Technology for Emissions Reduction

A FRAMEWORK FOR AOTEAROA'S CLIMATE TECHNOLOGY ROADMAP

NZTech

digitalnation.nz
REPORT SERIES

Acknowledgements

NZTech would like to acknowledge the following contributors;

The NZTech research team, including Mark Thomas of Serviceworks and Mitchell Pham of CodeHQ leading the programme, collating data, writing and Leeanna Kohn-Hardy of Finappster for contributing to some sections. Graeme Muller and Andrea Molloy for editing the report, and Laura Chamberlain for project management.

We would also like to acknowledge and thank the many project partners who provided the funding and feedback during the research process that enabled the report to be produced, in particular the Ministry for the Environment, the Ministry for Business, Innovation and Employment, the Climate Change Chief Executive's Board and Spark.

Thank you also to the many other stakeholders who have provided valuable feedback during the preparation of this report.

NZTech is a not-for-profit that provides the voice of the New Zealand technology ecosystem, representing 20 technology associations funded by over 2,000 members, who collectively employ more than ten percent of the New Zealand workforce. These organisations are redefining the world we live in. Our goal is to stimulate an environment where technology provides important social and economic benefits for New Zealand. NZTech's vision is a safer, more equitable, sustainable and prosperous Aotearoa New Zealand underpinned by good technology.

Contents

Introduction

03

Thank you to our project partners and supporters

Project Partners

Ministry for the Environment
Manatū Mō Te Taiao

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

NZTech

Spark nz

Supporters

AgriTech NEW ZEALAND

AI Forum New Zealand
Te Kāhui Atamai Iahiko o Aotearoa

BIOTECH NEW ZEALAND

FinTechNZ

New Zealand IoT Alliance

Serviceworks

FOREWORD
NZTech

On behalf of NZTech, we are delighted to present *Technology for Emissions Reduction: A Framework for Aotearoa's Climate Technology Roadmap*. This important piece of work marks a significant milestone in our ongoing journey to harness the power of technology for the benefit of all in Aotearoa New Zealand.

Mitchell Pham
Co Chair,
Sustainability Sub Board
NZTech

For some time, NZTech has passionately advocated for the integration of tech into the critical decisions surrounding climate change. Our belief in the transformative potential of tech has only grown stronger over the years - both through observing the developments and potential in industry and acknowledging the challenges New Zealand faces in meeting its 2050 emissions reductions obligations.

This report signifies a further commitment on behalf of NZTech to work with industry, Government, and other partners to deliver a sustainable future through tech innovation. It reflects the efforts of our dedicated team who have been working on various initiatives over the past few years. This includes our substantial submission on the first Emissions Reduction Plan, our regular engagement and capability building with industry, and the establishment of an internal Environment, Social and Governance (ESG) framework. Our ESG work underscores our commitment to responsible business practices, ethical considerations and environmental stewardship.

This report has been informed by the NZTech national Technology and Emissions Reduction Survey and follow up industry sprint workshops designed specifically for this project. We extend our gratitude to everyone who contributed to its development. We are especially thankful to our partners within the Government and the other experts who generously shared their insights during the discovery phase. Your expertise and input have helped inform and shape the recommendations presented here.

As we embark on this journey towards an Aotearoa Climate Technology Roadmap, we have an even clearer understanding from industry that climate tech is crucial to lower emissions and support a more resilient future. Together, we can drive meaningful change, embrace innovation and chart a course towards a more sustainable, prosperous and inclusive future for all New Zealanders.

FOREWORD
Government

A thriving tech sector is essential for rebuilding the economy, ending the cost-of-living crisis, and lifting incomes. To achieve this, we need to adopt a more strategic approach to investing in technology that will attract investors from within New Zealand and internationally.

The Climate Technology Roadmap is designed to provide clarity for government agencies and private sector investment across a wide range of technologies, including – but not limited to – climate tech, agritech, artificial intelligence and fintech. Given the rapid pace of technological advancement, such clear guidance is invaluable.

The Roadmap was born out of a comprehensive dialogue among industry leaders – through NZTech, its associations and members – and government. It reflects a synergy of ideas and aspirations, and reinforces the importance of collaboration between the government and the tech industry. This partnership is crucial, leveraging our collective expertise and resources to boost the sector.

Developing robust policies to better facilitate technology investment in New Zealand is a major focus for Government. We need to make sure our policy settings and regulations are fit for purpose to make the most of these opportunities. Working with industry experts to ensure New Zealand's digital technology remains at the forefront of international innovation is crucial to a vibrant economic future.

Hon Judith Collins
Minister of Science, Innovation and Technology

FOREWORD

Government

The challenges posed by climate change are immense, but they also present unparalleled opportunities for innovation and leadership. This government is committed to meeting New Zealand's ambitious emissions reduction targets.

We understand that meeting these goals is critical not only for safeguarding our natural environment, but also for achieving economic resilience and prosperity.

Central to realising this vision is the collaboration between the public and private sectors. Together, we can unlock new technologies and innovations that reduce emissions across all of New Zealand's key drivers of emissions – agriculture, energy, transport, waste, and industry. The scale of transformation required to meet our targets can only be achieved by working hand in hand.

The Climate Technology Roadmap outlines a clear path for harnessing technology to meet our emissions reduction targets. It emphasizes the role of digital solutions in monitoring and reducing emissions, the development of clean energy technologies, and the importance of innovation in sustainable agriculture and transportation. By providing a roadmap, we can offer clarity and direction for the private sector, encouraging investment and development in green technologies, and point the way to a brighter, more prosperous future.

Hon Simon Watts
Minister of Climate Change
for New Zealand

Executive Summary

What is the problem?

Insufficient emissions reduction

New Zealand is not on track to meet its emissions reduction targets. Despite making important steps and increasing activity across New Zealand, officials have reported to Cabinet that the country will not meet the first Emissions Budget. The global climate action body Climate Action Tracker has also assessed New Zealand's climate response as Highly Insufficient.

Although New Zealand is a world leader in its use of renewable energy, in 2021 New Zealand had 16.9 tonnes of CO2e per capita - the sixth highest emissions per capita of OECD countries.

Earlier investments in New Zealand's climate actions are essential to avoid the significant costs that will otherwise be required to purchase offshore mitigation to meet the country's National Determined Contribution Investment (NDC).

Treasury and the Ministry for the Environment (MfE) indicative assessment indicates the direct costs for increased investment on a series of key mitigation technologies up to 2050 could be $155 million to $460 million per annum ($4 billion to $12 billion over the period).

However, it says that if an insufficient domestic response is made, a significant risk is presented to the country with the requirement to purchase offshore mitigation to achieve New Zealand's first NDC. The cost range for these purchases, based on MfE's projection for the country's domestic emissions, is between $8.8 billion and $20.6 billion.

The assessment also notes that further investment in mitigation technologies is expected to be required for New Zealand to reach its emissions targets.

Not enough technology

Technology is pivotal in addressing the pressing global challenge of climate change. However, New Zealand's first Emissions Reduction Plan (ERP) is generally considered to have minimised the role technology can play enabling the country's emissions response. This was recognised by the Minister for Climate Change who conceded it was an oversight to underplay the role of technology when targets were set.

Recent analysis found that up to 42 percent of New Zealand's 2030 emissions budget targets could be met by actions enabled by digital technology.

To better understand the opportunities for technology to support emissions reductions in New Zealand, NZTech conducted a national survey and several

follow up sprint workshops with participants across multiple sectors in early 2023.

This industry survey found that 97 percent of respondents considered technology's role was very significant or considerable in helping our climate change response and 95 percent said it needed to play a more central role.

A recent assessment by the New Zealand Treasury identified that the more effectively the economy reallocates resources and adopts productivity-enhancing technologies and practices, the more resilient New Zealand's economy is likely to be, and the smaller the impact on GDP.

Climate technologies, those technologies that reduce greenhouse gases and mitigate the impacts of climate change, are therefore critical for New Zealand's response to this global issue.

Climate technology includes a diverse range of technologies from electric vehicles (EVs) to renewable energy storage systems to low-carbon cement. It can also include digital technologies such as artificial intelligence (AI) systems deployed to enable better energy management and transport logistics, or biotechnology solutions in agriculture and waste management.

Technology can contribute to reducing emissions, promoting sustainability, and driving economic growth. However, research respondents noted the importance of a clear climate response roadmap, integrating technology and aligned with the country's objectives.

The Solution

A Climate Technology Roadmap

Despite policy changes, some new funding and new innovations announced as part of the first ERP, New Zealand's existing technology and innovation ecosystem will not fill the gap. New Zealand's climate response remains fundamentally sector or silo based without a cohesive link connecting ongoing initiatives with areas requiring support.

Our research shows that technology is just one part of the equation. To realise the benefits of technology, we must address various factors including skills, capital, uptake, industry partnership, regulation and other critical foundations.

The international Network Readiness Index, which measures the extent countries are

making use of the opportunities presented by technology ranks New Zealand at 19th, with our impact using technology only 23rd in the world. The countries identified by this index that are using climate technology roadmaps, are all ranked considerably higher than New Zealand.

WHAT IS A CLIMATE TECHNOLOGY ROADMAP?

A climate technology roadmap (CTR) is a strategic framework that outlines the technologies, and the related critical foundations, a country is prioritising to achieve its climate response goals and accelerate the adoption of emission reduction solutions. CTRs serve several key purposes, including prioritising existing technologies, identifying new technology opportunities and highlighting critical enablers. A CTR is a practical tool to guide a sustainable and climate-resilient future while demonstrating New Zealand's commitment to meeting its global climate commitments.

Technology will be a significant driver in achieving emissions reduction goals however it needs to be integrated into a clear climate response roadmap aligned with the country's objectives.

Based on the research feedback, the aggregation of insights from multiple New Zealand focused studies and examples of leading international roadmaps, we have created a framework for supporting the development of a uniquely Aotearoa New Zealand approach to a climate technology roadmap.

The Recommendation

A coordinated, systems-wide framework

To support the creation of a coordinated, system-wide approach we have developed a framework that could be used to help shape a climate technology roadmap for New Zealand.

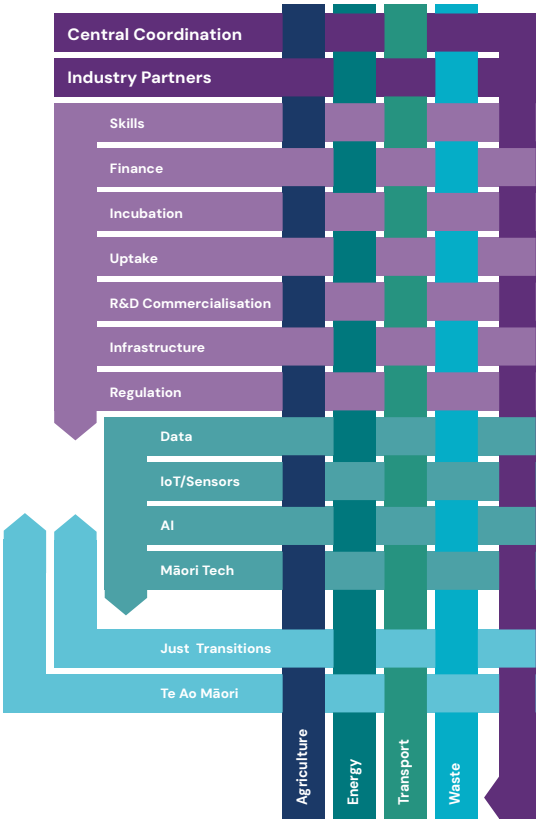
We recommend putting in place a strong foundation of guiding and connecting principles, followed by clear and coordinated leadership, prior to layering seven critical foundations identified to maximise the impact of technology. These foundations, and a number of emerging enablers, should also be considered while developing sector opportunities.

Connecting Principles

The framework for an Aotearoa Climate Technology Roadmap should be informed by the principles of a te ao Māori worldview, highlighting the significance of the relationship between nature and people. This holistic worldview emphasises interconnections and is grounded in tikanga, local values and mātauranga knowledge.

Think of the framework as weaving together essential foundations and aronga directions. Similar to how flax weaving symbolises family bonds and human relationships, our framework must intertwine and connect these vital foundations. These interwoven foundations, along with technology enablers can also link to specific sector technology opportunities.

Additionally, a Just Transition must be one of the guiding and connecting principles of a framework for an Aotearoa Climate Technology Roadmap.



Strong Leadership

A successful climate technology roadmap requires effective coordination and oversight, involving both industry and political support.

Ideally, a Government agency would administer the drive for a climate technology roadmap, but it should also have oversight from a collaboration of industry, Government, Māori and research institutions.

Effective leadership is crucial, as it fosters collaboration, defines clear goals, tests and prototypes, selecting the right technologies, and includes everyone. This leadership should

also encourage partnerships and innovative solutions beyond traditional services.

Participants in the NZTech survey noticed that New Zealand's climate tech efforts often lack broad industry involvement and are isolated. Research and experience suggest that collaborating more with industry to resolve issues and progress opportunities is essential.

This can stimulate new innovations, attract investment and provide necessary expertise. This includes strong partnerships across various sectors, aligning interests and ensuring stakeholders support the goals of the roadmap.

Critical Foundations

Our research identified seven critical foundations required to support an effective climate technology system in New Zealand. An Aotearoa Climate Technology Roadmap should consider each of these from a systems change perspective and for their impact on each climate technology sector or sub-sector.

The critical foundations include:

Skills - maintain focus on critical skills training and acquisition.

Finance - enable greater investment and finance.

Incubation - establish a climate tech incubation ecosystem.

Uptake - create fast tracks and early adoption support for climate tech uptake.

R&D commercialisation - more effective and faster commercialisation of R&D.

Infrastructure - critical enabler for transport, energy, telecoms and digital.

Regulation - enabling technology with appropriate regulatory and policy making.

Emerging Technology Enablers

In addition, several emerging technology enablers may play a vital role in New Zealand's approach to emissions reduction, including:

1. **Data-driven decision-making** - building an effective data foundation for enhanced decision-making in emissions reduction.
2. **Internet of Things (IoT) and Sensors** - for monitoring and responding to help meet environmental regulations, manage resources and improve operational efficiencies.
3. **Artificial Intelligence (AI)** - to analyse data from various sources, providing accurate and timely insights or predictions on the environment.
4. **Māori tech** - the rapidly emerging Māori tech ecosystem brings opportunity for localised solution development.

Complemented by a sector focus

1. **Agricultural sector:** In agriculture, there are many climate tech opportunities. These range from using digital tech to new biotechnology and gene editing possibilities. Whilst the most impactful gains will come from biotechnologies, the most immediate gains appear to be better use of existing digital technologies. By embracing precision agriculture and digital innovation alone, we could reduce emissions in agriculture by 1.9 Mt.
2. **Energy sector:** Energy is another sector where technology opportunities have been identified for emissions reduction. In New Zealand, a recent study has estimated there is potential for 2.4 Mt emissions reduction in energy and industry through digital innovation. This includes building automation, grid load smoothing, industrial process automation and even increased use of cloud infrastructure.
3. **Transport sector:** Transport is a significant source of emissions and technology opportunities, deployed in other markets, can be utilised. In New Zealand an estimated 2.9 Mt of emissions could be reduced from transportation by using digital innovations.
4. **Other sectors:** Emission reduction opportunities exist across New Zealand's other key emissions sectors with digital technologies in particular enabling monitoring and adaptation opportunities in the near term.

Next Steps

The research identified several areas that need to be improved to better enable climate technology for New Zealand. A significant amount of Government funding is already targeted at many of these critical foundations, however much of it is not well aligned with the need to support emissions reduction. This framework would create a systems response to better enable technology that can help reduce emissions.

We recommend putting in place a framework to help coordinate Government and Industry activity and the development of an Aotearoa Climate Technology Roadmap.

Recommendations for the development of the Climate Technology Roadmap include:

Assess the current climate technology landscape.
Assess New Zealand's current technology landscape to identify and quantify opportunities for action, including emissions, technology readiness and adaptation efforts.

Incorporate international models.
Draw on the climate technology responses and roadmaps identified here to inform New Zealand's approach and the material that can be applied. Note the important enabling opportunity a climate technology roadmap would provide to existing agency and other organisation climate technology activity in New Zealand.

Promote a co-design approach.
Enable consultation and cross-agency collaboration to ensure an informed and inclusive climate technology roadmap, where agencies retain ownership of their contribution to the roadmap. Foster authentic collaboration and knowledge-sharing with stakeholders.

Underpin with connecting principles and strong leadership.
Use the framework to enable the coordination and alignment of agencies and organisations in climate technology activities. Ensure senior political leadership and collaboration with industry stakeholders to drive climate tech solutions.

Secure the foundations
Ensure the Climate Technology Roadmap includes the seven critical foundations:

1. Skills development for climate technology professionals
2. Financial support mechanisms for climate tech innovation and adoption
3. Incubation programmes to nurture climate tech startups
4. Strategies to facilitate the uptake of climate-friendly technologies
5. R&D commercialisation strategies for climate-related innovations
6. Infrastructure planning and investment to enable climate tech progress
7. Regulatory frameworks to encourage and support climate tech advancements

Integrate with Emissions Reduction Plans

Align the development of the Climate Technology Roadmap with the second Emissions Reduction Plan, ensuring broader climate mitigation and adaptation.

Gain shorter-term climate tech opportunities

Identify and prioritise shorter-term climate technology opportunities that yield quicker wins.

Monitor and evaluate

Establish appropriate monitoring and evaluation indicators to measure the effectiveness of the Roadmap. The roadmap should be updated periodically on a section-by-section basis as technology developments require this.

Timely completion

Progress the development of at least the priority areas of the Climate Technology Roadmap to inform the release of the second Emissions Reduction Plan.

This could help ensure a cohesive and integrated approach to climate action.

Developing Aotearoa's Climate Technology Roadmap would represent a pivotal moment in the country's emissions reduction response. A roadmap, enabled through strong public and private partnership and which tackles the systemic challenges confronting sectors, will more likely secure New Zealand's emissions reductions commitments, contain significant positive economic benefits and establish the country as an international climate and technology leader. Committing to the design and implementation of Aotearoa's Climate Technology Roadmap will guide a more sustainable future for all New Zealanders.

What is the Problem?

Insufficient emissions reduction, not enough tech

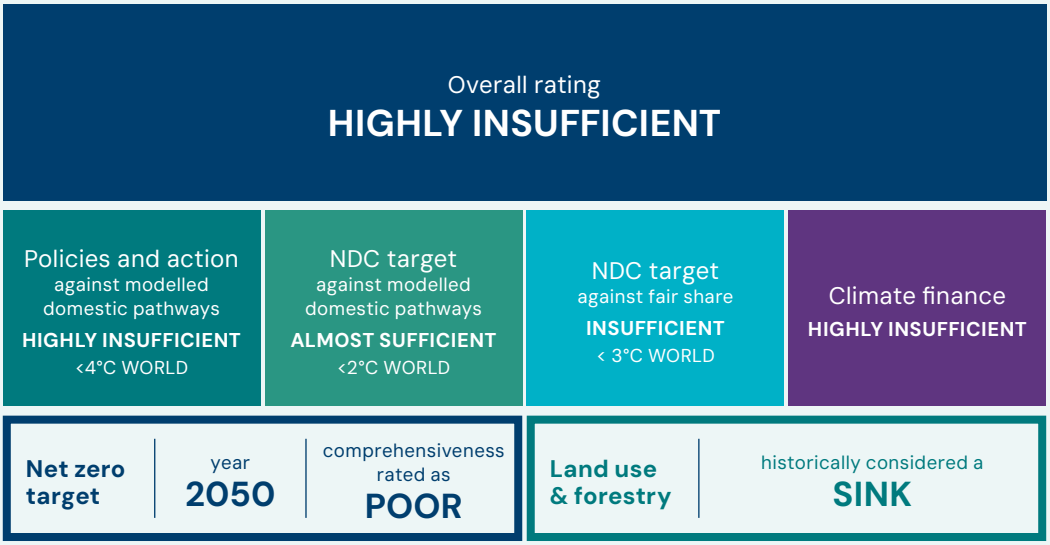
New Zealand's evolving climate landscape

New Zealand continues to show long-term trends toward higher surface air and sea surface temperatures, more hot extremes and fewer cold extremes, and changed rainfall patterns. Warming is projected to continue through the 21st century along with other changes in climate.[1]

New Zealand has transformed its overall climate change response in a relatively short period of time, with the Climate Change Response (Zero Carbon) Amendment Act 2019, the establishment of the Climate Change Commission, and the subsequent first Emissions Reduction Plan in 2021, preceded by the Climate Change Response Act 2002.

Despite these important steps, and the growing climate response activity across New Zealand, officials have highlighted that the country will miss its 2025 Emissions Budget target (EB1).[2] Additionally, the global climate action body Climate Action Tracker has assessed New Zealand's climate response as Highly Insufficient.

Figure 1 - Climate Action Tracker



Source: ClimateActionTracker.org, March 2023

Although New Zealand is a world leader in its use of renewable energy, in 2021 New Zealand had 16.9 tonnes of CO2e per capita - the sixth highest emissions per capita of OECD countries.[3]

In a recent report, Aotearoa New Zealand's Turning Point, Deloitte highlighted that New Zealand has untapped potential and must embrace new and emerging technologies to take decisive action on reducing emissions.

"Clearer and more consistent policy direction is required" from the Government by technology enterprises so greater action can be taken.[4]

The Emissions Reduction Plan (ERP) marked a significant start, however progress in various technology areas, for example, bio-reactors or mobility-as-a-service, is inadequate. A strong Government climate technology strategy could drive private sector change and, in turn, stimulate more private sector action and investment.

CLIMATE CHANGE, EQUITY AND TE TIRITI O WAITANGI

New Zealand's unique position regarding emissions reduction, driven by Te Tiriti o Waitangi and the inequitable impacts of climate change is characterised by a disproportionate impact on Māori, Pacific, low income and disabled people in some scenarios.[5] To address this issue New Zealand has integrated an equity perspective into its public institutions and legislation. Both the Zero Carbon Act and the Emissions Reduction Plan (ERP) have a dual purpose: reducing emissions and ensuring a leading role for Māori in the country's transition to a low-carbon economy, focusing on equity.[6]

Some iwi and hapū have been developing their own climate change adaptation and mitigation plans. Research conducted by Ngā Pae o te Māramatanga (NPM) and Manaaki Whenua – Landcare Research using a kaupapa Māori approach to climate change risk assessment examines the latest climate change research through a Māori lens. It identified potential impacts, implications, mitigation and adaptation strategies for whānau, hapū, iwi and Māori business.[7]

Opportunities exist to support Māori enterprises investment in decarbonisation, enabling iwi to leverage their existing resources for economic growth. This includes enabling Māori enterprises to develop new low-emissions services and products or enhance existing ones.

Focus on climate tech

Technology plays a crucial role in tackling the urgent global issue of climate change.

Rising greenhouse gases and their weather effects demand immediate technology-driven climate action. Achieving our emissions reductions targets requires innovative technology solutions and public-private partnerships.

Technologies that can be used to reduce negative environmental impacts are known by many names including clean tech, green tech and climate technology. The term 'climate tech' has emerged recently to boost efforts in addressing climate change.

CLIMATE TECH

In this report we use the term 'climate tech', to encompass a diverse range of technologies, including electric vehicles (EVs), renewable energy storage systems, low-carbon cement and more. It can also include digital technologies for example, artificial intelligence (AI) for energy management and transport, as well as biotechnology solutions in agriculture and waste management.

Why is climate tech important?

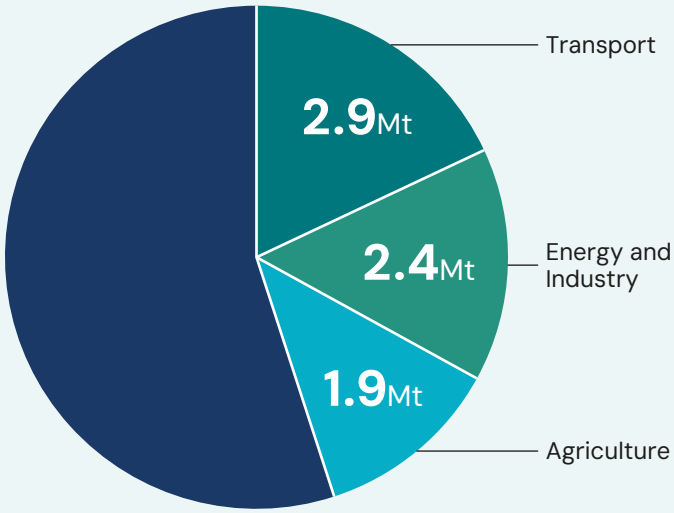
Technology is crucial to reduce the worst effects of climate change, with the potential to contribute 60 percent of the emissions reductions necessary for climate stability by 2050.[8] Developing and sharing

technologies is vital for nations to fulfil their emission reduction commitments.[9]

Several European countries including the United Kingdom, Denmark and Finland have made climate tech a priority, and the Australian government has also recognised the importance of technology. They are encouraging industries to innovate and adopt smarter practices and technologies. Investment in energy technology is now an essential aspect of Australia's response to climate challenges.[10]

Recent analysis found that up to 42 percent of New Zealand's 2030 emissions budget targets could be met by actions enabled by digital technology.[11]

Figure 2 - Digital technologies enabled emissions reduction



Transport

- Reduction in travel through remote work, e-Health, e-Learning, e-Banking, e-Commerce, remote monitoring
- Optimising business fleet, freight and logistics
- Accelerate EV transition by enabling rural connectivity and smart charging infrastructure

Energy and Industry

- Smart automated buildings reducing energy consumption
- Reduction in centralised facilities – e.g. e-Health
- Grid load smoothing through connected devices, e.g. EVs
- Centralising IT Infrastucture through cloud services*

Agriculture

- Precision agriculture – reduction in fertiliser application
- Precision agriculture – nitrous oxide inhibitor
- Robotics and smart sensors – improving animal health and productivity
- Precision agriculture reducing pesticide use in horticulture

Source: Spark & thinkstep-anz, 2023

• modelled but not included in the total

New Zealand needs innovative tech solutions to address climate change and meet our global emissions targets.

The Global e-Sustainability Initiative (GeSI) has identified four fundamental ways technology can reduce emissions:

Digitalisation and dematerialization: Substituting or eliminating the need for an emissions-intensive product or process.

Data collection and communication: Real-time data analysis and communication, feedback, and learning to enable better decision-making.

System integration: Managing the use of resources.

Process, activity, and functional optimisation: Improving efficiency through simulation, automation, redesign or control.[12]

A recent assessment by the New Zealand Government highlights that adopting productivity enhancing technologies and practices, can enhance the country's economic resilience and minimise the impact on GDP.[13]

Climate technologies, which reduce greenhouse gases and address climate change, are crucial for New Zealand's response to this global challenge.

The vital role of technology and innovation

Aotearoa New Zealand has a significant opportunity to improve its transition to a low-carbon future, with technology playing a vital role.

To gather industry insights on technology's role in supporting emissions reduction

Figure 3 - How digital technology enables a low carbon New Zealand

1 | Connects people

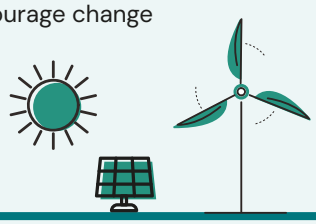
Enables interpersonal connection and secure access to digital services such as work systems, education and health

2 | Connects things

Enables data collection from systems and the environment, informing action and optimising smart systems and processes

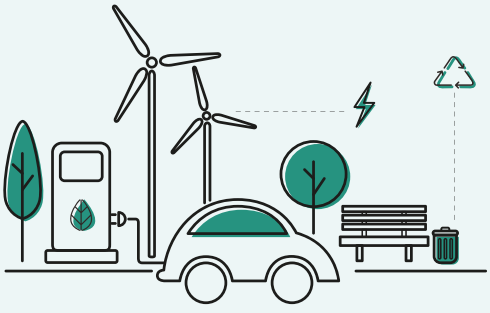
4 | Influences behaviour

Shares information and tools and connects communities to drive awareness, inform choices and encourage change



3 | Creates insights

Harnesses data to create insights to inform efficient, responsible decisions by humans and automated systems



5 | Drives innovation

Creates new low carbon industries and new jobs, enabling transition and decarbonisation of existing industries

Source: Spark & thinkstep-anz, 2023

NZTech conducted the Technology and Emissions Reduction Survey. The survey was promoted through various technology associations and industry partners. Additional demographic information is included in the Methodology section in the appendix.

The survey found that 97 percent of respondents considered technology's role was very significant or considerable in helping our climate change response and 95 percent said it needed to play a more central role.[14]

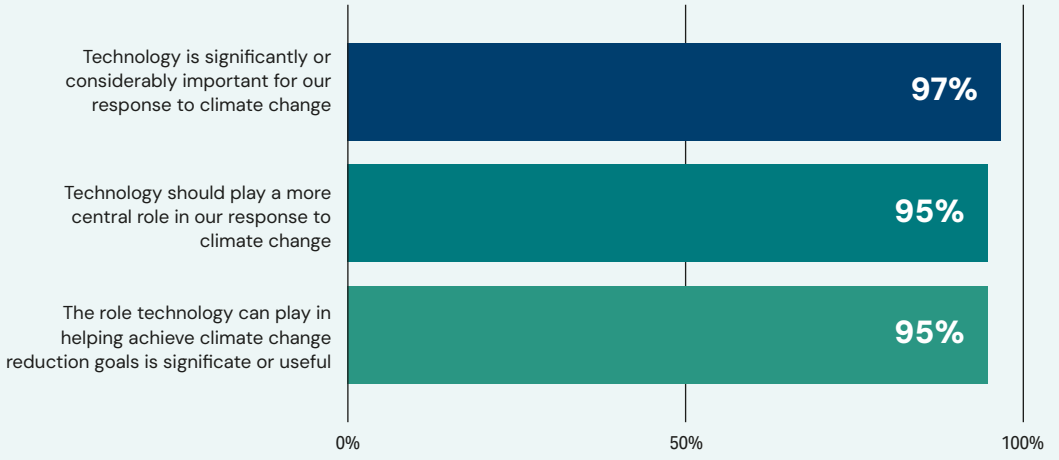
In an earlier member survey, 95 percent of respondents rated the role technology can play in helping New Zealand achieve its climate change reduction goals as significant or useful.[15]

Technology can contribute to reducing emissions, promoting sustainability, and driving economic growth. However, respondents noted the importance of a clear climate response roadmap, integrating technology and aligned with the country's objectives.

In its 2021 advice to the Government, the Climate Change Commission recognised the role of innovation in achieving emissions reduction goals.[16]

> *"The Government can help make sure Aotearoa will have more options for reducing its emissions in the future by putting in place measures to support and encourage research, development and innovation for low-emissions solutions."*
>
> **Climate Change Commission, 2021**

Figure 4 - How important is technology in our response to climate change?



Source: NZTech surveys, 2023. n=148

However, the first emissions reduction plan (ERP) is generally considered to have minimised the role technology can play in New Zealand's emissions response. This was recognised by then Minister for Climate Change who conceded it was an oversight to underplay the role of technology when targets were set.[17]

In New Zealand's economic transformation, innovation is essential for successful export of unique, high value products. The Productivity Commission recommended investing in innovation ecosystems and frontier firms in key focus areas, including climate change.[18]

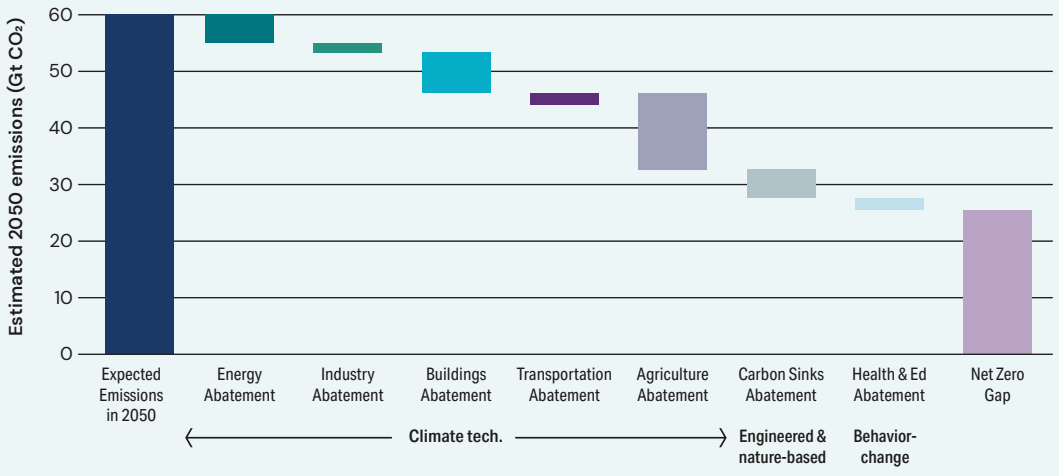
Climate tech requires comprehensive system response

New Zealand's current climate efforts do not align with its 2050 emissions' reductions targets.[19] Despite policy changes, additional funding and new innovations from the first ERP, the existing technology and innovation ecosystem falls short in bridging the gap. New Zealand's climate response remains fundamentally industry or silo based without a cohesive link connecting ongoing initiatives with areas requiring support.

Our research shows that technology is just one part of the equation. To realise the benefits of technology, we must address various factors including skills, capital, uptake, industry partnership, regulation and other critical foundations.

Currently, nearly half of the necessary reductions required to reach net zero emissions will rely on technologies currently in the prototype stage. This presents both opportunities and challenges.[20] As shown in Figure 5, the current rate of innovation in

Figure 5 - Sector emissions abatement in 2050 enabled by today's solutions



Source: Pathways to Net Zero, Deloitte

climate technology, which involves making these technologies more feasible and commercially viable, and the funding allocated for it, is insufficient to reach net zero by 2050, leaving a substantial "Net Zero Gap."[21]

In addition, climate technology faces challenges in deploying industrial equipment in real-world settings, including service interruptions, technology standards, regulation, safety, and financial capital, presenting adoption challenges. To address these challenges, the Government in strong partnership with industry, can use policy, procurement, infrastructure investment and finance to accelerate and encourage the commercialisation and adoption of these new solutions by industry.[22]

Innovation will also be critical, however, New Zealand's innovation ecosystem lags behind other small advanced economies (SAEs), including in key sectors like agriculture.[23]

New Zealand's investment in climate technology also lags behind other SAEs. Our innovators receive far less funding than other SAE peers, for example in Finland, Netherlands and Norway. These have all launched at least double the number of funded innovators.[24] This challenge is an issue for both the public and private sectors to collaboratively address.

Nevertheless, there are a range of climate technologies that can be deployed across New Zealand's sectors. These technologies need to be identified and assessed to help achieve emissions reduction goals.[25]

The Solution

Climate tech roadmaps

27

International evidence clearly shows that climate technology roadmaps (CTR) hasten and stimulate the earlier adoption of emission reductions solutions.

The international Network Readiness Index, which measures the extent countries are making use of the opportunities presented by technology ranks New Zealand at 19th, with our impact using technology only 23rd in the world.[26]

The countries identified by this index, using climate technology roadmaps, are all ranked considerably higher than New Zealand. Further information on the international landscape and climate technology roadmaps is in the International Approaches section in the appendix.

What is a climate technology roadmap?

A climate technology roadmap (CTR) is a strategic framework outlining how a country will use technology to achieve its climate goals. The purpose is to accelerate the deployment of technology solutions.

Internationally, roadmaps are considered to have three principle uses:

- agreeing on needed technologies for certain goals
- predicting new technology developments
- coordinating and planning technology advancements.[27]

McKinsey's research shows the best roadmaps deliver the following advantages, helping organisations to:

- Develop the right technologies, capabilities, and organisational structures at the right time, to meet the project's needs,
- Boost returns on technology investments by focusing resources (including governance and management attention) on the technology most likely to unfold,
- Enhance transparency into what the direction of travel is and what to invest in,
- Build consensus on technology innovation activity and foster horizontal learning from innovation experiences across different parts of the ecosystem,
- Better align government, private sector and other institutional resources and capabilities,
- Improve communication on technology activity between internal and external stakeholders.[28]

A climate technology roadmap has the vital role of signalling to industry and research organisations where new investment would be supported.

Using a climate technology roadmap approach could encourage broader innovation, data sharing and technology deployment to support New Zealand's emissions reduction goals. In other countries, adopting this approach has helped unite industry, government and research organisations into a more organised ecosystem.

Climate crossroads for Aotearoa New Zealand

With escalating climate challenges, Aotearoa New Zealand faces an important crossroad.

As the country works to achieve the emissions reduction targets committed to both New Zealanders and the international community, we consider the development of an Aotearoa Climate Technology Roadmap as an essential action. In our view, a roadmap holds the key to not only effective climate response but also unlocking innovative local climate solutions.

The development and implementation of a roadmap that is specific to New Zealand's needs should provide a comprehensive strategy to tackle these challenges.

Customised solutions: A roadmap could enable New Zealand to identify and develop greater solutions aligned with our unique resources. Whether harnessing the power of wind and solar energy, advancing regenerative agriculture practices or implementing resilient infrastructure, a roadmap can ensure the solutions are not only effective, but also practical for our context.

A climate technology roadmap holds the key to not only effective climate response but also unlocking innovative local climate solutions.

Stimulating innovation: A well-structured roadmap would foster greater industry innovation by setting clear goals and targets for research and development (R&D) in climate technologies. By more clearly identifying technology opportunities and further stimulating local innovation, we can actively contribute to the global efforts to combat climate change, while supporting our economy,

Informed decision-making: A climate tech roadmap equips policymakers, businesses and communities with strategic guidance for their decision-making. It provides a clear pathway to help New Zealand meet its emissions reductions goals.

Collaborative enablement: as reported in NZTech's survey there is an overwhelming level of support for a climate technology framework to support and enable a collaborative approach to the innovation, development and deployment of technology solutions. Respondents believe a New

Zealand climate tech roadmap will stimulate the earlier adoption of emission reductions technology solutions. This should guide the development and investment of New Zealand's climate R&D ecosystem.

Long-term view: Climate change is a long-term challenge requiring a long-term solution. New Zealand's emissions reduction plan provides an overview of the road ahead. It is strongly informed by the advice from the Climate Change Commission, but a recent parliamentary review of ERP 1 recommends that Ministers and officials should examine more than one possible pathway to meet New Zealand's mitigation obligations. Specifically, it recommends officials provide a coherent set of whole-of-economy and sector-level pathways informed by, among other things, a whole-of-economy assessment of the broad opportunities and leverage points for reducing emissions out to 2050.[29]

A supporting climate tech roadmap could help enable these pathways and inform the opportunities.

Developing a climate tech roadmap sends a strong signal to the global community that Aotearoa New Zealand is stepping up to its climate goals. This could help attract both domestic and international investment, driving growth in climate tech innovation, boosting economic growth and creating new job opportunities.

The latest assessment of New Zealand's environment showed ongoing declines in many aspects of environmental quality.[30] This poses a serious challenge to the country's green reputation. To address this, New Zealand could lead internationally in climate technology, harnessing its existing tech sector expertise.

Developing a framework

The International Energy Agency (IEA) recommends using roadmaps to enable governments, industry and partners to make the right decisions.

They suggest a dynamic approach, where the roadmap is a living process and continues to evolve.[31] McKinsey also emphasises that regularly updating the roadmap is vital for it to remain useful over time.[32]

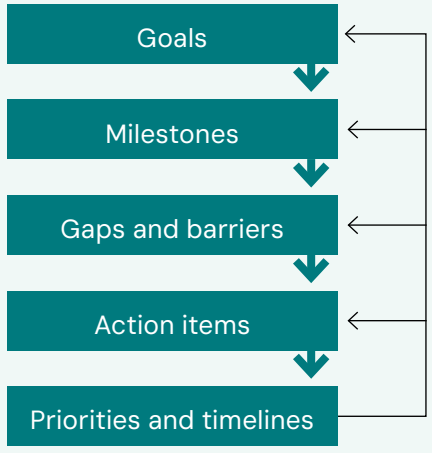
This approach avoids the need for a mega-roadmap document, which is not recommended, and would see development of a flexible, adaptive roadmap driven by priority action areas.

The role of industry

NZTech's survey respondents confirmed they see a range of non-governmental organisations (NGOs) playing a role in the development and implementation of a climate tech roadmap. These include industry, research institutions, iwi and other NGOs. Businesses will research, pilot and invest in the technology required but they also want to partner with the Government to establish the roadmap's priorities, milestones and measurability targets. Survey respondents provided feedback on the value of a climate technology roadmap and essential requirements, including:

- A shared vision, accountability, and allowance for breakthrough ideas.
- Clear goals, timeframes, responsibilities, and actionable outcomes.
- Priorities, milestones, and steps should be outlined in the short, medium, and long term, considering execution concerns.
- A long-term roadmap involving government, industry, and inclusive approaches provides clarity.
- Measurable targets, linked to industry transformation plans, and collaboration connections specified to existing related work are important.
- Implementation and follow-through are crucial for a successful roadmap.[33]

Figure 6
– Key elements of a successful roadmap



Source: International Energy Agency, 2014

Co-designing our roadmap

In late 2021, following NZTech's submission on the Emissions Reduction Plan, the organisation held early discussions about the role a roadmap could play with the Ministry of Business, Innovation and Employment (MBIE), the Ministry for the Environment (MfE), the Ministry of Transport (MoT), and the Energy Efficiency and Conservation Authority (EECA). Subsequently, representatives from the following agencies were engaged in discussions about the value of a roadmap: Callaghan Innovation, Ministry for Foreign Affairs & Trade (MFAT), Ministry of Primary Industries (MPI), New Zealand Trade and Enterprise (NZTE), universities and research institutes. All have indicated support for a climate technology roadmap providing a focus for industry to collaborate more effectively and partner with Government agencies.

The MoT agrees new innovations must be shaped to deliver positive outcomes for the transport network and climate.[34] EECA also highlights a wide range of internationally available technologies that could be applied to process heat, one of the country's largest opportunities to reduce energy-related greenhouse gas emissions.[35]

The Government's agency, Callaghan Innovation, supports a CTR approach. In 2021, when launching the New Zealand Climate Tech For The World report they commented that climate innovation was a key step towards achieving the country's carbon targets.[36] It can also help create a more valuable export sector and generate new employment opportunities, as observed in other countries.

The New Zealand CleanTech Mission partnership was established in 2021 by Callaghan Innovation, New Zealand Growth Capital Partners (NZGCP), the Science for Technological Innovation National Science Challenge, Tātaki Auckland Unlimited and UniServices. Its aim is to convert local CleanTech into thriving and profitable businesses.[37] Initiatives like this can be prioritised and extended within a CTR.

For comparison, Finland employed an advanced co-design model as the foundation for their 2030 Agenda roadmap, which became their national sustainable development strategy. A peer review study showed that using facilitation tools allowed participants to engage more effectively in co-designing pathways, helping them understand their role in implementing the strategy. The online process also enabled sub-groups to discuss difficult issues more productively, reducing conflict between participants.[38]

> Finland used a highly developed co-design model to form the basis of their roadmap which became Finland's national sustainable development strategy.

We believe a collaborative co-design model is essential for the development of an Aotearoa Climate Technology Roadmap.

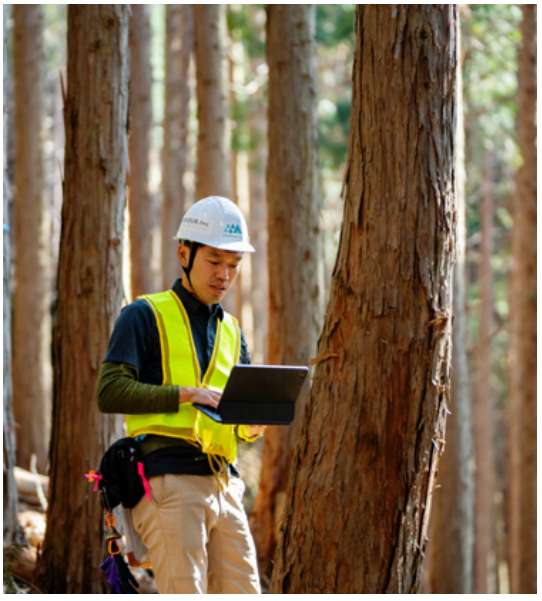
Assessing emissions reductions impact

It is widely acknowledged that digital technologies hold substantial potential

to reduce carbon emissions, enhance energy efficiency and contribute to the mitigation of climate impacts. However, simply implementing technology solutions is insufficient.[39] It is crucial to quantify their impact, not only to guide investment decisions but also to accelerate their adoption.

As part of this project we were asked to consider how to assess the relative impact of different solutions.

A standard methodology has been developed by Global e-Sustainability Initiative (GeSI) to assess the capacity of technologies to reduce the carbon footprint of other sectors. It achieves this by quantifying carbon dioxide equivalent emissions. It does not assess other environmental impact categories such as acidification or land use. However, the methodology may be able to be adapted to consider these impacts.[40]



To model emissions reduction estimates, the three primary factors used are:

- base input data, for example population, household numbers and GDP growth.
- expected adoption rates, for example the uptake of household smart meters.
- sustainability impact, including the emissions savings enabled by the technologies.[41]

This methodology was employed in the emissions reduction modelling provided in the Spark Thinkstep-anz report which reported 42 percent of New Zealand's emissions reductions budget targets (or 7.2Mt emissions annually) could be collectively reduced by 2030 with the enabling action of digital technology.[42]

This impact assessment indicated transport emissions were the largest area of opportunity at 40 percent (or 2.9Mt), followed by energy at 33 percent (or 2.4Mt) and agriculture at 26 percent (or 1.9Mt). Analysis of our respondents indicated a broadly similar view. This modelling approach is recommended, alongside a roadmap to guide investment, policy and regulatory decision making.

Early investment necessary

Earlier investments in New Zealand's climate mitigation efforts are crucial to avoid the high costs of having to purchase offshore mitigation to meet the country's National Determined Contribution Investment (NDC).

The Treasury and the Ministry for the Environment (MfE) indicative assessment,[43] indicates the direct costs for increased investment on a series of key mitigation technologies up to 2050 could be $155

million to $460 million per annum ($4 billion to $12 billion over the period). This is based on a Government contribution of 10-30 percent of investment costs.[44]

The assessment emphasises that the Climate Emergency Response Fund (CERF), funded by the Emissions Trading Scheme, allows the Government to finance its part of climate policy action, for example, investment in a climate technology roadmap.

It warns that if there is not a strong response within the country, there is a high risk of having to purchase offshore mitigation to achieve New Zealand's first NDC.

For the country's domestic emissions, the cost range for these purchases, based on MfE's projection, is between $8.8 billion and $20.6 billion.

Further investment in key mitigation technologies is expected to be required to meet New Zealand's emissions targets. The roadmap can provide the architecture to guide this investment more efficiently.

The cost of not getting this right, not reducing emissions enough, could be as high as

$20 billion

Systemic response is critical

To create lasting and comprehensive solutions, the interconnectedness of Aotearoa's climate challenges requires a systemic response. This includes a holistic perspective, interdisciplinary approach, authentic collaboration and long-term planning.

Many reports have discussed the various ways to improve technology readiness, but they are disconnected and often exist independently. While these reports highlight opportunities and challenges, they do not thoroughly address the role of technology in New Zealand's climate response. Although most of the eight relatively recently

completed Industry Transformation Plans acknowledge the climate challenge, their technology responses are inconsistent.

Additionally, while MBIE provides stewardship over the research, science and innovation system including Callaghan Innovation and the Crown Research Institutes, none of the 17 regulatory systems refer directly to climate or technology.[45]

These issues means neither climate or technology are addressed in a meaningful way that could provide collective impact. Internationally, a CTR has the role of connecting the silo activities of government and private sector. Similarly, New Zealand's climate challenges require the interconnected, systemic solution a CTR could provide.

Our research participants highlighted several barriers to better use of technology for emissions reduction that were relevant across all sectors. For example, critical enablers for the use of technology include appropriate development and deployment of skills, legislative and regulatory levers, greater investment and finance options and national leadership.

While MBIE provides stewardship over the research, science and innovation system none of the 17 regulatory systems refer directly to climate or technology.

Based on this research feedback and the aggregation of insights from multiple New Zealand focused studies we have developed a framework for supporting the development of a uniquely Aotearoa New Zealand approach to climate technology roadmaps.

The Recommendation

A framework for an Aotearoa climate tech roadmap

37

Co-ordinated, system-wide plan

Developing a framework for New Zealand's climate technology roadmap should be informed by global best practices.

We can look to examples from other countries, guided by the International Energy Agency, the World Economic Forum and the United Nations. However, our research suggests that New Zealand needs a holistic, systems-based approach, instead of an individual sector focus.

To support the creation of a co-ordinated, system-wide approach we have developed a framework (Figure 7) that could be used to help shape and connect New Zealand's climate technology roadmap.

We recommend putting in place a strong foundation of guiding and connecting principles, followed by clear and coordinated leadership, prior to layering seven critical foundations identified to maximise the impact of technology. These foundations, and a number of emerging enablers, should also be considered while developing sector opportunities.

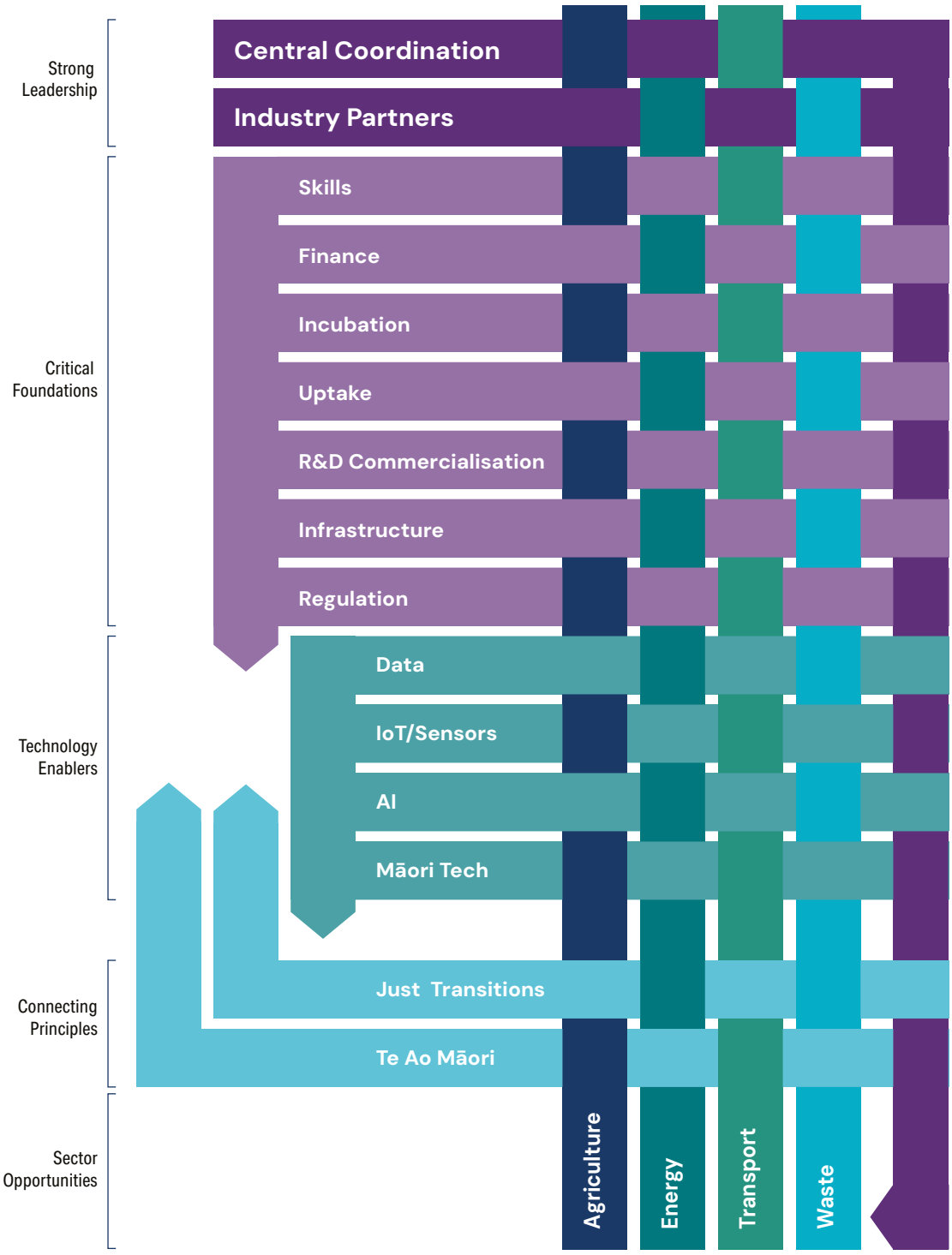
Aligned with the Capitals Models

This framework has been drawn together from feedback from our research and cross checked against the Capitals Models used by Treasury and those used for integrated reporting. The capitals are stocks of value that are affected or transformed by the activities and outputs of an organisation. The Integrated Reporting Framework categorises them as financial, manufactured, intellectual, human, social and relationship, and natural.[46] The cross checks with the Capitals Models are detailed in the Appendix: Aligning to the Capitals Models.

Early opportunities are identified

The following sections review each of the horizontal enablers and vertical sectors of the proposed framework for an Aotearoa Climate Technology Roadmap. While undertaking this research we were presented with several potential climate technology opportunities. These have been detailed in the Appendix: Opportunities Identified and include recommended actions, estimated time horizons, availability of the solution, who will likely need to drive it (Government, industry or partnership), and potential impacts on resourcing.

Figure 7 – Framework for an Aotearoa Climate Technology Roadmap



Connecting Principles

Te Ao Māori

The framework for an Aotearoa Climate Technology Roadmap should be shaped by the principles of a te ao Māori worldview, highlighting the significance of the relationship between nature and people. This holistic worldview emphasises interconnections and is grounded in tikanga, local values and mātauranga knowledge.

Think of the framework as weaving together essential foundations and aronga directions. Similar to how flax weaving symbolises family bonds and human relationships, our framework must intertwine and connect these vital foundations. These interwoven foundations, along with technology enablers can also link to specific sector technology opportunities.

Just Transition

Under the Paris Agreement, the Government has agreed to 'take into account the imperatives of a just transition of the workforce and the creation of decent work and quality jobs…'

Just Transition will ensure climate change driven economic and social transitions are fair and inclusive, by working with affected groups, ensuring opportunities are more evenly distributed.

Transitions have traditionally disadvantaged some groups more than others. This is acknowledged and incorporated into planning to make the transition more fair, equitable and inclusive.[47]

This must be one of the guiding principles of a framework for the Aotearoa Climate Technology Roadmap.

Strong Leadership

For successful climate technology roadmaps our research identified two key leadership characteristics - central coordination and engaged industry partners.

Government coordination and leadership

Governments worldwide are prioritising digital transformation to boost social development and economic prosperity. Digital transformation enables governments to offer better services, cost savings, improve access, make data-driven decisions, enhance transparency, engage citizens, support disaster resilience, promote economic growth and stay competitive globally.

The World Bank has identified eight key characteristics essential for coordinating a national digital transformation programme, and these are also relevant for a national technology roadmap:

- **Coherence** – aligned with related domestic and international strategies and/or policies;
- **Comprehensiveness** – covers multiple sectors;
- **Inclusivity, empowerment and human-centering** – aims at closing all societal gaps;
- **Collaborativeness** – engages all relevant stakeholders, including different parts and levels of government, non-governmental stakeholders and civil society, and establishes shared vision and values;
- **Data-driven and evidence-based** – assesses key trends, evaluates existing baselines, and existing policies, identifies opportunities and challenges;
- **Ambitious but feasible** – provides a clear strategic vision;
- **Measurable** – specifies concrete expected results and outcomes;
- **Agile** – has thorough monitoring and evaluation. [48]

A successful climate technology roadmap requires effective coordination and oversight, involving both industry and political support.

Ideally, a Government agency would lead the proposed Climate Technology Roadmap, but it should also have oversight from a collaboration of industry, Government, Māori and research institutions. This coordination would likely be MBIE working closely with MfE and maintaining a relationship with the Climate Change Chief Executives Board.

Effective leadership is crucial, as it fosters collaboration, defines clear goals, tests and prototypes, selecting the right technologies, and includes everyone. This leadership should also encourage partnerships and innovative solutions beyond traditional services.

Industry engagement and partnership

The World Bank recognises that tackling complex challenges requires a more involved and partnership-focused approach to achieve sustainable solutions.[49]

NZTech survey participants noticed that New Zealand's climate tech efforts often lack broad industry involvement and are isolated. For example, in the vital area of procurement, only 26 percent of technology providers rated the quality of the government's procurement activity as positive.[50]

Research and experience suggest that collaborating more with industry to resolve issues and progress opportunities is essential. This can simulate new innovations, attract investment and provide necessary expertise.

The International Energy Agency's guide on roadmaps highlights that when interested parties work together towards shared goals, it builds lasting relationships that greatly contribute to roadmap implementation. Effective roadmapping involves engaging participants, building consensus and increasing the likelihood of implementing the roadmap's priorities.[51]

Callaghan Innovation's CleanTech report prioritises external organisations supporting innovators through clusters and partnerships.[52] An example can be found with the Government Industry Transformation Plans, based on the principle of partnerships between business, workers, Māori, and the Government, aiming for long-term transformative change.[53]

Critical Foundations

Our research also identified that an Aotearoa Climate Technology Roadmap should consider each of these seven critical foundations – both from a systems change perspective and for their impact on each climate technology sector or sub-sector.

The critical foundations are:

Skills – maintain focus on critical skills training and acquisition.

Finance – enable greater investment and finance.

Incubation – establish a climate tech incubation ecosystem.

Uptake – create fast tracks and incentives for climate tech uptake.

R&D commercialisation – more effective and faster commercialisation of R&D.

Infrastructure – critical enabler for transport, energy, telecoms and digital.

Regulation – enabling technology with appropriate regulation and policy making.

Relevant skills training and acquisition

In an era of rapid technological advancement, the landscape of job growth is also undergoing a profound transformation.

According to the World Economic Forum, the biggest drivers of technological job growth are likely to be driven by climate change and environmental management technologies, supported by big data analytics and cybersecurity.[54] In a recent New Zealand survey, 79 percent of companies have faced recruitment challenges for digital staff.[55]

Further research has identified a need to boost New Zealand's technical capability (highly skilled people) and calls for a more streamlined process for accessing support.[56]

Based on current trends, it is unlikely there will be sufficient workers with relevant skills to develop, deploy and manage climate technologies.

A practical, time-bound plan is needed to direct skilled workers on appropriate development pathways. The Digital Skills Aotearoa report recommends greater coordination throughout the economy to help ensure sufficient advanced digital technology skills.[57]

Enabling greater investment and finance

New Zealand's efforts to reach its emissions reduction goals would benefit greatly from targeted investment, which could also attract private funding.

As outlined in the first Emissions Reduction Plan, funding and finance are critical enablers of our emissions reduction activity.[58] New Zealand needs better links between its innovators and investors, both locally and globally, because it's falling behind other similar-sized advanced economies in climate tech funding.[59]

In our research, businesses reported examples of companies unable to secure capital for credible technology opportunities. A respondent to the NZTech survey noted that while only a few prominent startups attract funding there are a further 30-40 companies in the pipeline and most will struggle to secure adequate next stage funding.

Measures such as the MfE's NZ$24.7 million Climate Data Infrastructure initiative[60] and the BlackRock Inc NZ$2 billion (US$1.22 billion) climate infrastructure fund[61] are promising developments. However, the terms for accessing these funds are still unclear. Usually, the issue has been a companies' ability to secure funding, rather than its availability.

The Upstart Nation report includes relevant recommendations that could be included in a climate technology roadmap, for example, increasing support for the Government's New Zealand Growth Capital Partners (NZGCP) Elevate fund, enhancing investor skills, and offering incentives for investing in startups.[62]

Mandatory climate-related financial disclosures for large publicly listed companies, insurers, banks, non-bank deposit takers and investment managers are essential for encouraging the necessary investment in rapid decarbonisation.

Still, more incentives are needed for the finance sector to invest in decarbonisation efforts. The Government could potentially provide funding, incentives, regulations and tax rebates for climate technologies. It could also provide additional support for R&D of new climate tech, particularly in agriculture, transportation, energy efficiency and waste management.

Establish incubation ecosystem

Establishing a climate tech incubation ecosystem will help foster innovation, nurture startups and accelerate economic growth.

The most impactful ecosystems provide a nurturing environment where aspiring entrepreneurs or startups can transform their ideas into viable businesses. By offering accelerators, mentorships, resources and networking opportunities, an incubation ecosystem will create a supportive space that encourages experimentation. These environments will attract a diverse range of talents, from tech innovators to creative visionaries which will help fuel cross-disciplinary collaborations to drive breakthrough solutions.

In addition to nurturing startups, an incubation ecosystem serves as a catalyst for regional economies. By bringing together entrepreneurs, investors, mentors and academia, these ecosystems stimulate job creation, attract investment and contribute to the development of high-value industries. As startups mature through the innovation cycle, they will continue to generate employment opportunities and create a network of emerging businesses.

Survey participants reported frustration and many barriers with business cases frequently disregarded. For example, transport participants reported a greater tendency to utilise or adapt existing large technology applications, in preference to supporting New Zealand solutions.

Greater support for early-stage startups and the scaling of technologies is needed.

Developing well targeted clusters can provide community amongst innovators, promote high levels of collaboration and significantly benefit customers. These advantages are more likely to arise from groups or 'clusters of innovators' rather than individual innovators.[63]

In 2020, Foresight, the leading cleantech accelerator in Canada, launched the first of a series of focused cleantech ecosystems. WaterNEXT forms a national water technology network in Canada, uniting various water-related entities to accelerate the use and implementation of innovative technologies for critical global water challenges.

The ecosystem now extends across many of the country's largest sectors, including utilities, energy, mining, agriculture, and manufacturing, encompassing more than 750 water technology companies, enablers and research organisations from across the country.

This approach has resulted in more than 130 ventures being supported and Canada is now recognised as a global leader in water technology.[64]

In early 2022, the Government reviewed the existing Founder Incubator and Accelerator system and discovered that worldwide, most of these programmes struggle to sustain themselves. They are generally reliant on government, university or corporate support.[65] Deep tech startups face even more challenges and costs compared

to software as a service (SaaS) startups. To support deep tech development, a more comprehensive ecosystem and incubation approach is necessary.[66]

Enhance uptake of new technologies

One of the most important ways for New Zealand to use its climate technology more effectively is by adopting new technologies. Boosting the use of new technologies usually requires creating awareness, providing training and offering support. The goal is to close the gap between introducing a new technology and making it widely and effectively used in real-world scenarios.

During the development of most of the Government's Industry Transformation Plans (ITPs) it became clear that embracing technology could enhance productivity. For example, the Manufacturing ITP highlighted the potential to improve productivity by adopting advanced technologies and fostering innovation.[67] Within the primary sector, AgriTechNZ has pinpointed key barriers to technology adoption in their industry, including costs, proof of return on investment and inadequate internet connectivity.[68]

However, our analysis shows Climate does not fit neatly into any of the digital, agritech, and manufacturing ITPs.

NZTech survey respondents also emphasised the significance of encouraging and rewarding technology adoption. They proposed having a cohesive plan, a clear roadmap, and consistent policies to promote and direct technology use. Collaborative efforts among the Government, private sector and other stakeholders were also seen as crucial for making technology adoption easier. There was an emphasis on coordinated efforts and support for technology adoption in New Zealand, alongside expediting approval for certain technologies.[69]

International research has identified three key challenges that affect technology adoption – the technology itself, the organisation using it and the regulatory or economic barriers. The study emphasises that achieving substantial changes in technology adoption is more difficult without an appropriate technology strategy (roadmap).[70]

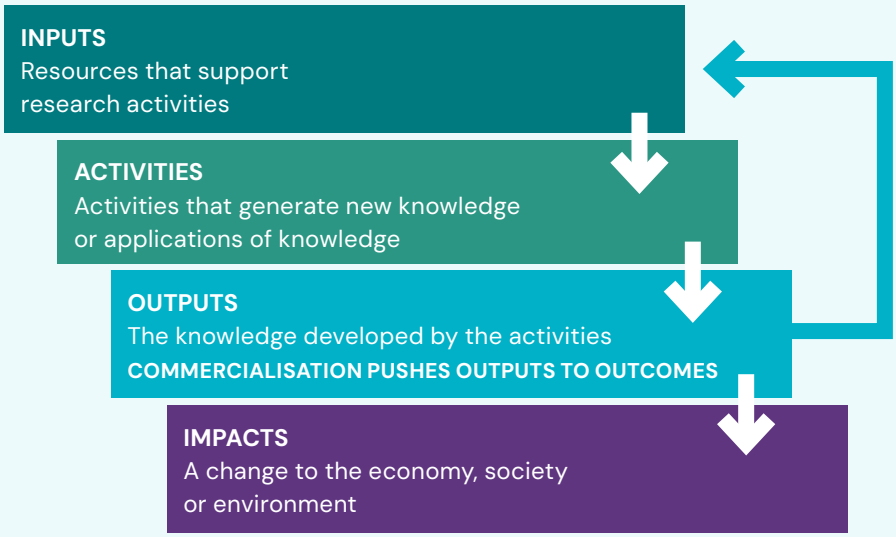
Improve R&D commercialisation

Improving research and development (R&D) commercialisation should be a key foundation for several reasons; accelerating climate action, economic growth, scalability, export opportunities, attracting investment and global competitiveness. This process is critical for turning research into practical solutions that benefit both society and the environment.

In their 2023 review of New Zealand's policies, the International Energy Agency suggests that New Zealand's current 15 percent R&D expenditure tax credit allows companies to choose their areas of focus, but a more structured approach would better support the energy transition deploying technology.[71]

The Kiwi Innovation Network (KiwiNet) emphasises that commercialising research is a vital step in converting knowledge and skills into real-world impact, as shown in Figure 8.[72] Successful commercialisation can lead to the creation of products and services that solve significant social, economic, and environmental problems, which is what climate tech aims to address.

Figure 8 – R&D Commercialisation Process



Source: International Energy Agency, 2014

While R&D spending in New Zealand increased 11 percent between 2020 and 2022, reaching $5.2 billion, the country's average R&D expenditure as a percentage of GDP was only 1.46 percent (which is lower than the OECD countries average of 2.74 percent).[73]

In its recent report, the Productivity Commission said New Zealand invests relatively little in research and development. It recommends including an increased focus on funding in priority areas and greater alignment of government and business activity.[74]

New Zealand lags well behind other small advanced nations in terms of R&D commercialisation.[75]

To tap into the full potential of climate tech and make the most of the research investment, New Zealand needs to enhance its R&D commercialisation efforts. Callaghan Innovation recommends:

- developing relevant policies and strategies
- enhancing market validation for R&D funded publicly and privately
- improving monitoring of the progress and outcomes of publicly-funded R&D
- fostering connections with global CleanTech hubs and accelerators.[76]

Additionally, a climate technology roadmap can help identify research and innovation with commercial potential as part of the commercialisation process.

Ensure infrastructure in place to enable tech

Meeting the country's 2050 target requires system transformation enabled by high levels of investment in new infrastructure.[77] In many cases, significant infrastructure investment may be required to enable climate technologies that reduce emissions.

Most climate tech infrastructure commentary tends to focus on the obvious, such as a charging network to support EVs. However, better infrastructure planning and development is needed for different types of infrastructure, including transport, energy, telecommunications and digital.

Many climate technologies involve electrification, or connectivity, meaning investment in resilient, low-carbon energy and telecommunications infrastructure is vital.

New Zealand is not effectively leveraging the value of digital, geospatial and data technologies to address our infrastructure deficit, resilience and decarbonisation priorities. Digital tools enable ongoing performance modelling and adaptation, allowing for performance optimisation of the built environment, but remain underutilised.

Infrastructure solutions like digital twins are not new and have seen success both here and overseas. However, the provision of the high-quality data that is the bedrock of the value they provide, has been inconsistent. The challenge now is designing a system where stakeholders are incentivised to require, provide and use data to improve New Zealand's infrastructure.[78]

Wellington City Council has been developing a digital twin that looks and behaves like the everyday reality of the city. This digital reflection connects complex infrastructural, social, economic and environmental systems with the decisions being made by the council and their impacts on communities. The ability to correlate decisions and impacts comes from the evolving architecture of the digital twin. The digital twin consists of data, whether it's models of buildings and assets, surface or regulatory data, or real-time sensors. The digital twin helps the council to coordinate growth, communicate what its investments can mean for the city and understand the longer-term future of climate adaptation.[79]

With increasing opportunities to use digital technologies to help reduce emissions across multiple sectors, we must ensure that the efficiency of our networks and digital infrastructure continue to improve, replacing legacy technologies with modern alternatives that have lower emissions profiles.

Enabling technology appropriate regulation and policy making

Improving the way regulations are made is crucial for advancing climate technology developments.

In the NZTech survey, participants highlighted the role of regulations in shaping the adoption of technology in the context of climate change and sustainability.

They stressed the importance of aligning regulations related to technology with the Government's emissions reductions agenda.

They suggested that regulatory frameworks should be prioritised, identified, reviewed, and potentially adjusted to reduce barriers and support technological advancements in emission reductions.

Consistent policies, standards, and regulations are also needed to create a fair environment and achieve desired outcomes. Closer collaboration with industry and research institutions on specialised regulations for priority technologies. For example, Minimum Energy Performance Standards (MEPS) are an example of a very effective regulation requiring products to meet minimum energy efficiency standards. Since their introduction, 1.98 million tonnes of GHG emissions have been avoided with $1.23 billion in benefit.[80]

An example of outdated regulation affecting outcomes is the electricity market, where current regulations are not designed for carbon reduction or digitisation, leading to unintended outcomes. In the agri sector approval pathways for new materials are impacting outcomes. Additionally, infrequent updates to legislation can limit the deployment of new technology. Some new technologies cannot be used because they do not align with existing laws, for example Mobility as a Service in transportation. There are other examples where legislation may potentially delay climate technology including genetic modification techniques, the development of a hydrogen industry, off-shore wind farms and rules related to sensors and data.

It is urgent to align the regulatory framework with New Zealand's climate response and other relevant goals.

Please refer to the appendix for further detail and examples.

Emerging Technology Enablers

In addition to the seven critical, system-wide foundations, our research also identified several emerging cross-sector technology enablers that play a key role in New Zealand's efforts to reduce emissions.

These enablers include establishing a strong foundational data system for decision making, utilising internet of things (IoT) and sensor technologies to collect data from various sources, and employing artificial intelligence (AI) to rapidly analyse the data for impact.

Ultimately, when developing sector-based roadmaps these enablers should be considered, regardless of the sector.

Enabling better capture and use of data

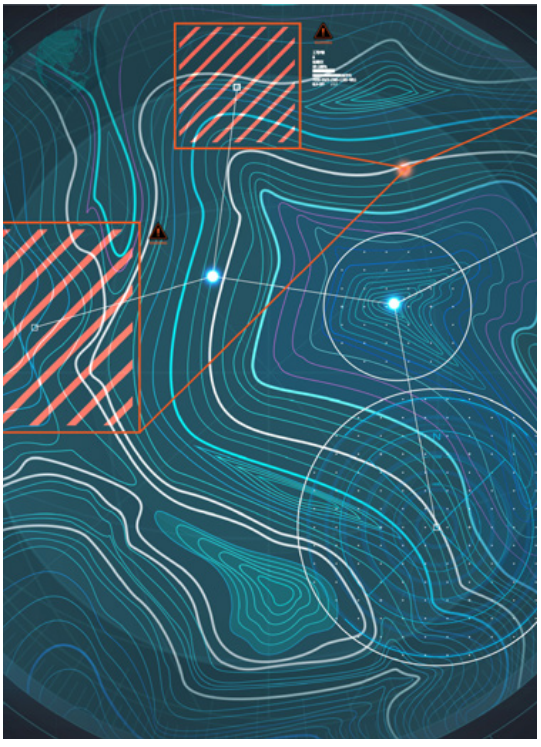
In New Zealand's efforts to reduce emissions and adapt to climate change, data is essential. We need various data including, climate information, emissions data, supply-chain efficiency data, organisation productivity data and financial data.

For example, climate data helps us understand emissions trends, risk factors, outcomes of assessments, functional abilities and intervention patterns.

To evaluate risks and support the transition to a low-carbon economy, investors and other stakeholders require information such as a company's vulnerability to climate impacts, its volume of greenhouse gases, and its emission reduction plans.

In the race to create new digital services that help people and businesses reduce their carbon footprint, open banking (a form of open data) is becoming a crucial tool for the financial services industry. It provides clarity that can empower individuals to take sustainable actions.

Open Banking enables secure interoperability by allowing third-party service providers to access banking transactions and other data from banks and financial institutions.



Cogo is a New Zealand headquartered fintech startup that has successfully integrated its carbon management products with data from banks to provide customers with a way to measure and reduce their carbon footprint.

The Cogo app connects users with businesses that align with their social and environmental values. The app, which is free to use, gathers data that allows users to understand their carbon footprint by assigning a carbon emission factor every time they spend. Cogo then shows users how to improve and compensate for their climate impact, with a selection of credible, global carbon offsetting projects.

Open Data is more than just financial data. It connects one person's transactions across multiple sectors. Open Data can support emissions reduction because it helps organisations understand the carbon footprint of their customers, both individuals and businesses.[81]

Open data is especially important in agriculture, where it can help us understand and reduce emissions. However, good quality data is not always available and this can impact decision-making. For this reason, building data infrastructure and promoting market cooperation is needed to address potential data gaps. Having standard datasets on emissions factors will make it easier to measure emissions consistently. However, no single site or source can do it all, so sharing information between organisations is vital.

Digital Twins should also be considered to support emissions reduction. Virtual copies of physical assets like pipes and roads that consolidate a raft of information from different infrastructure players and live data from sensors in the real environment.

Registries of emissions reduction characteristics, outcomes, and adverse events are also required. Making these registries freely available and easily accessible can help avoid extra costs for users.

AWS in New Zealand provides open access to climate-related data sets to support researchers and policymakers, and which democratises tools and information that anyone can use to develop climate responses for their business or project. They are implementing such a project with Toitū Te Whenua – Land Information NZ.[82]

Government and industry partnerships can accelerate data science and analysis. A regulatory sandbox could provide a cost-effective method for testing and validating solutions, particularly in regulated industries, for example finance and energy. Sharing results through application programming interfaces (APIs) can also influence future actions and regulations, while remaining on track with goals and funding.

The Internet of Things (IoT) and sensors

The Internet of Things, or IoT, is a network of physical devices. These devices can

transfer data to one another without human intervention. IoT can include anything with a sensor that is assigned a unique identifier (UID). The goal is to create self-reporting devices that can communicate with each other (and users) in real time.

IoT networked sensors can easily provide accurate monitoring of air quality, temperature, humidity, soil moisture, noise and light (outdoors and indoors), in small areas and at scale. They are being used to meet environmental and safety regulations but also to remotely manage resources and improve operational efficiencies.

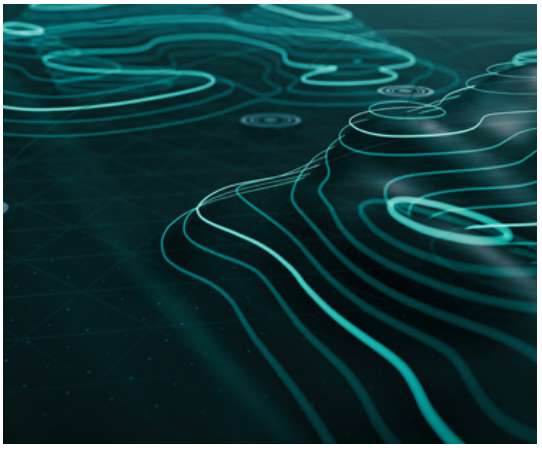
There are four critical components for IoT-based environmental monitoring to support insights and decision-making:

Observation (Monitoring the environment and collecting climate data)

Analysis (Measuring data)

Storage (Cataloguing data)

Action (Providing actionable insights from the data and analysis)



The Green Artificial Intelligence Technology company measures carbon abatement digitally. It uses sensors to collect data on atmospheric gases and satellites collect spatial data - while the IoT platform analyses it. It gives carbon projects – including tree-planting, conservation work, waste conversion and renewable energy – better and more immediate awareness.[83]

IoT networks require ubiquitous high-speed internet connectivity. In May 2023, the New Zealand Minister for the Digital Economy and Communications announced the signing of contracts with major telecommunications network operators to accelerate the rollout of 5G to regional towns across New Zealand, critical infrastructure for effective IoT.[84]

A data buoy with an in-situ salinity sensor helped mussel farmers reduce boat travel times to clean the buoy and therefore carbon emissions. It measures ocean salinity every 15 minutes and sends the results to the farmers via Spark's IoT Cat M1 network.[85]

Artificial intelligence (AI)

Artificial intelligence (AI) is already demonstrating an ability to connect a wide range of data sources to help make more accurate and timely sense of our environment.

The use of AI technologies has been shown to provide meaningful solutions towards major environmental outcomes, such as:

- Preserving and bolstering biodiversity through the protection of native plants, animals and ecosystems in land, freshwater and marine environments.
- Understanding impacts of changing land use such as changes to vegetation across the country and the use of land in urban areas.
- Reducing pollution from our activities by rapidly monitoring and adjusting outputs, substances or kinds of energy (noise, light, heat) that are harmful to the environment.
- Protecting our freshwater and marine resources like how we fish and the taking of water from waterways for various purposes.
- Climate change mitigation such as reducing greenhouse gas emissions and mitigating the effects of climate change for Aotearoa New Zealand.

Recent research into New Zealand's AI for the environment has highlighted that providing fast data analysis at scale and drawing inferences from complex interconnected processes can provide benefits in our efforts to address a range of environmental issues. This research identified five areas that AI technologies can assist with:

- processing big data and providing near real time information
- more accurate predictions and modelling
- answering specific questions to support decision-making and identify where to put effort
- detecting and labelling features of interest in data collected from sensors
- gaining new insights from historical data.[86]

Wherever there is data there is potential for faster response with the support of AI. For example, the AI augmentation of the New Zealand National Environmental Monitoring and Reporting System, where monitoring is required by a range of legislative tools, could generate new insights and better responses.

The Land Use and Carbon Analysis System (LUCAS) keeps track of land use change in Aotearoa New Zealand, especially in forests. Deforestation is an important form of land use change, with assessments conducted in New Zealand every two years to meet international reporting obligations (the United Nations Framework Convention on Climate Change and the Kyoto Protocol). LUCAS uses aerial imagery of New Zealand that is georeferenced and analyses them using machine learning models to detect areas of deforestation. This has enabled more rapid assessment of replanting by the Ministry for the Environment for greenhouse gas reporting.

Māori Tech

Māori have strong traditions for the stewardship of environmental and natural resources, including an inter-generational focus. A rich body of mātauranga knowledge relates to understanding the natural world and its mauri life force.[87] This knowledge is place-based observation of the environment, and a holistic view of the ecosystem and humans' place within it.

A mātauranga Māori-centred understanding of the environment often uses indicators

relating to observable states and wellbeing descriptors (for example the clarity of river water, or whether people feel a sense of calm and enrichment when they are in the area). This cultural approach guides how innovators develop climate tech solutions, how businesses adopt solutions and climate adaptation.

The Toha Network, by Toha Foundry, has been working to build a system that creates new value for climate action, from Aotearoa, with urgency, and the belief that we all have a role to play in the regeneration of our planet.

The Toha Network is an ecosystem of ventures, impact investors, scientists and regenerators cooperating to create new value for science-based regenerative action. Their collective goal is to enable economic prosperity through regeneration, starting in Aotearoa New Zealand. In new markets, they can allow the true value of regenerative action to be recognised and traded - inviting impact investment to be unleashed to the frontline of climate action at scale.

The network is supported by a group of foundation entities working together to deliver a climate platform as an ecosystem and a public good, including the lead entity Toha Network Trust (charitable trust), a science trust, a data lab and a tech platform provider.

Recent data-driven Māori led research into the Māori tech ecosystem identified a number of technology and data elements that could inform and influence Aotearoa's Climate Technology Roadmap. The Toi Hangarau report on Māori-owned technology companies highlights that Māori tech businesses are well aligned with global mega trends such as climate change.[88]

There is work underway in the New Zealand ecosystem to advance and grow Māori innovation and tech businesses. This presents the opportunity to add a climate tech lens to impact emissions reduction and climate adaptation plans. Adding a te ao Māori perspective to climate technology innovation will also provide additional insights, wisdom and cultural benefits.

Further work, by Māori for Māori, is needed to fully understand and implement this potential emerging enabler for emissions reduction.

Sector Opportunities

Technology enablers are essential for creating the optimal environment for system wide change and the greatest emissions reduction impact. However, there are also many opportunities to reduce emissions in the major sectors.

The ability to take advantage of these opportunities will depend on the readiness of the enabling environment. However, the proposed framework should support the identification of sector-specific opportunities while considering skills development, financing, the regulatory environment and other enablers.

Agriculture

In agriculture, there are many climate tech opportunities. These range from using digital tech to new biotechnology and gene editing possibilities.

The most impactful gains will come from accelerating the rate of development and adoption of new technologies such as animal feed additives, animal genetics, plant genetics, fertiliser formulations and effluent management. Developments in feed additives, methane vaccines, slow-release bolus devices, grass species and effluent pond treatments are all underway. The public-private partnership between the Ministry for Primary Industries and leading NZ Agribusinesses (ANZCO Foods, Fonterra, Rabobank, Ravensdown, Silver Fern Farms and Synlait) is focused on accelerating such developments and catalysing the availability of technologies to farmers. No one technology is a silver bullet and a portfolio of products are required to match both system and season interventions to reduce methane and nitrous oxide.

There are also other opportunities in agriculture, including ways to manage emissions from large animals, biotech and seaweed nutrient trials, biochar production, using closed loop algae aquaculture, and developing low-methane livestock supply chains. These could all be part of a roadmap for climate tech in agriculture.

In addition to these technologies, more immediate gains appear to be better use of digital technologies. By embracing precision agriculture and digital innovation, we could reduce emissions in agriculture by 1.9 Mt.[89]

Precision agriculture includes using tech to monitor crops, sensors for animals and remote sensing. Many of these technologies are already available.

New Zealand agritech firm Pastoral Robotics has developed a solution, Spikey, that detects urine patches on-farm using spiked electrode disks that provide a fast and accurate detection system. Spikey detects and treats the urine patches with NitroStop, which consistently increases grass growth by up to 25 percent and reduces nitrate leaching by up to 20 percent on paddock scale.[90] Another example is Ruminant BioTech who have developed a slow-release device, called a bolus, that sits in the cow's stomach for up to six months and delivers high levels of methane knockdown over that time period. Trials to date show a 70 percent methane reduction over six months.[91]

The extensive work undertaken by industry and Government partners in developing an Agritech Industry Transformation Plan (ITP) can be aligned with climate goals, especially in increasing digital adoption in farming. Improving data standards, for example, can also help enable the use of AI and other digital tools for more efficient farming.

Energy

Energy is another sector where opportunities have been identified for emissions reduction. A recent New Zealand study estimated there is potential for 2.4 Mt emissions reduction in energy and industry through digital innovation. This includes building automation, grid load smoothing, industrial process automation and even increased use of cloud infrastructure.[92] Digital demand management and improvements to electricity regulations should be priorities for New Zealand.

Simply Energy's Demand Flex programme rewards customers for 'flexing' their electricity usage. A sophisticated technology platform, built in-house, automatically powers down or turns off customers' load when the grid needs a helping hand and pays customers for offering load into electricity markets.The 15 MW of interruptible load provided by the programme's 44 participants is like a virtual power station and has the potential to be a valuable tool to help meet New Zealand's climate goals.[93]

The International Energy Agency's (IEA) Net Zero by 2050 roadmap highlights a number of short-term priorities in the energy sector that countries should be focused on.[94] This includes banning new sales of fossil fuel boilers, stopping new unabated coal plant approvals, and stopping new oil and gas field approvals or mine extensions.

NZTech's survey respondents identified that investing more in renewable energy sources like wind and solar should be a priority to help New Zealand reach its climate change goals. Other opportunities include making our electricity system smarter, using technology to track and manage power demand, redesigning the regulatory framework to support decarbonisation, enabling greater involvement from new market participants, and making homes more energy-efficient. New Zealand has the technology to solve these problems now.

There are also opportunities to adapt initiatives from the UK Clean Growth Strategy[95] to include in our own roadmap.

Carbon Capture, Utilisation and Storage (CCUS)

A recent Productivity Commission review showed New Zealand has fewer large polluting factories than average, so CO_2 capture is unlikely to be a significant part of our plan.[96] Instead, we should explore methods to remove carbon dioxide from the air, which can have a significant impact. This process, known as CO_2 removal, extracts carbon from the air, making it carbon-negative.

Hydrogen

New Zealand has a highly renewable electricity system and significant potential for new generation capacity that could be used to produce green hydrogen as a next generation, low-emissions fuel and energy carrier. Green hydrogen has the potential to help reduce our emissions in some hard-to-electrify applications such as long-distance trucking, specialty vehicles, industrial feedstocks, process heat, and in future aviation and marine transport.[97]

MBIE are currently developing a roadmap for hydrogen to provide direction in this area[98] and a significant number of projects are also underway across New Zealand exploring hydrogen production, distribution and use.[99]

Transport

Transport is a significant source of emissions, so extensive research has been undertaken to identify reduction opportunities. In New Zealand an estimated 2.9 Mt of emissions could be reduced from transportation by using digital innovations.[100]

The UK has a plan to decarbonise their transportation by 2050. This includes exploring opportunities from hydrogen-fuelled transport, decarbonising the vehicle fleet by incentivising the replacement of vehicles, infrastructure development, short-term research and innovation interventions, and improved battery technology.[101]

Other opportunities that have been identified in the UK, include smart systems to reduce the cost of electricity storage, advanced innovative demand response technologies and the development of new ways of balancing the grid to prepare for the impact of electric vehicles (EVs).

NZ Post have been trialling electric vans to help reduce their emissions. The EV fleet has proven to be both economic and practical. Vehicle-based emissions reduced by approximately 90%, and drivers saw an 80% reduction in fuel costs and a 50% reduction in maintenance costs.

Finland is also focusing on transportation. Digitisation is a key enabler as passenger transport moves towards smart, easy-to-use transport that is based on the sharing and services practice called MaaS (Mobility as a Service). Their roadmap outlines the development of incentives and policy tools which encourage technology use to deliver a more service-based transport system. This includes developing and promoting alternative forms of transport and replacing more carbon-intensive modes.[102]

UBCO, winner of the 2022 NZ Emerging HiTech Company of the Year Award, has developed a versatile electric motorbike that has many rural and urban applications from conservation to food delivery. The UBCO electric farm bike has been found to emit 99% less CO_2 than a quad bike, with the bonus of 98% fuel cost savings.

In Australia, the NSW Government's transport technology roadmap is focused on the use of intelligent systems and sensor technologies, and the benefits they bring, including reducing emissions. New Zealand does not have a similar public strategy.[103]

Sydney Coordinated Adaptive Traffic System (SCATS) is an intelligent real time traffic management platform that monitors, controls and optimises the movement of people and goods in cities. It has resulted in reduced emissions compared to earlier systems.

Our survey respondents also highlighted several opportunities including digitalisation of freight management, the electrification of transport fleets and expanding mobility-as-a-service (MaaS).

Other Sectors

Waste

Several reports suggest ways to improve New Zealand's waste management and approach to a circular economy. When dealing with waste, it's vital to understand where resources can be used again. This reinforces the importance of a systems approach as waste for one sector can be valuable for

another. For example, The Hot Lime Labs CO_2 capture system converts wood waste biomass into clean CO_2 for commercial greenhouses, increasing crop productivity and growth.[104]

Construction

To make buildings more sustainable, we can create more new green buildings and upgrade older buildings. Development of low carbon cement should be supported as this presents a near-term win. However, our research sprint participants highlighted that businesses trying to do this are struggling to gain both Government and private sector funding support. This may require new regulations to support sustainable building or mandating low carbon cement.[105]

Data standardisation and increased use of building information modelling (BIM) have been found to reduce design and construction risks, create better safety outcomes, greater collaboration, and reduced construction time and costs, lowering emissions.[106]

Platform8 is a New Zealand founded solution for sustainable supply chains, helping businesses to achieve sustainability goals and net-zero emissions with visibility, CO_2 reduction, and circular trade. Their marketplace connects supply chains, offering tailored solutions to overcome challenges such as limited visibility, ESG performance management, compliance, risk mitigation, and economic optimisation.[107]

Where to from here?

61

Deploying a Climate Tech Roadmap

This project has identified the challenge New Zealand faces in meeting its agreed emissions reduction targets.

It has also highlighted the absence of a planned approach for employing technology to reach these goals. The consequences of the current haphazard approach could potentially result in a $20 billion cost to New Zealand.

Several countries have begun to show progress in addressing their climate challenges. Many of these countries are ranked higher than New Zealand on several metrics, including use of technology. These countries share a common practice of using climate technology roadmaps, which are strategic planning tools. These roadmaps help a country prioritise existing technologies, identify new climate technology opportunities and coordinate critical enablers.

Our research identified critical foundations that need to be strengthened to enable climate technology. While the Government allocates a substantial amount of funding to these areas, it lacks coordination and alignment with emissions reduction goals. New Zealand requires a more coordinated, systems approach to enable climate technology that can effectively reduce emissions.

We recommend introducing a framework to help coordinate Government and Industry activity and the development of an Aotearoa Climate Technology Roadmap.

Recommendations

These recommendations aim to guide the establishment of a comprehensive and forward-thinking Climate Technology Roadmap for Aotearoa New Zealand. Its aim is to foster innovation, resilience and sustainability in the face of climate change.

Recommendations for the development of the Climate Technology Roadmap include:

1. Assess the current climate technology. landscape. Assess New Zealand's current technology landscape to identify and quantify opportunities for action, including emissions, technology readiness and adaptation efforts.

2. Incorporate international models. Draw on the climate technology responses and roadmaps identified here to inform New Zealand's approach and the material that can be applied. Note the important enabling opportunity a climate technology roadmap would provide to existing agency and other organisation climate technology activity in New Zealand.

3. Promote a co-design approach. Enable consultation and cross-agency collaboration to ensure an informed and inclusive climate technology roadmap, where agencies retain ownership of their contribution to the roadmap. Foster authentic collaboration and knowledge-sharing with stakeholders.

4. Underpin with connecting principles and strong leadership. Use the framework to enable the coordination and alignment of agencies and organisations in climate technology activities. Ensure senior political

leadership and collaboration with industry stakeholders to drive climate tech solutions.

5. Secure the foundations. Ensure the Climate Technology Roadmap includes the seven critical foundations:

1. Skills development for climate technology professionals
2. Financial support mechanisms for climate tech innovation and adoption
3. Incubation programmes to nurture climate tech startups
4. Strategies to facilitate the uptake of climate-friendly technologies
5. R&D commercialisation strategies for climate-related innovations
6. Infrastructure planning and investment to enable climate tech progress
7. Regulatory frameworks to encourage and support climate tech advancements.

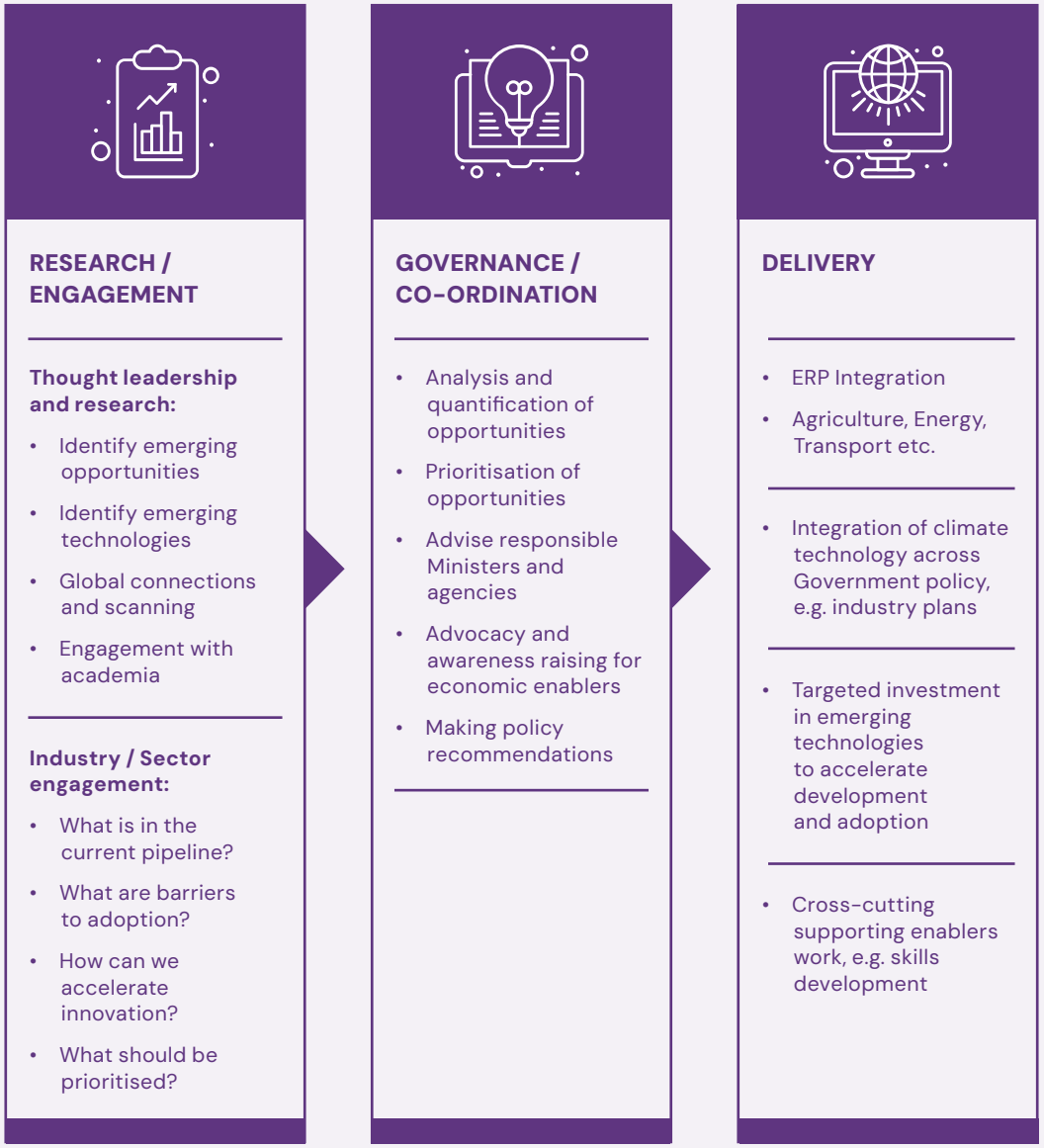
6. Integrate with Emissions Reduction Plans. Align the development of the Climate Technology Roadmap with the second Emissions Reduction Plan, ensuring broader climate mitigation and adaptation.

7. Gain shorter-term climate tech opportunities. Identify and prioritise shorter-term climate technology opportunities that yield quicker wins.

8. Monitor and evaluate. Establish appropriate monitoring and evaluation indicators to measure the effectiveness of the Roadmap. The roadmap should be updated periodically on a section-by-section basis as technology developments require this.

9. Timely completion. Progress the development of at least the priority areas of the Climate Technology Roadmap to inform the release of the second Emissions Reduction Plan. This could help ensure a cohesive and integrated approach to climate action.

Figure 9 - Next steps to developing an Aotearoa climate tech roadmap



Source: NZTech 2023

Potential quicker wins

Quicker wins are simple and immediate actions that can have a positive impact on addressing climate change or advancing sustainable practices. These wins are typically focused on reducing greenhouse gas emissions, improving energy efficiency or promoting environmentally friendly practices.

Our research participants contributed a series of short term technology opportunities they believe can help our climate response. However, all participants emphasised these opportunities are also linked to the critical foundations.

While quick wins are valuable for making initial progress in addressing climate change, they are just one part of a longer-term strategy. Long-lasting and substantial climate action requires more comprehensive and systemic changes that a roadmap can provide.

Quick wins can help build momentum for significant sustainable solutions. Broadly speaking, quicker wins can be categorised as follows:

- Energy efficiency upgrades
- Renewable energy integration
- Transportation solutions
- Waste reduction and recycling
- Retrofitting existing infrastructure
- Afforestation and reforestation
- Behavioural change campaigns to raise public awareness

A collection of ideas and opinions collected during this research is located in the appendix.

Appendices

67

Appendices: International approaches

Despite significant progress being made, New Zealand's climate policy settings and actions remain internationally assessed as 'highly insufficient'.

The international Network Readiness Index, which measures the extent countries are making use of the opportunities presented by technology ranks New Zealand at 19th, with our impact using technology at 23rd in the world. Additionally, in the future technologies area New Zealand ranks 35th, it is 39th in ICT regulatory environment and only 36th in government promotion of investment in emerging tech.[108]

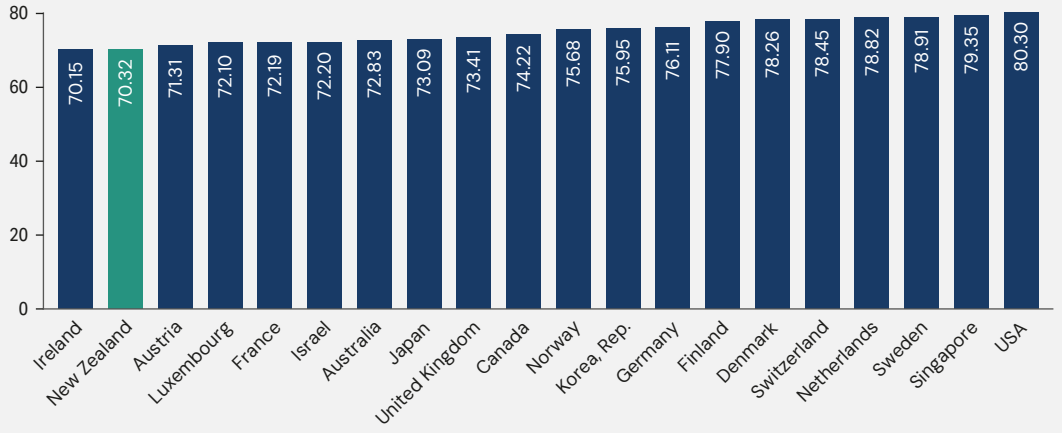
The countries identified by this index that are using climate technology roadmaps, are all ranked considerably higher than New Zealand: Sweden - 3rd, Denmark - 6th, Finland - 7th and United Kingdom - 12th.

Climate Technology Roadmap Examples

We have an opportunity to follow the lead of other countries making greater carbon emission reduction progress by developing and implementing our own roadmap.

International evidence shows implementing climate tech roadmaps can stimulate the earlier adoption of emission reductions solutions. Several European countries have adopted the roadmap approach, including Sweden which is at the forefront of climate change action. Three other European countries, broadly comparable to New Zealand in size (Denmark, Finland and Ireland) had higher per capita CO2 emissions than New Zealand, and these have since declined. The development and implementation of a climate tech roadmap has likely been a key contributing factor.

Figure 10 - Low ranking for network readiness and use of technology



Source: Network Readiness Institute, 2022

The United Kingdom's Climate Change Act 2008 inspired New Zealand's climate change legislation,[109] and the United Kingdom (UK) launched its first version of a roadmap in 2010.

A decade ago, the Technology Executive Committee of the United Nations Framework Convention on Climate Change published a report recommending countries adopt roadmaps to advance climate change mitigation and adaptation.[110]

The United Kingdom

Technology has underpinned the UK's climate response since it established its climate change framework in 2008. This has contributed to it achieving the largest greenhouse gas emissions reduction of any G20 economy.[111]

Today it has a well developed CTR ecosystem. For example, to decarbonise domestic transport, a series of seven roadmaps address cars and light goods vehicles; buses (see roadmap excerpt example Figure 11); coaches; heavy goods vehicles; rail; domestic shipping; and domestic aviation.[112]

Each roadmap considers the progression of relevant solutions by 2050, aligned to the goal of decarbonisation. The roadmaps recommend research and innovation interventions required in the next five to ten years. They also consider the recommended role of policy making and fiscal/regulatory measures in helping to enable progress.

The UK also has an integrated connectivity technology roadmap for their transport sector, outlining the core technology solutions being progressed.[113]

This format demonstrates the flexibility the roadmap tool has depending on industry sector requirements.

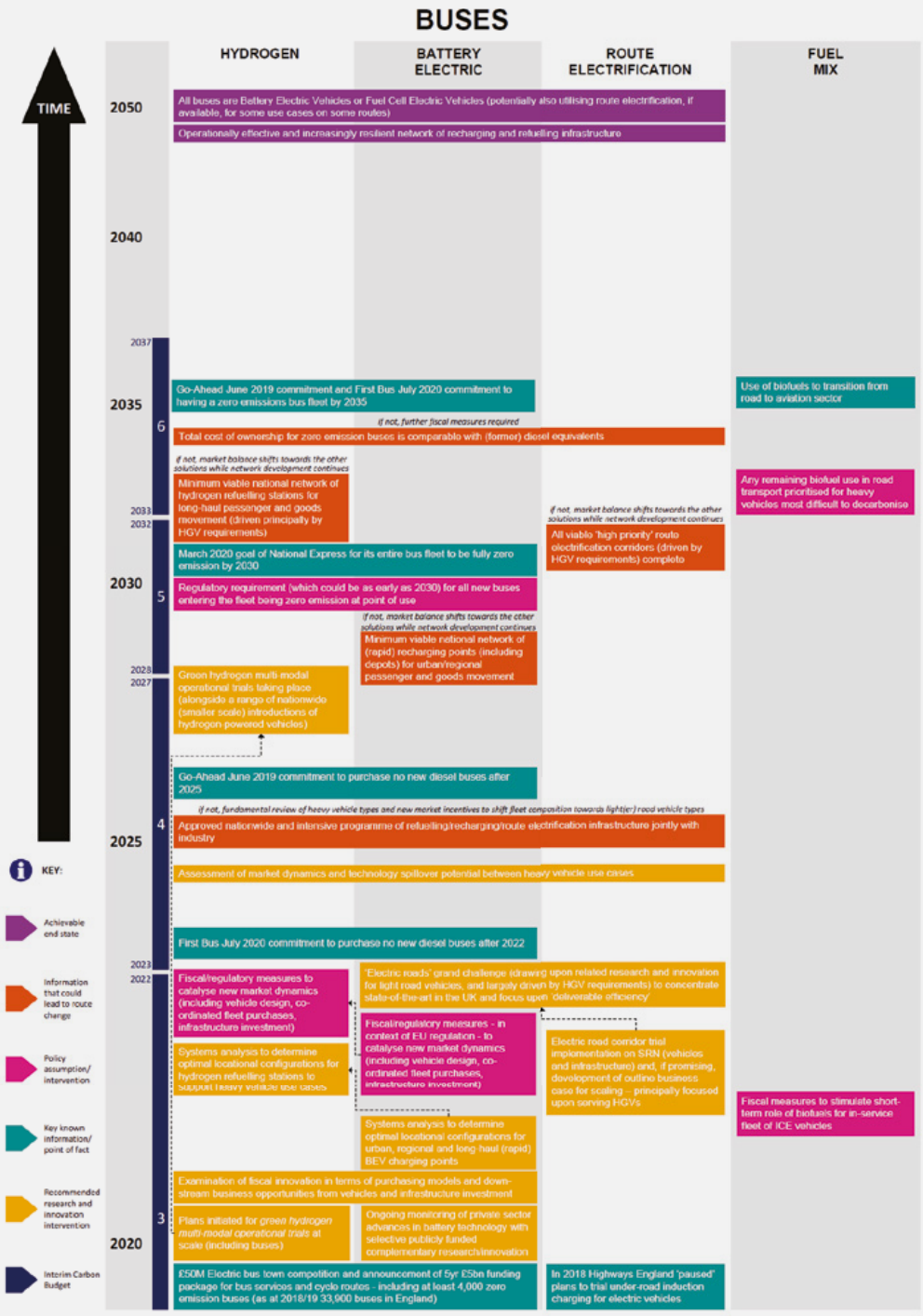
Denmark

Denmark has recognised a CTR is key to achieving optimised, economical, and environmentally sustainable carbon capture, usage and storage. The Danish roadmap (see roadmap excerpt example Figure 12) takes a systems approach to carbon capture and storage. Their roadmap allows for the development of technical solutions and regulatory frameworks along the entire roadmap value chain. Five tracks provide the backbone of the roadmap including biological CO2 capture and storage, chemical CO2 capture, geological storage, non-fuel utilisation and cross cutting tracks. [114]

Finland

Finland's CTR highlights the potential for significant reductions in greenhouse gas emissions in different sectors. Their objective of a carbon-neutral Finland by 2035 can be achieved in industry and other sectors with existing or emerging technologies. The process of developing the Finnish roadmap identified technology solutions to advance decarbonisation across sectors (see roadmap excerpt example Figure 13). Finland's objective is so ambitious that emissions need to be reduced in every sector. Although emissions vary widely in scale by sector, collective contribution is required, hence the need for a roadmap.[115]

Figure 11 - Roadmap Example: UK transport climate tech roadmap



Source: Buses component from UK transport climate tech roadmap.

Figure 12 – Roadmap Example: Danish climate tech roadmap

UTILISATION	BASELINE				2025 GOAL			2030 GOAL		2050 GOAL
Finance and SRL	**Subsidiaries**									
	Societal readiness level									
	SRL 2	Assessment of current social acceptance and challenges	Involvement of general public	Outreach activities	SRL 6	Environmental study for specific sites		SRL 9		
Implementation	**International development**									
	Market extend: low	Bring technologies to DK	International Development projects	EU	3 International projects on utilisation	International demonstration of projects	Subsidiary system in place	Int. Deployment of technology	Export finalised technologies	Export worth 1 bn DKK
	Start-ups and first movers									
	Low activity	Efficient tech transfer	Seed capital	Lower marked barriers	15-30 Danish Start-ups	Legal support	First long-term contract	5-10 SMEs	Growth support funding	1-2 larger companies
	Catalysis									
	TRL8	Upscaling	FEED		TRL8 demonstration	P2X intergration	Smart Grids	Large scale construction initialisated	Up-scaling	5mtpa
Innovation	**Electrolysis conversion**									
	TRL2	Basic development	IPR		Demonstration	Up-scaling	Reactor optimisation	TRL8	Investment	TRL9, +100,000 Mtpa
	Direct utilisation									
	Existent	New application	Feasibility studies		TRL4 for new tech	Business cases	Proof-of-concept	Demonstration	Up-scaling	TRL9
	Thermo chemical technologies									
	TRL5	Demonstrations	Feasibility studies		TRL7	Industrial investment		TRL9	Contract negotiations	International deployment
	Biological technologies									
	TRL2	Proof of concept	New principles		TRL5	Demonstarion		TRL8	Large scale demo	First large scale facility

Source: CO_2 utilisation component from Danish climate tech roadmap. Danish Carbon Capture Utilisation and Storage Roadmap.

Figure 13 - Roadmap Example: Finland climate tech roadmap

Technology industry	Plan and process planning, IoT utilisation in manufacturing, specialised robotics, cybersecurity technologies, 5G applications, optimising harbour operations, and bioenergy technology.
Energy industry	Onshore and offshore wind power, extending the service life of nuclear power plants, biogas plants for combined heat and electricity production, geothermal energy technology, solar power technology, and battery technology
Chemical industry	Chemical and mechanical recycling, Power-to-Chemicals, synthetic biology and biochemistry, CCU/CCS, and process changes
Forest industry	New production technology for pulp, paper, and mechanical wood products, methods of optimising wood use, and water efficiency solutions.
Logistics and transport	Low-emission vehicles, remote technologies substituting for transport, autonomous cars, electricity distribution and recharging infrastructure, alternative sources for motive power, and synthetic fuels.
Food industry	Heat pump technology and biogas plant integration into biowaste processing.
Textile industry	RFID technology for textile identification, textile recycling technologies, and textile fibre technologies.
Sawmill industry	Sawing and drying technologies.
Agriculture	Farming technologies, manure processing technology, biogas plants, and alternative motive power sources for machines.
Construction industry	Insulation technologies, low-carbon building materials technology (e.g. for cement and steel), CCU, and smart thermostats and gauges.
Buildings	Smart automation and control systems, IoT solutions, and virtual power plant (VPP) technology.
Hospitality industry	Heat pumps and energy efficiency upgrades.
Commerce	Automation and recovery related to energy use, low-carbon refrigeration technology.

Source: Summary from Finland roadmap. Finland Climate Technology Roadmaps

Potential Quicker Wins

The insights presented here are not intended as a comprehensive catalogue of quicker wins. Instead, these are a range of views and opinions captured during our research from a variety of respondents.

These perspectives have not been validated or tested but do represent a diverse array of voices within the climate tech community. While their input offers potential directions for action, this serves as a starting point for discussion, recognising that further refinement may be necessary to transform these ideas into effective solutions.

Agriculture

- Align the Agritech Industry Transformation Plan with emission reduction plan priorities to enhance work currently underway to grow New Zealand agritech exports.
- Boost uptake support for the technologies already being deployed in top three on-farm areas: existing animal management (and milking), crop protection and fertiliser/ nutrient management.

- Take steps to address cost of technology implementation and proof of return on investment to increase uptake and deliver efficiency benefits.
- Strongly promote existing New Zealand agritech solutions.
- Prioritise anaerobic digestion opportunities as a way to manage organic residues.
- Prioritise the development of biochar production and use cases in agriculture and industry.
- Prioritise GMO technologies tailored for the farming business model and conditions which can help reduce methane emissions from animals.
- Utilise crop vision and sensing systems to reduce nitrogen use and nitrous oxide emissions
- Deploy animal sensors and management systems to increase efficiency and reduce impacts of animal farming.
- Implement methane inhibitors, vaccines, and changes to cows' rumen biome flora and microbiome to reduce methane emissions from dairy farms.
- Encourage and support use of big data/AI tools on-farm.
- Support the tailoring for NZ on-farm use of priority internationally available technology which can be deployed locally.

- Develop a low-methane livestock supply chain that consists of both sets of technologies but also systems of operating models between technologies that can be exported as a New Zealand model.
- Support development of a New Zealand agricultural digitalisation value chain.

Energy

- Act on energy line regulation policy to be set early next year by the Commerce Commission. This will (likely negatively) pre-determine ERP 2 energy pricing paths.
- Prioritise regulation for smart EV charging to plug the gap in demand response technology management to better optimise energy resources.
- Moving to smart demand management and the management of peaks is an urgent priority using new innovative approaches.
- High-temperature heat pumps need wider adoption in NZ as this provides a key step for process heat decarbonisation. Emerging steam heat pump technology is a further opportunity.
- Boost support to projects piloting distributed energy resources, both commercial and residential, as virtual power plants, for example. EV battery or other distributed energy power (solar, wind).
- Prioritise support for New Zealand heat battery storage solutions.
- Prioritise options to better encourage and support new solar energy systems.
- Boost promotion to farm waste for energy production solutions.
- Encourage industry and Government to accelerate cloud migration activity.

Transport

- Prioritise increase in EV infrastructure in urban centres to address EV uptake constraints.
- Encourage and support the use of sustainable fuels for long-distance transportation.
- Start a work programme to update legacy system traffic signals with new transport technology. Existing market technology can be deployed.
- Fast-track the deployment of small commercial vehicle technology and initiate pilots to demonstrate support/opportunity.
- Progress Mobility-as-a-Service (MaaS) service technology pilots using incentives and policy tools, similar to Finland, to encourage tech use to deliver a more service-based transport system.
- Fast-track smart systems to reduce the cost of electricity storage, advance innovative demand response technologies and develop new ways of balancing the grid to prepare for the impact of EVs.
- Start a work programme to promote greater public transport and other service information and payment system interfaces and develop compatibility for alternative forms of transport.
- Study insights from the UK's Centre for Connected and Autonomous Vehicles for a collaborative funding model with industry.
- Study insights from Finland's Circular Economy Roadmap, where digitisation has been identified as an essential enabler in the transport and logistics transition.
- Evaluate the urban mobility data system improvement opportunities identified by the Australia New Zealand Smart Cities Council in their Mobility Now report.

Other quicker wins

- Increase financial support to the small number of New Zealand companies developing low carbon cement.
- Pilot leading-use case carbon sequestration technologies.
- Encourage capture systems which convert wood waste biomass into clean CO2 for commercial greenhouses, increasing crop productivity and growth.
- Add Emission Reduction & Climate Adaptation lenses to existing Digital Boost efforts & investments to enable faster adoption.
- Raise awareness of the existing emission reductions counting calculator through a digital campaign targeted to SMEs.
- Add Emission Reduction and Climate Adaptation lenses to existing Government infrastructure development investments now to prevent rework and wastage.
- Share climate data between Government agencies and the private sector to enable more/faster innovation, richer insights, more meaningful disclosure, and better decision-making.

Opportunities Identified

While developing the framework we were presented with several potential climate technology opportunities.

The opportunities have been captured in the tables below and include recommended actions, estimated time horizons, estimated availability of the solution, an indication of who will likely need to drive it (Government, industry or partnership), and estimated impacts on resourcing.

These tables are not an exhaustive list of opportunities and should be considered as indications to support further work. Where possible some commentary has been included on potential impacts and rationale for proposed actions, however this was beyond the scope of this project. A more detailed analysis of impacts is recommended as part of the development of relevant Climate Technology Roadmaps.

Table 1 - Examples of Coordination and Leadership Opportunities

ACTIONS	HORIZON	AVAILABILITY	WHO	RESOURCING
1.1 Establish the appropriate level of political support to sponsor the coordination and development of a Climate Technology Roadmap.	Plan for soon	New	MBIE MfE CCCB	Adaptation of existing workstream
1.2 Utilise the World Bank framework for digital enablement to establish an Aotearoa Climate Technology Roadmap.	Plan for soon	New	**Partnership** MBIE, MfE NZTech Sector partners	New funding may be required
1.3 Co-design a strong system coordination and monitoring system involving industry into the roadmap's establishment.	Plan for soon	New	**Partnership** MBIE, MfE NZTech Sector partners	New funding may be required
1.4 Establish a Climate Technology Roadmap coordinated by a lead government agency but with oversight from a partnership involving industry, government and research institutions.	Plan for soon	New	**Partnership** MBIE, MfE NZTech Sector partners	New funding may be required

Table 2 - Examples of Industry Engagement and Partnership Opportunities

ACTIONS	HORIZON	AVAILABILITY	WHO	RESOURCING
2.1 Establish an industry, Government climate technology roadmap steering group.	Act now	Available	Partnership MfE Sector groups	Reprioritisation may be required
2.2 Collaborate with industry to review the current industry/ government initiatives underway for opportunities to overlay a climate tech lens. For example DIgital Boost.	Act now	Available	Partnership MBIE NZTech	Adaptation of existing workstream
2.3 Collaborate with industry to improve the quality and experience across the technology procurement process.	Act now	Available	Partnership NZ Government Procurement NZTech	Reprioritisation may be required
2.4 Identify opportunities to engage with business clusters such as Chambers of Commerce or industry associations to interweave a shared industry/government climate tech agenda.	Plan for soon	Available	Partnership MBIE Sector groups Chambers	Reprioritisation may be required

Table 3 - Examples of Skills Foundation Opportunities

ACTION	HORIZON	AVAILABILITY	WHO	RESOURCING
3.1 Develop a digital tech workforce plan.[116]	Act now	Available	Partnership Toi Mai NZTech IT Professionals	Existing workstream
3.2 Co-design work integrated pathways.[117]	Act now	Available	Partnership Toi Mai, MoE NZTech IT Professionals	Existing workstream
3.3 Introduce the SFIA standard for digital skills to align on a standard.[118]	Act now	Available	Partnership Toi Mai, DIA NZTech IT Professionals	Existing workstream
3.4 Aggregate demand for climate tech related skills (beyond digital workforce planning).[119]	Plan for soon	Available	Partnership MBIE NZTech	Adaptation of existing workstream
3.5 Engage in coordinated and collaborative efforts to attract rangatahi toward critical future skills required to support climate technologies.[120]	Consider for later	New	Partnership MBIE, MoE, MfE NZTech	Adaptation of existing workstream
3.6 Instigate programs to develop and retain our best scientists so that they are available for our deep tech startups.[121]	Consider for later	New	MBIE	Reprioritisation may be required

Impact Assessment Example

Digital technology in particular is an enabler of a variety of actions that could collectively reduce up to 7.2 Mt of annual emissions by 2030 – equivalent to 42% of Aotearoa's emissions budget targets.[122] Digital skills shortages are likely to limit our ability to achieve this. The NZTech Digital Skills Report 2023 states that if New Zealand does not improve the digital skills of its workforce, it will continue to experience low levels of productivity - which will continue to impact the country's emissions reduction effectiveness.[123]

Impact of skills shortages on emissions reduction requires further assessment as part of the Climate Technology Roadmap development.

Table 4 - Examples of Finance Foundation Opportunities

ACTION	HORIZON	AVAILABILITY	WHO	RESOURCING
4.1 Increase support for NZGCP and build investor capability.	**Act now**	**Available**	**Partnership** NZGCP Angel Assn. Callaghan.	Reprioritisation may be required
4.2 Increase engagement with international investors.[124]	**Act now**	**Available**	**Partnership** NZTE Business Councils	Adaptation of existing workstream
4.3 Increase funding and incentives for R&D into climate technologies.[125]	**Act now**	**Available**	MBIE Callaghan.	Reprioritisation may be required
4.4 Explore contestable non-dilutive funding streams for startups.[126]	Plan for soon	New	MBIE Angel Assn	Reprioritisation may be required
4.5 Explore how to further encourage and support the finance sector to deploy funding for decarbonization initiatives.	Consider for later	New	MBIE	Reprioritisation may be required
4.6 Explore tax incentives for climate technologies. [127]	Consider for later	New	MBIE, IR Callaghan.	Reprioritisation may be required

Table 5 - Examples of Incubation Foundation Opportunities

ACTION	HORIZON	AVAILABILITY	WHO	RESOURCING
5.1 Develop physical spaces set up for pilot plant development in a 'plug and play' manner.[128]	**Act now**	New	**Partnership** MBIE CRIs Outset Ventures	Reprioritisation may be required
5.2 Build collaboration across clusters where the country has a current advantage, foundation or aptitude for example AgriFood and Energy & Materials.[129]	**Act now**	New	**Partnership** MBIE NZTech AgriTechNZ	Adaptation of existing workstream
5.3 Undertake more deliberate co-location focused on Climate Tech, iterating on the high collaboration model pioneered in Wynyard Quarter/GridAKL.[130]	Plan for soon	New	**Partnership** MBIE Tātaki Auckland Unlimited	Reprioritisation may be required
5.4 Develop an organisation (Accelerate Aotearoa) responsible for supporting new emerging sectors like Climate Tech.[131]	Plan for soon	New	MBIE	Reprioritisation may be required

Table 6 – Examples of Uptake Foundation Opportunities

ACTIONS	HORIZON	AVAILABILITY	WHO	RESOURCING
6.1 Review the current ITP recommendations for improving technology adoption, especially the AgriTechNZ adoption report.	**Act now**	**Available**	**Partnership** MBIE AgriTechNZ	Adaptation of existing workstream
6.2 Promote New Zealand technology solutions more strongly for New Zealand use.	**Act now**	**Available**	**Partnership** MBIE Callaghan NZTech	Reprioritisation may be required
6.3 Stimulate private sector involvement, collaboration, and funding for technology development and implementation to boost uptake.	**Act now**	New	MBIE Callaghan	Reprioritisation may be required
6.4 Identify key climate technologies not covered by Industry Transformation Plans as priorities for integration into the ITP work programmes.	Plan for soon	New	Partnership MBIE NZTech	Adaptation of existing workstream

Impact Assessment Example

Digital technology in particular is an enabler of a variety of actions that could collectively reduce up to 7.2 Mt of annual emissions by 2030 – equivalent to 42 percent of Aotearoa's emissions budget targets.[132] Another study has found that using cloud technology is as much as 93 percent more energy efficient and as much as 98 percent more carbon efficient than on-premises solutions.[133]

Impact of increased uptake of digital technologies on emissions reduction requires further assessment as part of the Climate Technology Roadmap development.

Table 7 - Examples of R&D Commercialisation Foundation Opportunities

ACTIONS	HORIZON	AVAILABILITY	WHO	RESOURCING
7.1 Improve the market validation for publicly-funded and business-led R&D.[134]	Act now	Available	MBIE, CRIs, KiwiNet	Reprioritisation may be required
7.2 Improve monitoring of the progress and outcomes of publicly-funded R&D. [135]	Act now	Available	MBIE	New funding may be required
7.3 Consider additional incentives for innovative research with commercial outputs to further motivate researchers to be more invested in commercialisation activities.	Plan for soon	Available	MBIE	New funding may be required
7.4 Develop new guidelines to inform emissions reductions technology decision-making using a focus on processes and tools that ensures the broader application of evidence.	Consider for later	New	MfE	New funding may be required

Table 8 – Examples of Infrastructure Foundation Opportunities

ACTIONS	HORIZON	AVAILABILITY	WHO	RESOURCING
8.1 Invest in building capability across Government agencies to improve the ability to utilise infrastructure data effectively.	**Act now**	**Available**	MBIE	Reprioritisation may be required
8.2 Ongoing development of metadata standards for infrastructure need to be properly resourced and implemented.[136]	**Act now**	**Available**	MBIE	Reprioritisation may be required
8.3 Resolve the existing barriers to scaling up vehicle charging infrastructure.[137]	Plan for soon	New	MoT	New funding may be required
8.4 Develop ways to encourage and support the uptake of zero emissions commercial vehicles including vans, utes, and trucks.	Plan for soon	New	MoT	New funding may be required
8.5 Integrate digital infrastructure into the next national Climate Change Risk Assessment and in the long-term Climate Adaptation Plan.[138]	Consider for later	New	MfE	Reprioritisation may be required

Table 9 - Examples of Regulatory and Policy Making Foundation Opportunities

ACTIONS	HORIZON	AVAILABILITY	WHO	RESOURCING
9.1 Address barriers and better align regulations which support technological advancements in the Government's emissions reductions agenda.	Act now	Available	MBIE	Reprioritisation may be required
9.2 Urgently review legacy regulations governing the Commerce Commission, particularly in energy, to align them with New Zealand's emissions reductions requirements.[139]	Act now	Available	MBIE	Reprioritisation may be required
9.3 Develop a regulatory "sandbox" approach to reduce barriers to more readily pilot and demonstrate new technologies.[140]	Plan for soon	New	MBIE	New funding may be required
9.4 More clearly define what "climate investment" is to facilitate greater finance sector investment.	Plan for soon	New	MBIE, Treasury	Reprioritisation may be required

Table 10 – Examples of Data as an Enabler Opportunities

ACTIONS	HORIZON	AVAILABILITY	WHO	RESOURCING
10.1 Develop a national environmental open data framework.	**Act now**	**Available**	**Partnership** MfE, StatsNZ, MBIE, Industry	Adaptation of existing workstream
10.2 Coordinate the development of standards and best practices for environmental data management.	**Act now**	**Available**	**Partnership** MfE AI Forum NZTech	Adaptation of existing workstream
10.3 Within the Customer and Product Data legislation, accelerate the introduction of Open Banking and fast track the extension to Open Data across multiple sectors.	**Act now**	**Available**	MBIE	Reprioritisation may be required
10.4 Review education and training programs to ensure sufficient data professionals are able to be developed as demand increases.	Plan for soon	**Available**	**Partnership** MBIE, TEC NZTech IT Professionals	Adaptation of existing workstream
10.5 Consider an environmental open data regulatory sandbox bringing together cross-sectoral data sources to stimulate innovation.	Consider for later	New	MBIE	New funding may be required

Table 11 – Examples of IoT as an Enabler Opportunities

ACTIONS		HORIZON	AVAILABILITY	WHO	RESOURCING
11.1	Resource an improved second Mobile Showcase that encompasses the use of IoT and sensors for Manufacturing 4.0 to address productivity and emissions reduction.[141]	Act now	Available	Partnership Callaghan IoT Alliance Industry	Adaptation of existing workstream
11.2	Accelerate rural internet connectivity options including satellite and 5G to enable increased precision ag.	Act now	Available	Partnership	New funding may be required

Impact Assessment Example

Sensors and IoT provide crucial data capturing that can enable decision making leading to reduced emissions. For example, it has been calculated that better use of robotics and smart sensors on New Zealand farms could improve animal health and productivity creating 0.24 Mt of annual emissions reductions.[142]

Impact of better use of sensors and IoT on emissions reduction requires further assessment as part of the Climate Technology Roadmap development.

Table 12 – Examples of AI as an Enabler Opportunities

ACTIONS		HORIZON	AVAILABILITY	WHO	RESOURCING
12.1	Increase collaboration across the AI for the environment ecosystem between AI experts and environmental experts.	Act now	Available	Partnership MfE AI Forum	New funding may be required
12.2	Identify opportunities to deploy AI to enhance environmental data collection, monitoring and reporting.	Plan for soon	Available	MfE	New funding may be required
12.3	Target funding to accelerate AI for the environment uptake.	Plan for soon	New	MBIE	Reprioritisation may be required

Table 13 - Examples of Māori Tech as an Enabler Opportunities

ACTIONS	HORIZON	AVAILABILITY	WHO	RESOURCING
13.1 Establish Māori leadership and co-design principles into further Roadmap development.	Act now	Available	Partnership Te Matarau, DILG, Te Mana Raraunga MBIE, MfE	Adaptation of existing workstream
13.2 Ensure climate data is included in ongoing discussions about Māori data governance.	Act now	Available	Partnership DILG StatsNZ	Adaptation of existing workstream
13.3 Identify ways to support and accelerate Māori innovation and tech sector growth, with a focus on climate tech innovation.	Act now	New	Partnership Te Matarau MBIE	New funding may be required

Table 14 – Examples of Agriculture Sector Opportunities

ACTIONS	HORIZON	AVAILABILITY	WHO	RESOURCING
14.1 Align the Agritech Industry Transformation plan with emission reduction plan priorities to leverage and enhance work underway to grow New Zealand agritech exports.	**Act now**	New	**Partnership** MBIE AgriTechNZ	Adaptation of existing workstream
14.2 Align the proposed Agritech Opportunity Hub, an initiative to enable matching of international opportunities with the local agritech ecosystem, with climate tech needs.	Plan for soon	**Available**	**Partnership** MBIE AgriTechNZ	Adaptation of existing workstream
14.3 Develop a national technology platform view for agritech, including climate tech, outlining where expertise, equipment and support exists and how it can be accessed, along with a roadmap for further development.	Plan for soon	New	**Partnership** MBIE AgriTechNZ	Adaptation of existing workstream
14.4 Invest in bringing some of the best scientists in the world working on animal created methane emissions to New Zealand and ensuring that our regulatory framework allows them to do world leading science.	Consider for later	New	MBIE Callaghan	New funding may be required
14.5 Develop a world class research campus, that co-locates all our climate science capability in a single facility that can host the international teams.	Consider for later	New	MBIE	New funding may be required
14.6 Fund and develop technologies that are tailored specifically for its farming business model and conditions such as GMO pastures that can help reduce methane emissions from cows.	Consider for later	New	MPI MBIE	New funding may be required

Impact Assessment

Digital technology is an enabler of a variety of actions that could collectively reduce up to 1.9 Mt of annual emissions from the agri-sector by 2030. For example, the use of precision ag to monitor nitrogen and reduce fertiliser application.[143] Not included in this assessment has been the use of sensors on-farm for environmental monitoring, which deserves further assessment.

Impact of a broader view of technology on emissions reduction across the agri-sector requires further assessment as part of the Climate Technology Roadmap development.

Table 15 - Examples of Energy Sector Opportunities

ACTIONS	HORIZON	AVAILABILITY	WHO	RESOURCING
15.1 Undertake an urgent review of energy regulations and refresh to enable innovation and adoption of new technologies.	Act now	Available	MBIE	Adaptation of existing workstream
15.2 Introduce incentives for household energy consumers to purchase more energy efficient upgrades and appliances. [144]	Act now	New	MBIE	New funding may be required
15.3 Review existing legislation for CCUS to ensure fit for purpose and that appropriate incentives are in place to drive relevant industrial uptake in New Zealand.	Plan for soon	New	MBIE	Adaptation of existing workstream
15.4 Introduce incentives for bi-directional charging uptake in households so EVs can power homes in off peak times.[145]	Plan for soon	New	MBIE	New funding may be required
15.5 Establish a microgrid framework to alleviate grid strain and leverage public infrastructure, mandate public sector use of renewable energy. [146]	Plan for soon	New	MBIE	New funding may be required
15.6 Encourage/support increased renewable energy production with a focus on scalable renewable energy.	Consider for later	Available	MBIE	New funding may be required
15.7 Research viability for new low-cost, zero-emission industrial heat and power converters such as the Rondo Heat Battery.[147]	Consider for later	Available	MBIE	Adaptation of existing workstream

Impact Assessment

Digital technology is an enabler of a variety of actions that could collectively reduce up to 2.4 Mt of annual emissions from the energy sector by 2030. For example, grid load smoothing, smart automated buildings and centralising digital infrastructure.[148] Not included in this assessment are the impacts of new energy production and other systemic changes noted above.

Impact of a broader view of technology on emissions reduction across the energy sector requires further assessment as part of the Climate Technology Roadmap development.

Table 16 - Examples of Transport Sector Opportunities

ACTIONS	HORIZON	AVAILABILITY	WHO	RESOURCING
16.1 Prioritise increase in EV infrastructure in urban centres to address EV uptake constraints.	Act now	Available	MoT	Adaptation of existing workstream
16.2 Promote the adoption of electric vehicles and establish EV charging stations, as well as incentivizing the use of sustainable fuels for long-distance transportation.	Act now	Available	MBIE MoT	Existing workstream
16.3 Start a work programme to update legacy system traffic signals with new transport technology.	Act now	Available	MoT	New funding may be required
16.4 Expand Mobility-as-a-Service (MaaS) transport aggregation software pilots to improve current traffic network utilisation and promote less carbon intensive travel formats.	Act now	Available	Transport TLAs	New funding may be required
16.5 Encourage/support the trucking industry to install devices that bolt onto any tractor-trailer model to filter carbon emissions directly from the truck's tailpipe and capture 80% of emissions.	Plan for soon	Available	Partnership MBIE Industry	New funding may be required
16.6 An increased focus over the next 2 years on increasing alternative/biofuels use.	Plan for soon	Available	Govt - MBIE	New funding may be required
16.7 Encourage/support the use of smart chargers and solar panels to optimise the energy grid.	Plan for soon	Available	Govt - MBIE	New funding may be required
16.8 Improve optimisation of light/medium commercial vehicles in urban centres and increase EV-switch incentives.	Consider for later	New		New funding may be required

Impact Assessment

Digital technology is an enabler of a variety of actions that could collectively reduce up to 2.9 Mt of annual emissions from the transport sector by 2030. For example, fleet optimisation and accelerating EV transition by enabling rural connectivity and smart charging infrastructure.[149] Not included in this assessment are the impacts of mobility as a service and some of the other recommendations included above.

Impact of a broader view of technology on emissions reduction across the transport sector requires further assessment as part of the Climate Technology Roadmap development.

Methodology

NZTech Survey

NZTech undertook an online survey in February 2023 to gather insights into perspectives on the need for technology to support emissions reduction in New Zealand. The survey was distributed via multiple channels including the NZTech national member and followers database, and out via other association and agency networks.

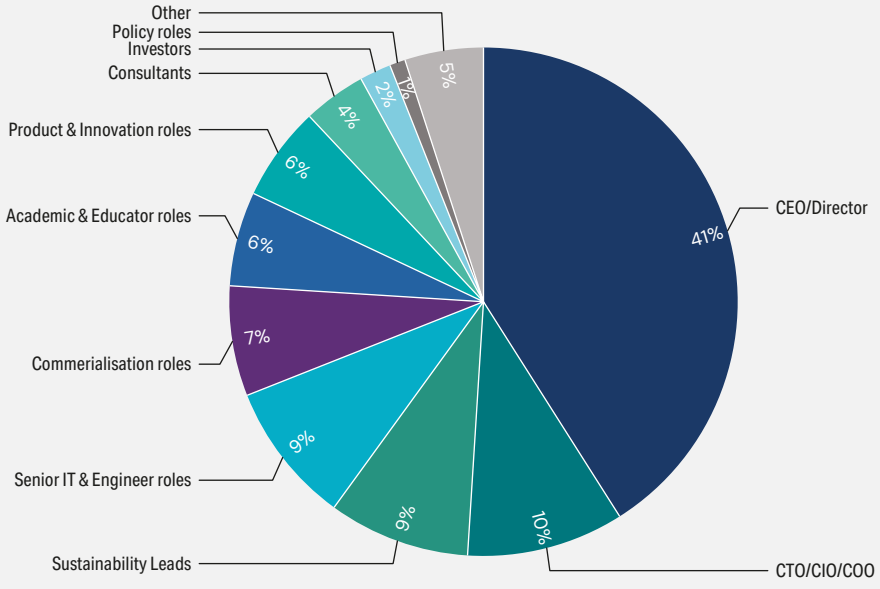
The Technology and Emissions Reduction survey received 267 responses of which 148 completed the survey and provided detailed insights.

More than half of the respondents were C-level executives including the CEO's, Founders and directors of large and small organisations. As shown in Figure 14 the respondents also included sustainability leads, commercialisation leads, academics, consultants and investors.

Survey & Sprint Participants

Participants from 170 organisations across multiple sectors and agencies participated in this research. The following table indicates the breadth of people and organisations involved. We thank them for their time and insights.

Figure 14 - Technology and Emissions Reduction Survey Demographics



Source: Technology and Emissions Reduction Survey, NZTech. February 2023

Table 17 – Organisations that participated in the research

AbacusBio
academyEX
Accel Technologies
Addressfinder
AFT Pharmaceuticals
Again Again
AgInnovate NZ
AgritechNZ
AI Forum
Air New Zealand
Angel Association NZ
Anne French Consulting
ANZ New Zealand
Applied Support Services
Ara Ake
Argus Tracking
AROTEC Diagnostics
ASB Bank
Aspiring Materials
Auckland Business Chamber
Auckland Chamber
AUT Ventures
Avertana
AWS
b.spkl
Biomass Solutions
Biome Trust
BioTechNZ
BNZ Bank
Bonafide
Brightly
Callaghan Innovation
Captivate Technology
Catalist Markets Limited
Centre for Innovation & Entrepre.
Cetogenix
CheekyLittle Monkey
CiRCLR
Clarity Advisory
Cogo
Concentrate
Creatives for climate
Critchlow + Associates
Dairy Technology Services
Datacom
DecarbonNZ
Deloitte
DETA Consulting
Digital Identity NZ
DURIE HILL
Ecosytm
Edmund Hillary Fellowship
EMA
Embrink
ERM
ESP
FeatureIT
Finappster
FinTechNZ
Fomana Capital
Forsyth Barr
Frankie Technologies
Genesis Energy
Gentrack Global
GoSee
GrowPay
Grundy Executive
Hi-Tech Packaging
HMI Technologies
HSBC Asset Management
HVP
Hydroxsys
iLEX Consulting Group
Independent entrepreneur
InsurTechNZ
Intelligensia
Intuit Regulatory
IoT Taranaki
Kernel Wealth
Kerr Consulting
Kiwibank
KiwiNet
KPMG
Logic group
Long White Cloud Genetics
MacDiarmid Institute
Map of Agriculture NZ
Maslow
Matū Group
Merkle Aotearoa
Method Recycling
Microchip Technology
Microsoft
Mindful Money
Ministry of Foreign Affairs & Trade
Mosaic FSI
MPI
NanoLayr
NZ Geothermal Assoc.
North Ridge Partners
NZ Green Investment Finance
NZSPL
NZTA
NZTE
NZTech
Open Parallel
Opinio Native Aotearoa
Our Energy
Overseer
Pacific Channel
Pastoral Robotics
PaymentsNZ
Plant & Food
Platform8
Precycle nz
Proxi
PwC
Raizor NZ
RBNZ
RegTechNZ
RIPA Global
ROBOS
Rock Stack Innovation
Sandfield Associates
Serviceworks
Shane Kerr Consulting
SilverLining
Slow Farm
Smart Māra
SmartTrade
Spark
Sparks Interactive
St Paul's Collegiate School
Startup Advisors Council
Statestreet
Sustainable Business Council
Sustainable Business Network
Sweeney advisors
Sydney University
Tait Communications
Taitaki Auckland Unlimited
Te Puna Whakaaronui
Techemy
TechWomen
TestItd
The Aotearoa Circle
The University of Waikato
Thinkstep
Toha Tech
Centre for Sustainable Finance
TradeWindow
UBCO
Ubiqetherm
UniVentures
University of Auckland
University of Canterbury
University of Waikato
Upflow
Utecture
Vector
Ventana Venture Studio
Vital
Webtools Agritech
Wellington High School
Wellington Univentures
WellingtonNZ
Wharf42
Wise Management Services
XR Pharmaceuticals
Ziptrek Ecotours

Source: Technology and Emissions Reduction Surveys and Sprints, NZTech. 2022–2023

Aligning to Capitals Model

The Capitals are stocks of value that are affected or transformed by the activities and outputs of an organisation or country.

In October 2021 the New Zealand Treasury launched their Living Standards Framework[150] which is underpinned by the Four Capitals Model - financial/physical, natural, human and social. These Capitals are interlinked and constantly changing. Together, they all directly impact New Zealand's wellbeing.

There is also momentum across large businesses towards reporting against Capitals. The Integrated Reporting Foundation describes Six Capitals that organisation business models draw upon as various capital inputs and shows how the organisation's activities transform them into outputs.[151]

The key to the Capitals Models is achieving the balance between inputs and outputs to create broader positive outcomes than simply financial.

The proposed Framework was developed based on direct input from our primary research. We then cross-checked it against the Capitals Models to ensure there were no major gaps.

Table 18 - Cross-checking Framework against Capitals Models

INTEGRATED REPORTING SIX CAPITALS	THE TREASURY FOUR CAPITALS	FRAMEWORK CRITICAL FOUNDATIONS
Manufactured	Financial/Physical	Infrastructure
Financial		Finance
Intellectural		R&D commercialistation
Social & Relationship	Social	Coordination & leadership Industry Partnership Regulation Uptake
Human	Human	Skills Incubation
Natural	Natural	The Outcome – emissions reduction

Source: Adapted from The Treasury and Integrated Reporting Foundation, NZTech 2023

References

1 Climate Change Implications for New Zealand, Royal Society Te Aparangi, 2016. https://www.royalsociety.org.nz/what-we-do/our-expert-advice/all-expert-advice-papers/climate-change-implications-for-new-zealand

2 Climate change: New Zealand 'no longer on track' to meet climate goals - officials. NZ Herald, October 2023. https://www.nzherald.co.nz/nz/politics/climate-change-new-zealand-no-longer-on-track-to-meet-climate-goals-officials/6GYWPR263VA5FI2XZFXQ3NK3JI/

3 How New Zealand compares to other countries, Ministry for the Environment, New Zealand Government. April 2021. https://environment.govt.nz/publications/new-zealands-greenhouse-gas-inventory-1990-2019-snapshot/how-new-zealand-compares-to-other-countries/

4 Aotearoa New Zealand's Turning Point, Deloitte. March 2023. https://www2.deloitte.com/content/dam/Deloitte/nz/Documents/about-deloitte/nz-turning-point-report.pdf

5 Predicted Distributional Impacts of Climate Change Policy on Employment, Motu. June 2021. https://motu-www.motu.org.nz/wpapers/21_07.pdf

6 Aotearoa New Zealand's Turning Point, Deloitte. March 2023. https://www2.deloitte.com/content/dam/Deloitte/nz/Documents/about-deloitte/nz-turning-point-report.pdf

7 He huringa āhuarangi, he huringa ao: a changing climate, a changing world, Ngā Pae o te Māramatanga (NPM) and Manaaki Whenua – Landcare Research. October 2021. https://www.landcareresearch.co.nz/news/release-of-te-ao-maori-climate-change-report/

8 COP27: Tech's role in achieving net zero. McKinsey & Company. November 2022. https://www.mckinsey.com/featured-insights/themes/cop27-techs-role-in-achieving-net-zero

9 Technology and the UNFCCC, Building the foundation for sustainable development. United Nations. June 2016. https://unfccc.int/ttclear/misc_/StaticFiles/gnwoerk_static/NAD_EBG/54b3b39e25b84f96aeada52180215ade/b8ce50e79b574690886602169f4f479b.pdf

10 Australia has raised its climate targets and now needs to accelerate its clean energy transition, says new IEA review. International Energy Agency. April 2023. https://www.iea.org/news/australia-has-raised-its-climate-targets-and-now-needs-to-accelerate-its-clean-energy-transition-says-new-iea-review

11 Meeting the climate challenge through digital technology, Spark and thinkstep-anz. November 2022. https://www.thinkstep-anz.com/assets/Whitepapers-Reports/meeting-the-climate-challenge-through-digital-technology.pdf

12 GeSI SMARTer 2020: The Role of ICT in Driving a Sustainable Future, Global e-Sustainability Initiative. December 2020.http://twosides.info/includes/files/upload/files/UK/Myths_and_Facts_2016_Sources/14-15/GeSI_SMARTer2020_The_Role_of_ICT_in_Driving_a_Sustainable_Future_2015.pdf

13 Ngā Kōrero Āhuarangi Me Te Ōhanga Climate Economic and Fiscal Assessment 2023. The Treasury and the Ministry for the Environment. April 2023 https://www.treasury.govt.nz/sites/default/files/2023-04/cefa23.pdf

14 Technology and Emissions Reduction Survey, NZTech. February 2023

15 Technologies Role in Emissions Reduction Survey, Supporting content for NZTech's Transitioning to a low-emissions and climate-resilient future submission, NZTech. October 2021. https://nztech.org.nz/wp-content/uploads/sites/8/2021/11/NZTech-ERP-Submission-PDF.pdf

16 Ināia tonu nei: a low emissions future for Aotearoa, Climate Change Commission. May 2021. https://www.climatecommission.govt.nz/public/Inaia-tonu-nei-a-low-emissions-future-for-Aotearoa/Inaia-tonu-nei-a-low-emissions-future-for-Aotearoa.pdf

17 "Tech snub in emissions targets an 'oversight' - Shaw", NZ Herald. November 2022. https://www.nzherald.co.nz/business/tech-snub-in-emissions-targets-an-oversight-shaw/3US6EAGNAFFJ3FDKIXE5GJRAQM/

18 New Zealand firms: Reaching for the frontier, Productivity Commission. April 2021. https://www.productivity.govt.nz/assets/Documents/Final-report-Frontier-firms.pdf

19 New Zealand Policies and Action, Climate Action Tracker. March 2023. https://climateactiontracker.org/countries/new-zealand/#:~:text=New%20Zealand's%20NDC%20target%20is,its%20climate%20finance%20is%20inadequate.

20 Climate Tech Intelligence Report, Deloitte. Developed for the Ministry of Business, Innovation and Employment. August 2023.

21 The Core Climate Technologies: How to Understand and Deploy Innovation, Deloitte. July 2022. https://deloitte.wsj.com/articles/the-core-climate-technologies-how-to-understand-and-deploy-innovation-01666803522

22 Ibid.

23 New Zealand Climate Tech for the World, Clean-Tech Group, Callaghan Innovation and Auckland Unlimited. July 2021. https://www.callaghaninnovation.govt.nz/sites/all/files/NZ_Climate_Tech_For_The_World_report.pdf

24 New Zealand Climate Tech for the World, Clean-Tech Group, Callaghan Innovation and Auckland Unlimited. July 2021. https://www.callaghaninnovation.govt.nz/sites/all/files/NZ_Climate_Tech_For_The_World_report.pdf

25 Climate Tech Intelligence Report, Deloitte. Developed for the Ministry of Business, Innovation and Employment. August 2023.

26 Network Readiness Index - New Zealand 2022, Portland Institute. https://networkreadinessindex.org/country/new-zealand/

27 Technology Roadmap Development, Acqnotes. https://acqnotes.com/acqnote/tasks/technology-roadmap

28 Building an integrated technology road map to drive successful innovation, McKinsey & Company. February 2017. https://www.mckinsey.com/capabilities/operations/our-insights/building-an-integrated-technology-road-map-to-drive-successful-innovation

29 How ministers and officials developed the first emissions reduction plan —and how to do it better next time. Parliamentary Commissioner for the Environment. September 2023. https://pce.parliament.nz/media/s4bdv45l/how-ministers-and-officials-developed-the-first-emissions-reduction-plan.pdf

30 Environment Aotearoa 2022. Ministry for the Environment. April 2022. https://environment.govt.nz/news/latest-state-of-the-environment-report-released/

31 Energy Technology Roadmaps - a guide to development and implementation, International Energy Agency, 2014. https://iea.blob.core.windows.net/assets/ca7594aa-1de1-4a3a-a531-121238ef5efb/TechnologyRoadmapAguidetodevelopmentandimplementation.pdf

32 Building an integrated technology road map to drive successful innovation, McKinsey & Company. February 2017. https://www.mckinsey.com/capabilities/operations/our-insights/building-an-integrated-technology-road-map-to-drive-successful-innovation

33 Technology and Emissions Reduction Survey, NZTech. June 2023

34 Public Transport 2045, Ministry of Transport. November 2018. https://www.knowledgehub.transport.govt.nz/assets/TKH-Uploads/TKC-2018/Public-Transport-2045.pdf

35 International Technology Scan - Alternative Technologies for Process Heat, Energy Efficiency and Conservation Authority. November 2019. https://www.eeca.govt.nz/insights/eeca-insights/international-tech-scan

36 New Zealand Climate Tech for the World, Clean-Tech Group, Callaghan Innovation and Auckland Unlimited. July 2021. https://www.callaghaninnovation.govt.nz/sites/all/files/NZ_Climate_Tech_For_The_World_report.pdf

37 https://www.callaghaninnovation.govt.nz/technology-and-product-development/new-zealand-cleantech-mission

38 Satu et al, Transition co-design dynamics in high level policy processes, Design Studies, Volume 88, 2023. https://www.sciencedirect.com/science/article/pii/S0142694X23000480

39 GeSI SMARTer 2020: The Role of ICT in Driving a Sustainable Future, Global e-Sustainability Initiative. December 2020. http://twosides.info/includes/files/upload/files/UK/Myths_and_Facts_2016_Sources/14-15/GeSI_SMARTer2020_The_Role_of_ICT_in_Driving_a_Sustainable_Future_2015.pdf

40 Evaluating the carbon reducing impacts of ICT: An assessment methodology. Global e-Sustainability Initiative. September 2010.

41 #SMARTer2030 ICT Solutions for 21st Century Challenges. Global e-Sustainability Initiative, 2015. https://smarter2030.gesi.org/downloads/Full_report.pdf

42 Meeting the climate challenge through digital technology, Spark and thinkstep-anz. November 2022. https://www.thinkstep-anz.com/assets/Whitepapers-Reports/meeting-the-climate-challenge-through-digital-technology.pdf

43 Climate Economic and Fiscal Assessment 2023. Treasury and the Ministry for the Environment. April 2023. https://www.treasury.govt.nz/sites/default/files/2023-04/cefa23.pdf

44 These costs exclude areas such as transport infrastructure and on-farm emissions reductions.

45 Regulatory systems and stewardship, Ministry of Business, Innovation and Employment. Accessed August 2023. https://www.mbie.govt.nz/cross-government-functions/regulatory-stewardship/regulatory-systems

46 Get to grips with the six capitals, Integrated Reporting Foundation.2023. https://www.integratedreporting.org/what-the-tool-for-better-reporting/get-to-grips-with-the-six-capitals/

47 Just Transition, Ministry of Business, Innovation and Employment. https://www.mbie.govt.nz/business-and-employment/economic-development/just-transition/

48 National digital transformation strategy – mapping the digital journey, The World Bank. July 2023. https://digitalregulation.org/national-digital-transformation-strategy-mapping-the-digital-journey

49 Collaboration and Engagement, World Bank Annual Report, 2022. https://www.worldbank.org/en/about/annual-report/collaboration-engagement

50 New Zealand Government Procurement Business Survey 2021. Ministry of Business, Innovation and Employment. December 2021. https://www.procurement.govt.nz/assets/procurement-property/documents/2021-business-survey-report-government-procurement.pdf

51 Energy Technology Roadmaps - a guide to development and implementation, International Energy Agency, 2014. https://iea.blob.core.windows.net/assets/ca7594aa-1de1-4a3a-a531-121238ef5efb/TechnologyRoadmapAguidetodevelopmentandimplementation.pdf

52 New Zealand Climate Tech for the World, Clean-Tech Group, Callaghan Innovation and Auckland Unlimited. July 2021. https://www.callaghaninnovation.govt.nz/sites/all/files/NZ_Climate_Tech_For_The_World_report.pdf

53 Industry Transformation Plans, Ministry of Business, Innovation and Employment. https://www.mbie.govt.nz/business-and-employment/economic-development/industry-policy/industry-transformation-plans/

54 Future of Jobs Report 2023, World Economic Forum. May 2023. https://www3.weforum.org/docs/WEF_Future_of_Jobs_2023.pdf

55 Digital Skills for Tomorrow, Today. Digital Skills Aotearoa Edition 3, NZTech. August 2023. https://nztech.org.nz/wp-content/uploads/sites/8/2023/08/NZTech-Digital-Skills-Report_final.pdf

56 Discussion paper – Support for industry scale-up of research spinouts and pilot plant development, Macdiarmid Institute. July 2021.

57 Digital Skills for Tomorrow, Today. Digital Skills Aotearoa Edition 3, NZTech. August 2023. https://nztech.org.nz/wp-content/uploads/sites/8/2023/08/NZTech-Digital-Skills-Report_final.pdf

58 Chapter 6 - Funding and Finance, Aotearoa New Zealand's first emissions reduction plan, Ministry for the Environment, New Zealand Government. May 2022. https://environment.govt.nz/assets/Emissions-reduction-plan-chapter-6-funding-and-finance.pdf

59 New Zealand Climate Tech for the World, Clean-Tech Group, Callaghan Innovation and Auckland Unlimited. July 2021. https://www.callaghaninnovation.govt.nz/sites/all/files/NZ_Climate_Tech_For_The_World_report.pdf

60 The Well Being Budget 2023, New Zealand Government. May 2023 https://budget.govt.nz/budget/2023/wellbeing/climate-change/commitments.htm

61 First of its kind climate fund to back 100% renewable electricity, Beehive.govt.nz. August 2023. https://www.beehive.govt.nz/release/first-its-kind-climate-fund-back-100-renewable-electricity

62 Upstart Nation, Startup Advisory Council. August 2023. https://www.mbie.govt.nz/dmsdocument/27179-upstart-nation

63 Ibid.

64 waterNext. https://foresightcac.com/waternext

65 Update to the Founder Incubator and Accelerator Programmes, Ministry of Business, Innovation and Employment. January 2022. https://www.mbie.govt.nz/dmsdocument/18519-update-to-the-founder-incubator-and-accelerator-programmes-proactiverelease-pdf

66 Discussion paper – Support for industry scale-up of research spinouts and pilot plant development, Macdiarmid Institute. July 2021.

67 Advanced Manufacturing Draft Industry Transformation Plan, Ministry of Business, Innovation and Employment. June 2022. https://www.mbie.govt.nz/dmsdocument/21243-advanced-manufacturing-draft-industry-transformation-plan

68 Baseline of Digital Adoption in Primary Industries, AgriTechNZ. August 2022. https://agritechnz.org.nz/resources/download-the-2022-agritechnz-baseline-of-digital-adoption-in-primary-industries-report

69 Technology and Emissions Reduction Survey, NZTech. June 2023

70 Strategies for Managing the Barriers to Technology Adoption, CPA Australia. https://www.cpaaustralia.com.au/-/media/project/cpa/corporate/documents/barriers-to-tech-report.pdf

71 New Zealand 2023 Energy Policy Review. International Energy Agency. April 2023. https://iea.blob.core.windows.net/assets/124ce0b0-b74e-4156-960b-bba1693ba13f/NewZealand2023.pdf

72 New Zealand Research Commercialisation Practice in Real Life, KiwiNet, 2021. https://kiwinet.org.nz/files/KiwiNet-Real-Life-Practices-Report-2021.pdf

73 Research and development survey: 2022. Statistics New Zealand. April 2023. https://www.stats.govt.nz/information-releases/research-and-development-survey-2022

74 Productivity by the numbers. Productivity Commission. July 2023. https://www.productivity.govt.nz/assets/PBTN-2023-digital-final-3-July.pdf

75 New Zealand Climate Tech for the World, Clean-Tech Group, Callaghan Innovation and Auckland Unlimited. July 2021. https://www.callaghaninnovation.govt.nz/sites/all/files/NZ_Climate_Tech_For_The_World_report.pdf

76 Ibid.

77 2023 Draft advice to inform the strategic direction of the Government's second emissions reduction plan. Climate Change Commission. April 2023. https://www.climatecommission.govt.nz/public/Advice-to-govt-docs/ERP2/draft-erp2/CCC4940_Draft-ERP-Advice-2023-P02-V02-web.pdf

78 Infrastructure New Zealand Position Paper: Digital, Infrastructure New Zealand. August 2023. https://infrastructure.org.nz/wp-content/uploads/2023/08/Infrastructure-NZ-Policy-Postions-Digital.pdf

79 Rautaki Hanganga o Aotearoa New Zealand Infrastructure Strategy 2022 - 2052, New Zealand Infrastructure Commission, 2022 https://media.umbraco.io/te-waihanga-30-year-strategy/kOhnqufg/rautaki-hanganga-o-aotearoa.pdf

80 Systems Thinking: A new approach to minimum energy performance standards. Energy Efficiency and Conservation Authority. April 2020. https://www.eeca.govt.nz/assets/EECA-Resources/Research-papers-guides/Systems-thinking_A-new-approach-to-minimum-energy-performance-standards.pdf

81 How can data drive carbon reduction in the supply chain? European Commission. February 2023. https://data.europa.eu/en/news-events/news/how-can-data-drive-carbon-reduction-supply-chain

82 AWS sponsors Toitū Te Whenua – Land Information NZ to upload geospatial imagery. Reseller News, September 2023. https://www.

reseller.co.nz/article/708716/aws-sponsors-toit-te-whenua-land-information-nz-upload-geospatial-imagery

83 The Kiwi leading the carbon crunch. NZ Herald, 2023. https://www.nzherald.co.nz/sponsored-stories/the-kiwi-leading-the-carbon-crunch/AG5TWLINPRFBJEZATGWMW3MQJA

84 Govt to speed up 5G rollout to regional towns. Beehive Release. New Zealand Government. May 2023. https://www.beehive.govt.nz/release/govt-speed-5g-rollout-regional-towns

85 Meeting the climate challenge through digital technology, Spark and thinkstep-anz. November 2022. https://www.thinkstep-anz.com/assets/Whitepapers-Reports/meeting-the-climate-challenge-through-digital-technology.pdf

86 AI for the Environment in Aotearoa New Zealand, AI Forum of New Zealand. May 2022. https://aiforum.org.nz/wp-content/uploads/2022/05/AI-for-the-Environment-Report-2022-1.pdf

87 Te Taiao - Māori and the natural world, Bateman Books, 2010.

88 Toi Hangarau - A Report on Māori Owned Technology Companies, 2023. Puau Interface. July 2023. https://publuu.com/flip-book/75621/226497/page/1

89 Meeting the climate challenge through digital technology, Spark and thinkstep-anz. November 2022. https://www.thinkstep-anz.com/assets/Whitepapers-Reports/meeting-the-climate-challenge-through-digital-technology.pdf

90 Pee is for precision when using a targeted fertiliser system. Farmers Weekly. July 2023. https://www.farmersweekly.co.nz/technology/pee-is-for-precision-when-using-a-a-targeted-fertiliser-system/

91 https://www.ruminantbiotech.com/our-solution

92 Meeting the climate challenge through digital technology, Spark and thinkstep-anz. November 2022. https://www.thinkstep-anz.com/assets/Whitepapers-Reports/meeting-the-climate-challenge-through-digital-technology.pdf

93 Simply Energy – Demand Flex.Energy Awards, 2022. https://www.energyawards.co.nz/content/simply-energy-%E2%80%93-demand-flex

94 Net Zero by 2050 - A Roadmap for the Global Energy Sector, International Energy Agency. October 2021. https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf

95 The Clean Growth Strategy Leading the way to a low carbon future, Department for Business, Energy & Industrial Strategy, UK Government. October 2017. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/700496/clean-growth-strategy-correction-april-2018.pdf

96 Low Emission Economy, Productivity Commission. August 2018. https://www.productivity.govt.nz/assets/Documents/lowemissions/4e01d69a83/Productivity-Commission_Low-emissions-economy_Final-Report_FINAL_2.pdf

97 Hydrogen in New Zealand, Ministry of Business, Innovation and Employment. https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-strategies-for-new-zealand/hydrogen-in-new-zealand

98 Ibid.

99 Current Hydrogen Projects in New Zealand, Hydrogen New Zealand. https://www.nzhydrogen.org/nz-hydrogen-projects

100 Meeting the climate challenge through digital technology, Spark and thinkstep-anz. November 2022. https://www.thinkstep-anz.com/assets/Whitepapers-Reports/meeting-the-climate-challenge-through-digital-technology.pdf

101 Decarbonising UK Transport, Prepared for the UK Department of Transport, Mott MacDonald. March 2021. https://www.gov.uk/government/publications/decarbonising-uk-transport-technology-roadmaps

102 Leading the cycle Finnish road map to a circular economy 2016–2025 https://media.sitra.fi/2017/02/28142644/Selvityksia121.pdf

103 Future Transport Technology Roadmap 2021-2024, NSW Government. 2016. https://www.transport.nsw.gov.au/system/files/media/documents/2022/NSW_Future_Transport_Technology_Roadmap_2021-2024.pdf

104 Hot Lime Labs. https://hotlimelabs.com/

105 Climate Tech Intelligence Report, Deloitte. Developed for the Ministry of Business, Innovation and Employment. August 2023.

106 The Value of BIM in the Construction Sector, Beca. August 2022. https://www.beca.com/ignite-your-thinking/ignite-your-thinking/august-2022/the-value-of-bim-in-the-construction-sector

107 Platform8 to Revolutionise Sustainable Supply Chains Across Australia and New Zealand, Solving Major Industry Challenges. Platform8, April 2023. https://platform8.io/news/p8launch/

108 Network Readiness Index - New Zealand 2022, Portland Institute. https://networkreadinessindex.org/country/new-zealand

109 Climate Legislation in Aotearoa/New Zealand, Canadian Climate Institute. June 2020 https://climateinstitute.ca/publications/climate-legislation-in-aotearoa-new-zealand/

110 Background paper on Technology Roadmaps, Technology Executive Committee of the United Nations Framework Convention on Climate Change. April 2103. https://unfccc.int/ttclear/misc_/StaticFiles/gnwoerk_static/TEC_tab_1/c4305238ff8d4dee90493855bf224fd1/0ee6a8165b634fb0861a4ea6cf2ce411.pdf

111 International action on climate change, Climate Change Committee. https://www.theccc.org.uk/international-action-on-climate-change/

112 Decarbonising UK Transport Roadmaps, Department of Transport, UK Government. March 2021. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1001439/decarbonising-uk-transport-final-report-and-technology-roadmaps.pdf

113 UK Transport Vision 2050: investing in the future of mobility, Innovate UK. August 2021. https://www.ukri.org/wp-content/uploads/2022/01/IUK-110122-UK-Transport-Vision-2050.pdf

114 The CCUS Roadmap, INNO-CCUS, Innovation Fund Denmark. Downloaded August 2023. https://inno-ccus.dk/assets/uploads/Merged-roadmap-final-1.pdf

115 Summary of sector-specific low-carbon roadmaps, Ministry of Economic Affairs and Employment. September 2019. https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/162851/TEM_2021_9.pdf?sequence=1&isAllowed=y

116 Digital Skills for Tomorrow, Today. Digital Skills Aotearoa Edition 3, NZTech. August 2023. https://nztech.org.nz/wp-content/uploads/sites/8/2023/08/NZTech-Digital-Skills-Report_final.pdf

117 Ibid.

118 Ibid.

119 Discussion paper – Support for industry scale-up of research spinouts and pilot plant development, Macdiarmid Institute. July 2021.

120 The 2023 budget initiative to introduce an applied doctorate programme is a good example of this. It will make research and skills more accessible to a greater range of businesses and other organisations.

121 Discussion paper – Support for industry scale-up of research spinouts and pilot plant development, Macdiarmid Institute. July 2021.

122 Meeting the climate challenge through digital technology, Spark and thinkstep-anz. November 2022. https://www.thinkstep-anz.com/assets/Whitepapers-Reports/meeting-the-climate-challenge-through-digital-technology.pdf

123 Digital Skills for Tomorrow, Today. Digital Skills Aotearoa Edition 3, NZTech. August 2023. https://nztech.org.nz/wp-content/uploads/sites/8/2023/08/NZTech-Digital-Skills-Report_final.pdf

124 New Zealand Climate Tech for the World, Clean-Tech Group, Callaghan Innovation and Auckland Unlimited. July 2021. https://www.callaghaninnovation.govt.nz/sites/all/files/NZ_Climate_Tech_For_The_World_report.pdf

125 Discussion paper – Support for industry scale-up of research spinouts and pilot plant development, Macdiarmid Institute. July 2021.

126 Upstart Nation, Startup Advisory Council. August 2023. https://www.mbie.govt.nz/dmsdocument/27179-upstart-nation

127 Ibid.

128 Ibid.

129 New Zealand Climate Tech for the World, Clean-Tech Group, Callaghan Innovation and Auckland Unlimited. July 2021. https://www.callaghaninnovation.govt.nz/sites/all/files/NZ_Climate_Tech_For_The_World_report.pdf

130 The State of the City: Benchmarking Tāmaki Makaurau Auckland's international performance, Tataki Auckland Unlimited. 2023. https://committeeforauckland.co.nz/the-state-of-the-city

131 Upstart Nation, Startup Advisory Council. August 2023. https://www.mbie.govt.nz/dmsdocument/27179-upstart-nation

132 Meeting the climate challenge through digital technology, Spark and thinkstep-anz. November 2022. https://www.thinkstep-anz.com/assets/Whitepapers-Reports/meeting-the-climate-challenge-through-digital-technology.pdf

133 The carbon benefits of cloud computing. Microsoft, 2020. https://www.microsoft.com/en-us/download/details.aspx?id=56950&culture=en-us&country=us

134 New Zealand Climate Tech for the World, Clean-Tech Group, Callaghan Innovation and Auckland Unlimited. July 2021. https://www.callaghaninnovation.govt.nz/sites/all/files/NZ_Climate_Tech_For_The_World_report.pdf

135 Ibid.

136 Infrastructure New Zealand Position Paper: Digital, Infrastructure New Zealand. August 2023. https://infrastructure.org.nz/wp-content/uploads/2023/08/Infrastructure-NZ-Policy-Postions-Digital.pdf

137 2023 Draft advice to inform the strategic direction of the Government's second emissions reduction plan. Climate Change Commission. April 2023. https://www.climatecommission.govt.nz/public/Advice-to-govt-docs/ERP2/draft-erp2/CCC4940_Draft-ERP-Advice-2023-P02-V02-web.pdf

138 Meeting the climate challenge through digital technology, Spark and thinkstep-anz. November 2022. https://www.thinkstep-anz.com/assets/Whitepapers-Reports/meeting-the-climate-challenge-through-digital-technology.pdf

139 The Future is Electric: A Decarbonisation Roadmap for New Zealand's Electricity Sector, Boston Consulting Group. October 2022. https://web-assets.bcg.com/b3/79/19665b7f40c8ba52d5b372cf7e6c/the-future-is-electric-full-report-october-2022.pdf

140 Discussion paper – Support for industry scale-up of research spinouts and pilot plant development, Macdiarmid Institute. July 2021.

141 Advanced Manufacturing Industry Transformation Plan. Ministry of Business, Innovation and Employment. March 2023. https://www.mbie.govt.nz/dmsdocument/26245-advanced-manufacturing-industry-transformation-plan

142 Meeting the climate challenge through digital technology, Spark and thinkstep-anz. November 2022. https://www.thinkstep-anz.com/assets/Whitepapers-Reports/meeting-the-climate-challenge-through-digital-technology.pdf

143 Meeting the climate challenge through digital technology, Spark and thinkstep-anz. November 2022. https://www.thinkstep-anz.com/assets/Whitepapers-Reports/meeting-the-climate-challenge-through-digital-technology.pdf

144 Climate Tech Intelligence Report, Deloitte. Developed for the Ministry of Business, Innovation and Employment. August 2023.

145 Ibid.

146 Ibid.

147 https://rondo.com/

148 Meeting the climate challenge through digital technology, Spark and thinkstep-anz. November 2022. https://www.thinkstep-anz.com/assets/Whitepapers-Reports/meeting-the-climate-challenge-through-digital-technology.pdf

149 Meeting the climate challenge through digital technology, Spark and thinkstep-anz. November 2022. https://www.thinkstep-anz.com/assets/Whitepapers-Reports/meeting-the-climate-challenge-through-digital-technology.pdf

150 Our Living Standards Framework, The Treasury, New Zealand Government. October 2021. https://www.treasury.govt.nz/information-and-services/nz-economy/higher-living-standards/our-living-standards-framework

151 Get to grips with the six capitals, Integrated Reporting Foundation.2023. https://www.integratedreporting.org/what-the-tool-for-better-reporting/get-to-grips-with-the-six-capitals/

NZTech

Phone +64 9 475 0204
Web **www.nztech.org.nz**

Auckland Level 1, 368 Beach Road, Mairangi Bay, Auckland
Wellington Level 4, 117 Lambton Quay, Wellington
Postal PO Box 65503, Mairangi Bay, Auckland 0754