emissions intensity allow comparison of emissions performance across different activities and tracking of progress over time, where changes in economic activity can obscure some types of progress such as efficiency improvements.
emissions leakage	Emissions leakage would occur if efforts to reduce emissions in one location caused an increase in emissions somewhere else so that global emissions overall did not reduce. Emissions leakage risk is created by the uneven implementation of climate policies around the world.
emissions reduction plan (ERP)	A plan setting out the policies and strategies for meeting an emissions budget, as required by the Climate Change Response Act 2002.
feedstocks	Material inputs to industrial processes needed to manufacture products. Potential sources of low-carbon feedstocks include clean hydrogen, bio-based feedstocks, and end-of-life materials like scrap steel and recycled plastics. These can be used to generate alternative fuels.
global warming potential (GWP)	A factor relating the warming effect of a tonne of emissions of a particular greenhouse gas, to those of a tonne of carbon dioxide emissions over a specified period of time. See also 'CO_2e'.
green anodes	See 'zero carbon anodes'.
green hydrogen	Hydrogen produced by splitting water into hydrogen and oxygen using renewable electricity.

greenhouse gases (GHGs)	Atmospheric gases that trap heat and contribute to climate change. The gases covered by the Climate Change Response Act 2002 are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6).
gross emissions	Gross emissions include total greenhouse gas emissions from agriculture, energy, industrial processes and product use (IPPU) and waste. Greenhouse gas emissions and removals from land use, land use change and forestry (LULUCF) are excluded.
heavy vehicle	A vehicle over 3.5 gross tonnes. These are typically trucks and buses.
Intergovernmental Panel on Climate Change (IPCC)	Intergovernmental panel under the United Nations, which prepares comprehensive Assessment Reports about the state of scientific, technical and socio-economic knowledge on climate change, its impacts and future risks, and options for reducing the rate at which climate change is taking place.
international shipping and aviation emissions	These are greenhouse gas emissions from shipping and aviation to and from Aotearoa New Zealand; they are currently not counted in the country's 2050 target, emissions budgets, or emissions reduction plans which cover only the shipping and aviation emissions related to domestic travel and transport.
Kyoto Protocol	Protocol which operationalised the United Nations Framework Convention on Climate Change by committing industrialised countries and economies in transition to limit and reduce greenhouse gas emissions in accordance with agreed individual targets. The Kyoto Protocol was the predecessor to the Paris Agreement.
light passenger vehicle	A vehicle under 3.5 gross tonnes. These are typically cars, SUVs, utes, vans and motorbikes.
long-lived greenhouse gases	Greenhouse gases that have a long lifetime in the atmosphere, i.e. they persist in the atmosphere without breaking down for multi-decadal, centennial, or millennial timeframes. For ease of presentation, we refer to all greenhouse gases other than biogenic methane collectively as long-lived gases, although this includes a small amount of other short-lived gas emissions (non-biogenic methane and certain fluorinated gases). See also 'short-lived greenhouse gases'.
low-carbon liquid fuels	Fuels that emit significantly lower amounts of carbon dioxide and other greenhouse gases when burned, compared to traditional fossil fuels. These include biofuels (derived from organic materials such as plants, algae, and waste), synthetic fuels (produced from renewable energy sources, water, and carbon dioxide through chemical processes), and advanced biofuels (derived from non-food biomass feedstocks such as agricultural residues and woody crops).

methane inhibitors and vaccines	Chemical compounds that reduce the production of methane in animals' rumen (stomachs). They typically do this by targeting enzymes that play a key role in the generation of methane.
mitigation	Human actions to reduce emissions by sources or enhance removals by sinks of greenhouse gases. Examples of reducing emissions by sources include walking instead of driving or replacing a coal boiler with a renewable electric powered one. Examples of enhancing removals by sinks include growing new trees to absorb carbon, or industrial carbon capture and storage activities.
MtCO_2e	Megatonnes of carbon dioxide equivalent (see 'CO_2e').
nationally determined contribution (NDC)	Each country that is party to the Paris Agreement must define its contribution to achieving the long-term goals set out in the Paris Agreement. The Nationally Determined Contribution of New Zealand (as updated in November 2021) is to reduce net greenhouse gas emissions to 50 per cent below gross 2005 levels by 2030.
net emissions	Net emissions differ from gross emissions in that they also include emissions from the land use, land use change and forestry (LULUCF) sector, as well as removals of carbon dioxide from the atmosphere, for example through absorption by forests as trees grow.
New Zealand's Greenhouse Gas Inventory (GHG Inventory)	Official annual report of all human-induced emissions and removals of greenhouse gases in Aotearoa New Zealand. It is the key source of evidence on Aotearoa New Zealand's greenhouse gas emissions trends. Emissions from fuel sold for use in international transport (e.g. international bunker fuels) are reported separately as a memo item, as required.
offshore mitigation	Offshore mitigation is a way for countries to meet their climate change obligations by using carbon dioxide reductions or removals that originate outside their borders.
Paris Agreement	An international treaty aimed at post-2020 climate change action that was adopted by Parties to the UNFCCC in December 2015.
permanence	When relating to removals of carbon dioxide through forestry: the expected duration of the carbon storage.
removals	The removal of carbon dioxide from the atmosphere, also called sequestration. In Aotearoa New Zealand, this usually refers to absorption of carbon by forests as trees grow.
short-lived greenhouse gases	Greenhouse gases that have a short lifetime in the atmosphere, typically shorter than two decades – see also 'long-lived greenhouse gases'.

stock change approach	Stock change accounting is a method of accounting for the amount of carbon in forest land. The stock change approach accounts for the short-term changes in carbon storage. Using this method, units are earned as the forest grows and need to be paid when it is cleared. Before 1 January 2023, only stock change accounting was available.
target accounting	The accounting system used to measure progress towards Aotearoa New Zealand's emissions reduction targets. Target accounting emissions include all gross emissions, but only a subset of emissions and removals from land use and forestry – namely emissions and removals that are the result of recent and future forestry activities. Target accounting is designed to incentivise emissions reductions and to avoid relying on actions that occurred before 1990 (such as forest planting in the 1970s and 1980s) that continue to result in emissions and removals today. It also applies an averaging approach to production forests to smooth out emissions and removals over harvest cycles.
UNFCCC	The United Nations Framework Convention on Climate Change is the major foundation global treaty focused on climate change. It was signed in 1992 at the Earth Summit in Rio de Janeiro.
vehicle kilometres travelled (VKT)	The number of kilometres travelled across a number of vehicles. For example, 4 people in one car travelling 1 kilometre is 1 VKT.
zero carbon anodes	Zero carbon anodes, also known as inert anodes or green anodes, are non-consumable materials like alloys or ceramics that replace carbon anodes in the smelting process. They can significantly reduce the carbon footprint of aluminium production by eliminating greenhouse gas emissions and producing oxygen instead of carbon dioxide. Also see green anodes.
2050 target	The target set out in the Climate Change Response Act 2002, for Aotearoa New Zealand to: • reduce emissions of greenhouse gases, other than biogenic methane, to net zero by 2050 and beyond – this relates to emissions of carbon dioxide, nitrous oxide, non-biogenic methane and fluorinated-gases (hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride). • reduce biogenic methane emissions by at least 10% by 2030 and 24–47% by 2050 and beyond, compared to 2017 levels. The target does not currently include international shipping and aviation emissions.

Piringa 2: Te taukōrero
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