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Green growth: opportunities for New Zealand

Report prepared for the New Zealand Green Growth Research Trust

Final report
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Foreword

Since the financial crisis and the Great Recession, economic growth has been at the top of the political agenda in most countries. In some quarters, there have been calls for urgent efforts to stimulate a return to business-as-usual growth, at any cost. In others, at least for a while, commentators have concluded that low or zero growth in developed economies is inevitable, and that nothing much can be done. Some even consider economic growth undesirable, often for environmental or social reasons.

Both the “business-as-usual” view and “no growth” views are dangerously misguided. Economic growth is a natural element of a flourishing society, where development goals are achieved, poverty is reduced and human wellbeing improves. But business-as-usual growth is self-defeating; it undermines the very assets that allow growth to occur. A new approach is required and is available.

Green growth integrates environmental concerns, especially climate change, into growth. It is the only growth path that allows humanity to develop and flourish, reduce poverty and achieve development goals, while at the same time protecting natural capital – such as climate stability – without which growth and development will be retarded or reversed.

The good news is in addition to being necessary, the green growth model is also incredibly attractive, because it:

1. Creates prosperity: A green growth model implies a new wave of technological change, full of innovation, the dissemination of new ideas, and will lead to a cleaner, quieter, safer, more efficient, more secure and more sustainably prosperous world;

2. Builds community: Key elements of green growth, such as energy efficiency, public transport and closed-loop consumption models, require bringing communities together to share lessons and insights and make the most out of resources;

3. Reduces risks: In addition to reducing the worst risks of climate change, a green growth model also reduces shorter-term economic risks. It is likely that 10 or 15 years from now, other countries will tax goods from countries that subsidise pollution (by not dealing with it). Those countries that do not transition early will eventually have the transition forced upon them. And early means the transition can take place in a measured and structured way.

Many countries – including New Zealand’s neighbours in the Asia-Pacific region – are already transitioning their economies onto a green growth path. Australia has introduced a broad-based carbon price, with full carbon trading by 2015. This will link with the European and New Zealand carbon trading systems. South Korea is making strong and determined moves to capture the benefits from green growth, and houses the headquarters for the new Global Green Growth Institute. China has taken a leadership position in the production and installation of wind and solar technologies, and has launched seven pilot carbon trading schemes. In Europe too, there is strong commitment of the EU as a whole, Sweden has had a strong carbon price for 15 years and the UK is putting a floor under carbon prices. The Californian carbon trading scheme is up and running. And so on. The fact that New Zealand's neighbours are transitioning to green growth makes it easier for New Zealand to do the same, and more costly if it does not.

I therefore warmly welcome research, such as this report, that develops and shares insights into green growth. This report shows that there are important economic opportunities for an agricultural trading nation such as New Zealand in rapidly transitioning to green growth. For instance, humanity needs to develop technologies to provide food for 9-10 billion people within a few decades. New Zealand has an enormous opportunity to develop a high-yield, low-emissions agricultural system that would both increase national prosperity and contribute to solving a major global problem.

More broadly, the green growth transition can protect New Zealand's current competitive advantages and globally respected clean green brand, and create new sources of wealth. Sharing this insight within New Zealand society will be critical to taking full advantage of the green growth opportunity, because success requires industry and government to work together. This report identifies 21 specific green growth opportunities that build on existing policy in important areas; these represent a good start to charting a green growth pathway for New Zealand.

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Executive Summary

A greener approach to what NZ does well

The New Zealand Green Growth Research Trust (NZGGRT) commissioned this report to support its thinking about how to grasp important opportunities that would improve the wellbeing of New Zealanders. These are opportunities to enhance New Zealand's (NZ) economic prosperity while raising environmental quality that might otherwise be missed through lack of action, leadership or understanding.

The report investigates the possible opportunities for NZ that could arise from a global shift to green growth, and identifies 21 valuable, feasible actions that NZ could take to help realise these opportunities. The report was prepared by Vivid Economics and the Energy Centre, University of Auckland Business School (UABS). Vivid Economics contributed the analyses of global opportunities and green growth comparative advantage. Professor Basil Sharp and Dr Stephen Poletti from UABS provided the portrait of NZ's economy (section 2) and the six detailed sectoral case studies in sections 4 and 5.

The report focuses on six important sectors across the trade-focused and the domestic economy. The analysis reveals green growth opportunities in each sector that have both direct environmental benefits as well as important co-benefits such as higher productivity, lower energy bills and fewer health risks. For example, in the forestry industry, a shift to higher value-added products that raised NZ's sectoral productivity to the level in Finland could deliver extra value over time, which a sustainable increase in output could increase further. Improving the energy efficiency of NZ homes would reduce health risks for the young and elderly.

While the report contains a large amount of research, it can be summarised in six points:

1. A green economy may improve wellbeing; these improvements can occur in diverse ways, and not all policies that improve wellbeing raise Gross Domestic Product (GDP) over the short term;
2. NZ could benefit from global green investment patterns in two main ways: by exporting to nations investing in green assets and technology and by importing both new technologies and ideas to craft more world-leading policies at home;
3. The economic opportunities are potentially large;
4. Not all global opportunities in the green economy translate into large export opportunities for NZ;
5. The potential green growth export opportunities for NZ include sustainable agricultural products and services, geothermal energy, biotechnology, and forestry, including second-generation biofuels. In the domestic economy, opportunities include improvements in building and transport energy efficiency and electricity grid technology; and
6. These opportunities generally require action from both industry and government, however, there are steps which businesses and industries can take unilaterally.

A green economy may improve wellbeing. These improvements can occur in diverse ways and not all policies that improve wellbeing raise GDP over the short term. There are a number of definitions of green growth in circulation and the similarities between them are strong. [1] This report follows these sources and adopts a definition of green growth as 'growth which maintains or improves wellbeing while staying within ecological constraints'. This definition does not mean that only green growth policies which increase short-run economic growth are desirable. Some policies act over the longer term to maintain the stocks of important natural capital that humans depend on, so that increases in living standards can continue into the future.

NZ could benefit from global green investment patterns in two main ways: by exporting to nations investing in green assets and technology and by importing both new technologies and ideas to enhance capabilities in domestic markets and craft more world-leading policies at home. While the focus is often on the first of these opportunity sets, opportunities in the second set are also important for national wellbeing. Imports of technology and ideas help to enhance resource efficiency, capabilities and production in non-traded sectors such as commercial and residential buildings, and international experience in policy development can help enhance domestic environmental policies. Apart from the intrinsic benefits, improved domestic policies can protect or enhance NZ's reputation as a nation with high standards of overall environmental quality, that is, NZ's green brand, which may influence demand for NZ's goods and services.

The economic opportunities are potentially large. Globally, the market to supply low-carbon power, transport and building technologies could be worth more than US$3 trillion per year in 2050 (IEA 2010).[2] The opportunities in low-carbon power alone could be around US$380 billion per year, spread across a range of technologies.[3] PWC's estimates for the World Business Council for Sustainable Development suggest annual sustainability-related investment opportunities in natural resource sectors in 2050, in food and agriculture and forestry of $1.2 trillion per year and $200 billion per year, respectively (WBCSD 2010; Hawksworth 2010).

Not all global opportunities in the green economy translate into large export opportunities for NZ. Export opportunities for NZ from global green growth are most likely in sectors where demand is expanding elsewhere as a result of ambitious environmental policy or other changes in an area in which NZ has comparative advantage. No country can specialise in everything, and NZ is no exception, so only some of the opportunities from a shift to global green growth will be opportunities for NZ.

The potential green growth export opportunities for NZ include sustainable agricultural products and services, geothermal energy, biotechnology, and forestry including second-generation biofuels. In the domestic economy, opportunities include improvements in building and transport energy efficiency and electricity grid technology. The report identifies these sectors by looking into the sectoral detail of

[1] See for example OECD (2011); United Nations Environment Program (2011); Earth Summit 2012 Stakeholder Forum (2011); Bowen and Fankhauser (2011).

[2] The IEA forecasts the investment in low-carbon energy required to stabilise greenhouse gas emissions at a level consistent with the goal of limiting temperature increases to 2 degrees on pre-industrial levels. It estimates that, across the world, investments in low-carbon energy could reach more than US$3 trillion per year by 2050 if the world shifts to an ambitious green growth trajectory.

[3] These projections were made prior to the Japanese earthquake and nuclear disaster of 2011 and the rate of nuclear deployment is now likely to be lower.

projections for the future global green economy. It identifies opportunities for NZ from among the technologies likely to be part of the future green economy and from within NZ's trade patterns and innovative ability. This global analysis is complemented with detailed case studies of important NZ industries to further refine the main opportunities identified.

These opportunities generally require action from both industry and government, however, there are steps which businesses and industries can take unilaterally. As many NZ businesses are adept at surveying global and local markets for opportunities, it is unlikely to be a lack of awareness of opportunities which holds NZ back from seizing the opportunities from global green growth. As the case studies in this report show, barriers can be present and both business and government action may be needed in order to surmount them. In some instances, this may involve collaboration between industries which have not previously been closely associated with one another, such as forestry and fuel manufacturers, in the case of second-generation biofuels. However, industry can take the first coordinated steps in many of the opportunities identified in this report. Early action from industry might facilitate subsequent policy action by government.

The opportunities have all been judged by the authors of this report to be valuable and feasible, however some might be implemented earlier, because they have either a larger expected impact or a longer lead time between implementation and results. The Annex to this executive summary lists the opportunities by sector. The detailed calculations necessary to estimate the expected benefits of these opportunities and to create a quantitative ranking are beyond the scope of this report. However, preliminary expert judgement of the opportunities against the criteria of potential impact and lead times suggests that the following specific actions may be among the highest priority: improving water allocation and management; raising the average share of R&D in GDP, especially in sustainable and low-carbon agricultural technologies; and improving the energy efficiency of land transport and buildings.

New Zealand Green Growth Research Trust now plans to work with local stakeholders to refine and select opportunities from the set identified here, subjecting this preliminary judgement on priorities to further scrutiny. The 21 green growth opportunities identified have informed the development of NZGGRT's understanding of green growth and enabled the organisation to hold a dialogue with key stakeholders. As one of those key stakeholders, Pure Advantage plans to announce support for seven Green Growth Initiatives, in conjunction with this report. Pure Advantage then proposes to build a multi-stakeholder group to undertake further detailed analysis of the opportunities presented here, and to determine the next steps needed to realise the most promising opportunities, including specific policy recommendations and estimates of investment and resources required for successful implementation.

The rest of this report is structured as follows. The Annex to this executive summary lists the 21 green growth opportunities identified in this report. Chapter 1 introduces the report and assesses the global opportunities from green growth, reviewing the possible size and composition of global green growth opportunities in the power, transport, buildings and agriculture sectors. Chapter 2 provides an overview of the NZ economy. It uses market data to identify NZ's comparative advantage and gives a portrait of the economy showing the sectoral mix of activities and importance of trade in generating wealth. Chapter 3 provides an introduction to green growth concepts and measurement. It explains how green performance can contribute to individual wellbeing directly and through the market economy. Chapter 4 provides an evaluation of NZ’s green growth performance in important merchandise export sectors, assessing the green credentials of key sectors relative to their international rivals, and complementing this with detailed case studies of the agriculture, forestry and fisheries sectors. Chapter 5 focuses on opportunities for the domestic economy, with case studies in the electricity, buildings and land transport sectors. Chapter 6 concludes.

Annex: green growth opportunities for NZ

The report identifies 21 opportunities for NZ across two broad domains: 5 opportunities to improve the frameworks on which sound green growth strategies rest, and 16 sector-specific opportunities. The opportunities cover both export-oriented and domestic opportunities for NZ from a shift to global green growth. The following paragraphs provide a brief description of each opportunity, its rationale and actions which could help to achieve it, and a reference to the relevant section of the main report.

Frameworks: understanding and underpinning sectoral opportunities

Innovation

1. **Opportunity:** build on recent reviews of innovation in NZ by setting a pathway to achieve the OECD average share of R&D in GDP and setting out the government's vision and policies for green innovation.
   Rationale: a great deal has been written about innovation in NZ over the past decade, and two recent reviews (OECD 2007; Raine, Teicher, and Reilly 2011) provide an understanding of the strengths and weaknesses of current policy and a range of detailed recommendations for improving performance. The government's plan to develop a 'unified, cross-government innovation plan based on the OECD's model of innovation policy' (Ministry of Science and Innovation 2012:10) is a positive step and the plan could draw on the recommendations from these recent reviews.
   Actions: as part of the government's forthcoming innovation plan, include a plan for meeting Recommendation 18 of the *Powering Innovation* review on raising public R&D as a proportion of the OECD average within ten years, and using this public spending to leverage a significant increase in private sector R&D. Green innovation could be a focus of any overall plan.
   Further discussion: section 2.2.4, and in sectoral case studies.

Energy efficiency

2. **Opportunity:** investigate further implementation of the IEA's priority energy efficiency policies to improve NZ's overall performance in energy efficiency.
   Rationale: well designed energy efficiency policies achieve low-cost emissions reductions, deliver financial savings and improve energy security. In a review of each IEA member country's performance, the IEA (2009) noted that, despite the strength in NZ's performance there were several areas for improvement, particularly in buildings, transport and cross-sectoral policies to support private sector investment in energy efficiency.
   Actions: review each of the IEA's 25 recommended energy efficiency policies which NZ has not yet implemented, prioritising the IEA's recommended cross-sectoral measures to support private sector investment. More specific opportunities in the areas of transport and buildings are discussed below.
   Further discussion: Section 4.2.3.

Support the clean green brand

3. **Opportunity:** investigate the value of an update of research on the economic value of NZ's clean, green brand and how this brand could be used to improve NZ export performance, particularly in Asia.
   Rationale: there is near-universal recognition that NZ's clean, green brand is valuable, however the last detailed attempt to estimate the value of the brand is now more than a decade old (Ministry for the Environment 2001). Given the importance of this brand to NZ it would seem worth updating this research and investigating how brand value has changed over time. Research could also illuminate whether there are cost-effective opportunities for leveraging this brand further, particularly in fast-growing Asian markets.
   Actions: a government or non-government organisation could conduct or commission a short scoping study investigating the case for updating the 2001 work on the value of NZ's clean green image, and on opportunities for leveraging the brand further in growing markets such as Asia. The full update of the 2001 study would be conditional on the scoping study finding that an update would be valuable.
   Further discussion: section 3.5.2.

4. **Opportunity:** business and government leaders can play a proactive international role in defending NZ's clean green brand and improving performance and policies where there is a mismatch between perceptions and reality.
   Rationale: NZ's clean green image may be important for service and merchandise experts. In some cases, international perceptions may be less favourable than actual performance, for example, NZ's emissions on a per capita basis are high when measured gross and lower on a net basis. In other cases, perceptions of under-performance could be accurate and damage the brand.
   Actions: within the set of welfare-improving environmental policies, prioritise policy improvements in areas where the gap between actual policy and that expected by key international stakeholders is large and commercially important. An example might be the overall level of NZ's 2020 emissions reduction targets.
   Further discussion: section 3.5.2.

5. **Opportunity:** learn more about NZ's potential opportunities from global green growth by applying methods used by World Bank researchers.
   Rationale: some of NZ's strongest potential capabilities in green products are likely to be in products which use technologies and skills similar to those associated with products in which NZ is internationally competitive. In a recent World Bank research paper, Dutz and Sharma (2012) estimate the share of 'green' and 'close to green' exports by region, identifying 'close to green' exports by looking at the similarity or 'proximity' between products. Similar analysis for NZ could provide detailed insights on how NZ's comparative advantage in green products could evolve, and could inform detailed policy recommendations.
   Actions: a government or non-government organisation could conduct or commission an analysis of NZ's green growth opportunities and the policy implications of these results.
   Further discussion: section 1.3.

Sectoral opportunities

Electricity

6. **Opportunity:** investigate the installation of smart grid and demand-response technology in NZ which could improve the efficiency of the power generation system, the integration of distributed generation and intermittent renewables, and the overall system reliability.
Rationale: smart grids open up the possibility for further managing increased renewable energy generation and the increased uptake of electric vehicles (EVs), making NZ a world leader in low-carbon transport and electricity generation.
Actions: industry and government to design a roadmap on the installation of a smart grid in NZ, drawing on the IEA's technology roadmap for smart grids and its near-term actions for business and government (IEA 2011a). In particular, consider government-industry demonstration projects such as the 'Smart Grid, Smart City' project in Australia, which would gather information about the benefits and costs of smart grid technologies in an NZ context.
Further discussion: section 5.1.6.

7. **Opportunity:** complement NZ's innovation policy with a framework for low-carbon energy innovation based on the IEA's best practice framework.
Rationale: while geothermal technology appears to have broadly adequate funding and support, other technologies in which NZ may develop a comparative advantage, such as wave energy, may need a considered R&D and innovation strategy.
Actions: industry and government to review the national energy innovation system to assess consistency with the IEA's best practice framework for energy innovation (IEA 2011a).
Further discussion: 5.1, in particular section 5.1.9.

Buildings

8. **Opportunity:** improve energy efficiency in both new and existing residential and commercial buildings.
Rationale: there are considerable financial, health and wellbeing benefits from improving the energy efficiency of NZ's existing and future building stock. Barriers to realising these improvements depend on the building type (residential or commercial) and tenure type (owner-occupied or rented).
Actions: drawing on a wealth of best practice material from overseas, government might evaluate measures for improving the energy efficiency of the current and new building stock. The review could cover financing mechanisms for reducing the barriers to residential energy efficiency retrofits, and the costs and benefits of a national energy saving schemes such as those in the UK and California and the scheme currently being investigated by the Australian government (Department of Climate Change and Energy Efficiency 2012).
Further discussion: section 5.2.

Transport

9. **Opportunity:** improve energy efficiency and security by implementing cost-effective mandatory light vehicle CO_2 emissions standards.
   Rationale: NZ is one of the few developed countries without mandatory vehicle emissions standards, and analysis from organisations such as the IEA (2010) demonstrates that feasible improvements in emissions provide consumers with net financial benefits while reducing transport emissions. Australia is currently consulting on the introduction of a mandatory standard (Department of Infrastructure and Transport 2012) and, given the history of common energy performance standards across the two countries, this is an opportunity for NZ to reflect the level of ambition in Australia.
   Actions: introduce mandatory light vehicle emissions standards for new vehicles with a goal of matching or exceeding any Australian standard, should one be introduced. Investigate efficient mechanisms for improving the emissions performance of imported used vehicles which make up a large share of vehicle imports.
   Further discussion: section 5.3.

10. **Opportunity:** make sure NZ is prepared for an eventual increase in the deployment of electric vehicles.
    Rationale: given NZ's low emissions intensity of electricity, EVs could eventually play an important part in reducing emissions from transport. The costs for vehicles would be expected to fall as deployment of the technology increases globally, and NZ can prepare to take advantage of this by ensuring that the grid and other systems necessary for smooth adoption of EVs are in place as the technology matures.
    Actions: electricity suppliers, business, government and consumer organisations could prepare for increasing EV penetration, including codes and standards for charging, metering arrangements, integration with smart grids (see Opportunity 7), recharging infrastructure, and so on, drawing on the near-term actions for EVs in the IEA's technology roadmap (IEA 2011b).
    Further discussion: section 5.3.

11. **Opportunity:** increase public transport investment and usage and facilitate switching to more active transport modes such as walking and cycling.
    Rationale: NZ land transport relies heavily on the private car, —much more so than nearly every other OECD country. The result is an inefficient and emissions-intensive transport system in which commuters are vulnerable to increases in real oil prices.
    Actions: Implement the recommendations to improve public transport outlined by the New Zealand Transport Agency in (2008). These include land use changes; direct and efficient pricing; infrastructure investment; and educational campaigns to encourage behavioural changes.
    Further discussion: section 5.3.3.

12. **Opportunity:** consider developing large-scale second-generation biofuel production in NZ.
    Rationale: large-scale second-generation biofuel production could, if successful and cost-effective, improve greenhouse gas emissions while reducing oil imports and improving NZ's energy security.

Actions: industry and government to continue assessing the expected net benefits of developing large-scale second-generation biofuels in NZ, and develop a strategy for large production if net benefits are expected. This strategy could include support for R&D; pilot plants, commercialisation of the technology; and large-scale afforestation.
Further discussion: section 5.3.3.

Agriculture

13. **Opportunity:** improve the allocation of water in NZ to ensure that it goes to its most valuable uses, taking the needs of the environment into account, and improve water quality and resource efficiency by increasing the efficiency of fertiliser use.
    Rationale: NZ has abundant water but experiences local areas of shortage and consequent environmental damage. Fertilizer use in NZ agriculture appears to be particularly intensive, with documented adverse impacts on water quality in some areas.
    Actions: build on and implement recommendations of recent policy reviews in NZ; enable transferability and pricing of water; facilitate and expand programmes to increase the efficiency of water use; invest in appropriate infrastructure for water transfer and storage; design cooperative programmes and incentives for land owners and managers to develop farming methods that economise on fertiliser use; and contribute to improved nutrient management that is compatible with community preferences.
    Further discussion: section 4.5.

14. **Opportunity:** develop information technology and communication systems to help farmers economise on inputs.
    Rationale: NZ has a history of being a world leader in pastoral agriculture. With precision agriculture, automated information systems and machine-to-machine communications, there is an opportunity to develop products for the domestic market and export.
    Actions: build on existing initiatives by bringing together farmers, industry groups and research providers, namely crown research institutes, universities and technology firms.
    Further discussion: section 4.5.

15. **Opportunity:** continue to improve emissions per yield from livestock and dairy cattle.
    Rationale: NZ has a strong programme of R&D in reducing emissions from agriculture, and future innovations and their deployment will be important in maintaining or improving NZ's relative performance in agricultural emissions.
    Actions: continue support for research into reducing greenhouse gas emissions from agriculture and the commercialisation of associated technologies and practices. In particular, consider prioritising low-carbon agriculture when increasing public R&D expenditure (opportunity 1).
    Further discussion: section 4.5.

Fisheries

16. **Opportunity:** develop the full economic potential of the Exclusive Economic Zone (EEZ) within the context of sustainable harvest levels.
    Rationale: NZ has a world-leading fisheries management regime. Economic growth will follow from sustainable utilisation of stocks.
    Action: explore aspects of the quota management system, including quota holdings, and public policy as it relates to the sector, to see if any limit the long-term economic potential of stocks in the EEZ.
    Further discussion: section 4.8.

17. **Opportunity:** realise opportunities from a sustainable expansion of the aquaculture industry.
    Rationale: the opportunity for economic growth in aquaculture may be considerable. Development over the years has been sporadic and controversial.
    Action: improve the efficiency of aquaculture regulations in ways that are consistent with growth while giving due attention to community concerns. Foster cooperative relationships between industry and research providers.
    Further discussion: section 4.8.

18. **Opportunity:** develop advanced information systems for harvesting and processing wild stocks and reducing adverse impacts on the marine environment.
    Rationale: fishing has an opportunity to innovate using precision harvesting and processing methods.
    Action: continue and enhance cooperative research programmes involving seafood industry groups, research providers, and technology firms.
    Further discussion: section 4.8.

19. **Opportunity:** reduce unit costs and greenhouse gas emissions by improving fuel efficiency in fishing.
    Rationale: the fishing industry will require a combination of measures to add value to the harvest and reduce input costs. The use of smart technology to optimise fuel consumption and information systems to optimise harvest effort with respect to stocks are examples of how the industry can reduce both its energy footprint and costs.
    Action: improve coordination between industry groups, crown research institutes and universities with the aim of advancing innovation to raise value added in fishing.
    Further discussion: section 4.8.

Tourism

20. **Opportunity:** identify public investments in NZ's natural capital, including NZ's biodiversity, which support sustainable private sector tourist investment.

Rationale: tourism is an important contributor to NZ's income. Primary attractions are the environmental and cultural assets. The environmental goods are public goods and so belong to and are managed by the state.
Actions: government to work with industry to develop a register of the assets that are or could become important to tourism and their condition and performance, and identify how these compare to NZ's rival tourist destinations. A review could also identify assets suitable for environmentally sustainable tourist development which lack supporting infrastructure, and consult on its provision.
Further discussion: section 3.5.2.

Forestry

21. Opportunity: create a smart, productive sustainable forestry sector and realise its potential.
Rationale: one of the key challenges the NZ forestry industry faces is to increase investment in processing to yield higher value products. Lack of investment in recent years means that an increasing proportion of the harvest is being shipped directly as unprocessed, low-value logs. Technological developments have the potential to enhance the industry from one of traditional wood products to one with a range of supplementary liquid and solid biofuels, bio-plastics and bio-chemicals. Demand for these products is likely to increase and NZ might take advantage of these opportunities.
Actions: industry and government to develop a roadmap for the development of a forestry-sector-led bio-economy. The roadmap could include proposals to develop a forestry cluster which encourages industry cooperation and promotes innovation along the lines of that in Finland.
Further discussion: section 4.7.4.

Contents

List of tables

List of figures

List of boxes

1 Introduction

What this report addresses and why it matters

Section Contents:

This report was funded by the New Zealand Green Growth Research Trust. It explores the definition of green growth and asks how it works, why it might be important and how to measure it. The report reviews recent materials in this area and makes its own contribution by identifying New Zealand's trade rivals in its key export sectors and benchmarking New Zealand's environmental performance against theirs.

'Can an argument be made for New Zealand to invest in green growth as a matter of self-interest?'

1.1 Scope of the report

The questions addressed by the report

1.1.1 Aims and contributors

The report investigates the possible opportunities for NZ that could arise from a global shift to green growth, and identifies 21 valuable, feasible actions that NZ could take to help realise these opportunities. The report was prepared by Vivid Economics and the Energy Centre, University of Auckland Business School (UABS). Vivid Economics contributed the analyses of global opportunities and green growth comparative advantage. Professor Basil Sharp and Dr Stephen Poletti from UABS provided the portrait of NZ's economy (section 2) and the six detailed sectoral case studies in sections 4 and 5.

1.1.2 Origins

The study is funded by the New Zealand Green Growth Research Trust, an organisation whose strategic objective is to ensure that New Zealand *'improves its own environmental stewardship, to protect the clean, green image that benefits so much of what we produce and export.'* Founders of the Green Growth Charitable Trust recognise that New Zealand's 'clean and green' image brings it current and potential future economic advantage. They are concerned that this advantage might be undervalued at home, with consequent under-investment in New Zealand's natural assets which could result in lost economic opportunities and wellbeing.

1.1.3 Questions answered and structure of the report

This report sets out answers to a number of questions.

- *What is green growth?* It provides a working definition (section 1.2.3) and a selection of metrics which relate to it (section 3);
- *Why is green growth important?* It explains how green performance can contribute to individual wellbeing directly and through the market economy, section 3;
- *What are the global opportunities related to green attributes of growth?* It identifies broad drivers of value in green performance using in-depth studies of the environmental performance of selected sectors within New Zealand, sections 1.3and 4.1;
- *How competitive is New Zealand in key sectors?* It uses market data to identify New Zealand's comparative advantage and gives a portrait of New Zealand's economy showing the sectoral mix of activities and importance of trade in generating wealth, section 2;
- *How 'green' are NZ's key sectors?* It assesses the green credentials of key sectors relative to their international rivals in New Zealand's principal export sectors, section 4.1;
- *How can New Zealand exploit the opportunities from a shift to green growth?* It reviews the possible size and composition of global green growth opportunities in the power, transport, buildings and agriculture sectors (section 1.3), and drills down into the details of what these global opportunities mean for NZ through sectoral case studies (throughout sections 4 and 5).

1.2 Why green growth matters

How green performance contributes to wellbeing and why opportunities arise from policy and current comparative advantage

1.2.1 The origins of growth

For the last 200 years, the developed world has enjoyed a fairly continuous pattern of increases in per capita consumption. This marks it out from the rest of human history, when consumption levels remained essentially flat or slowly rising for hundreds of years and even millennia (Maddison 2001).

This remarkable change has at its root, several causes. The first, and most important, is technical change, in the means of production, such as equipment and the ways of organising and combining labour, and in institutions such as markets, government, law and education. The second is the consumption of natural capital, using up fossil hydrocarbons, undeveloped land, minerals and the atmosphere's regulating capacity. The third, which is partly a product of the first two, is population growth which has brought advantages of scale and density.

As time rolls forward, further growth in the short run can come from the laying down of additional capital, paid for out of the surpluses of production today, to the benefit of future generations. This is because to generate more income, a person, through the same labour input, must be able to produce more output, and this can come from more capital either in the form of physical assets (natural or manufactured), education or intangible techniques. So long as there is net investment in assets, and the capital stock per person rises, future per person income may be expected to grow. However, additional capital comes from investing a portion of income, sacrificing current consumption. In the long run, the neoclassical model of growth tells us, growth per person comes only from technical progress.

The standard, conventional definition of growth for a country is an increase in Gross Domestic Product. Of more interest here is the figure per capita, which simply divides the aggregate figure by the population. GDP itself consists of private consumption plus gross investment plus government spending plus net exports. It is equal to all income (or all expenditure).

Higher income (expenditure) is closely linked to greater wellbeing, because much of it relates to the consumption of goods and services that lead to a longer, healthier life with more satisfaction. However, some of this consumption does not enhance wellbeing, such as military defence, and some wellbeing-enhancing activities, such as caring for dependents, is not recorded, so it is by no means a perfect metric.

1.2.2 Why growth matters

It is not growth *per se* that matters but the level of wellbeing that people enjoy and the level that they enjoy relative to others. Naturally, people aspire to improve their circumstances, and hope that their children will have greater wellbeing than their parents or grandparents. They may also aspire to the levels of consumption they see their peers enjoying in other countries and ask why they too should not have the same. If one believes that the wellbeing of people matters, then growth in consumption is desirable.

1.2.3 From growth to green growth

For over a hundred years, levels of output have been measured in developed countries based on the value of market goods and the costs of supplying certain non-market goods such as defence, education and health care. This has been a useful but not yet complete account of output, failing to take full account of net changes in market assets and omitting untraded environmental goods and services.

The extension of the measurement of growth to take into account environmental goods and services and natural capital converts the conventional measure of output to one of green output, and the conventional measure of growth to green growth. Environmental goods and services are important as inputs to production and in direct consumption by individuals. The environment provides services of temperature regulation, clean air and water, waste transformation, pollination of food and fuel crops, fuel and fish and many others. It also provides pleasant and inspiring places in which to reside, work and enjoy leisure. These are just some of the benefits of a productive, healthy environment. Many of them are not recorded in GDP.

The working definition of green growth used in this report is introduced here and the concepts are discussed in more detail in section 3.

There are a number of 'green growth' definitions and the similarities between them are strong.[4] This report follows these sources and adopts a definition of a green growth as 'growth which maintains or improves wellbeing while staying within ecological constraints'. This definition does not mean that green growth policies have to raise short-run economic growth to be desirable. Some policies act over the longer term to maintain the stocks of important natural capital that humans depend on for survival, so that increases in living standards can continue into the future (see Box 1).

Many readers will notice a strong similarity with some definitions of sustainable development (see for example World Commission on Environment and Development (1987)). Green growth and sustainable development are complementary concepts. Those differences which do exist revolve around emphasis. Much of the analysis around green growth emphasises the economy and markets, both as engines of growth over the short and longer term, and as vehicles for delivering improvements in environmental outcomes. Sustainable development definitions generally emphasise equity between current and future generations.

This definition is human-centred and allows an economic framework and analysis to be applied. The authors do not wish to be insensitive to other perspectives on this issue but have chosen this one to follow here. The advantage is that it proffers a clear articulation of the way green growth contributes to wellbeing.

[4] See for example OECD (2011a); United Nations Environmental Program (2011); Earth Summit 2012 Stakeholder Forum (2011); Bowen and Fankhauser (2011).

Box 1. **Green growth policies and the timing and nature of economic benefits**

To see that green growth policies do not have to cause an increase in short-run economic growth in order to be desirable, consider carbon pricing. A carbon price implemented through a tax or emissions trading scheme encourages businesses and consumers to reduce the emissions intensity of their production and consumption. This shifts demand towards goods embodying fewer emissions, resulting in a gradual move from more- to less-polluting production processes over time. While the demand for clean technologies and services increases and expands employment in those fields and sub-national regions that produce them, such policies are projected to have a modest adverse impact on the aggregate economy including on rates of economic growth, see for example, OECD (2012a). However, the impact on the growth rate does not take into account the environmental and longer-term economic benefits of the policy. Ambitious global emissions reductions, realised in part through carbon pricing, can improve the chances that global average surface temperatures do not cross thresholds above which catastrophic changes in the earth’s subsystems could occur.

1.2.4 Why greenness matters

In a brief thought experiment, let us ask how a green growth perspective differs from a conventional economic growth perspective for a country like New Zealand. First, there is the wellbeing generated from New Zealand’s domestic activities, where it produces and consumes its own goods and services. To the extent that it maintains or enhances its environmental assets, these will continue to contribute to wellbeing. Advancing technology and accumulating physical capital lead to higher levels of wellbeing per person over time. Since New Zealand is a small country, many of the technical improvements will be adopted from overseas and paid for with earnings from exports. A proportion of the capital assets and equipment will also be imported. The natural assets contribute to domestic production and to the production of exports sold in exchange for other goods. The shape of New Zealand’s economy is described in section 2.

The thought experiment stands in contrast to another question which is commonly asked, which is ‘In which direction will a shift towards green growth (generally driven by public policies) drive investment?’ The studies that are produced identify the geographical and sectoral distribution of investment and the total sums involved. This investment question interests a number of parties: those who hold shares in firms whose free cash might be diverted into investment; equipment manufacturers who sell the products that become capital assets; the service providers who install and service the equipment.

The thought experiment is also in contrast to a second common question: ‘What is the potential growth of green sectors in the economy?’ Here there are various possible definitions of green sectors (Box 2). These forecasts of potential growth are of interest to investors and firms, and they may be of interest to politicians concerned with the success of national champion firms. Nevertheless, a country is not a company (Krugman 1996). The investment flows which these studies chart will change the resource allocation in an economy where some of its producers are involved in the capital programme, either making final investments or increasing output of intermediate goods, but many firms will not be involved. One of the purposes of this study is to find out how much exposure New Zealand may have to these trends. The capital programmes will make large use of currently available technologies and many of the firms involved will be those who are currently most competitive, with margins and market shares which show their strength. Section 1.3 discusses the opportunities for NZ from potential growth in the global green economy.

1.3 Opportunities for NZ from a global shift to green growth

Benefits from both exporting and importing green products, services and ideas

The global green economy (see Box 2 for its measurement) is large and growing. Estimates of the future size of the global green economy generally look to figures calculated using one of two methods:

The first method identifies the **additional investment** in a sector or sectors, relative to business as usual investment, which is required to meet an environmental outcome.

The second method begins with a definition of green sectors, and estimates their **future value,** for example by forecasting near-term growth based on recent market conditions.[5]

Two examples of the first method are from the IEA (2010) and the World Business Council for Sustainable Development (2010). The IEA forecasts the investment in low-carbon energy required to stabilise greenhouse gas emissions at a level consistent with the goal of limiting temperature increases to two degrees on pre-industrial levels. They estimate that, across the world, investments in low carbon energy could reach US$750 billion per year in 2030 and more than US$3 trillion per year by 2050 if the world shifts to an ambitious green growth trajectory (IEA 2010). The WBCSD draws on earlier IEA scenarios to provide broad indications of the green growth opportunities in a larger range of sectors (WBCSD 2010; Hawksworth 2010). The Council looks at natural resource sectors (energy forestry, agriculture, water, food, metals), estimating that the global value of potential additional commercial opportunities from the shift to a green world economy is up to $6.1 trillion a year by 2050. An example of the second approach to projecting the size of the green economy is INNOVAS, (2009). They focus on the UK and more on the near term.[6]

NZ could benefit from global green investment patterns in two main ways: by exporting to nations investing in green assets and technology and by importing both new technologies and ideas to enhance capabilities in domestic markets and craft more world-leading policies at home. While the focus is often on the first of these opportunity sets, opportunities in the second set are also important for national wellbeing. Imports of technology and ideas help to enhance resource efficiency, capabilities and production in non-traded sectors

[5] In order to avoid any confusion, note that our working definition (section 1.2.3) implies that 'green growth' is not just the contribution to growth generated by sectors explicitly engaged in improving environmental performance, but growth in any sector that raises or maintains wellbeing while staying within ecological constraints.

[6] INNOVAS estimate the growth of the global market for low carbon and environmental goods and services to 2015 assuming global growth rates are similar to those in the UK (p.84). As many environmental markets are driven by national policy and the UK has a relatively strong set of environmental policies this may overstate growth in other countries and hence the near-term size of the global green economy.

such as commercial and residential buildings, and international experience in policy development can help enhance domestic environmental policies. Apart from the intrinsic benefits, improved domestic policies can protect or enhance NZ's reputation as a nation with high standards of overall environmental quality, that is, NZ's green brand, which may influence demand for NZ's goods and services. Examples of opportunities in the second set include adapting 'smart grid' technology to upgrade the electricity grid in NZ and drawing on international experience in financing household energy efficiency to incentivise retrofits of the NZ's existing inefficient residential building stock.

In identifying export opportunities, the challenge is to be visionary enough to see opportunities NZ has not yet fully exploited but which seem both promising and feasible. Of course, not all global opportunities in the green economy translate into large export opportunities for NZ. Export opportunities for NZ from global green growth are most likely where expanding demand as a result of ambitious national environmental policy or other changes matches an area in which NZ has comparative advantage. For example, if there were a proliferation of sustainable agriculture and water quality initiatives in NZ's Asian neighbours this would increase the size of the market for NZ's existing expertise in these areas. When considering how NZ might take advantage of these opportunities it is important to avoid 'picking winners'. However, this is *not* the same as advocating inaction: while the report is not advocating support for particular firms, it does suggest actions which can help to reduce the barriers for NZ taking advantage of export opportunities from green growth.

In many countries, the global financial crisis has influenced the recent development of green growth policies, seeking fiscal consolidation and the pursuit of economic co-benefits from environmental improvement. The recent global financial crisis created a push for green investment in many countries to a greater degree than in NZ. Many countries devoted a proportion of their fiscal stimuli to spending with environmental co-benefits, such as household energy efficiency and railway infrastructure. Around one tenth of the US and UK fiscal stimulus packages, around one third of China's and about 80 per cent of South Korea's were devoted to measures with environmental co-benefits (HSBC 2009). In addition to this recent driver of green growth policies, there are several other longer-term drivers, with the most pressing factors varying by country. These drivers include:

- the potential for shifting the tax mix towards well-designed environmental taxation in order to improve long-term fiscal sustainability (see for example Vivid Economics 2012a);
- the desire to capture some of the emerging global markets for green goods and services such as those discussed in this section;
- for some natural resources, emerging pressures and conflicts between users, creating impetus for improving the mechanisms by which resources are allocated (for example water allocation in Australia's Murray Darling Basin); and
- public desire to improve environmental protection of valuable natural capital for future generations independently of any purely financial benefits this can bring.

Introducing pioneering policies which provide overall benefits but create winners and losers is not easy. While concerns remain about the ability of the New Zealand emissions trading scheme to incentivise investment in low-emissions assets, NZ's scheme was the first mandatory trading scheme outside of Europe, and this track record of success would seem to provide good grounds for optimism that further world-leading policies to improve NZ's wellbeing can be developed in other challenging areas such as the allocation of water resources.

This section looks into the sectoral detail of projections for the future global green economy to identify where export opportunities for NZ might lie. Following (Vivid Economics (2012), forthcoming), this report looks into the detail of investment-based projections of the future size of the global green economy and identifies opportunities for NZ by comparing the key technologies likely to be part of a the future green economy with NZ's trade patterns and innovative ability.

In the next five to ten years, NZ's current skills and capacities are a good guide to the kinds of green growth opportunities that might be most promising. Some of NZ's strongest potential capabilities in green products are likely to be in products which use technologies and skills similar to those associated with products in which NZ is internationally competitive. In a recent World Bank research paper, Dutz and Sharma (2012) estimate the share of 'green' and 'close to green' exports by region, identifying 'close to green' exports by looking at the similarity or 'proximity' between products. Similar analysis for NZ could provide detailed insights on how NZ's comparative advantage in green products could evolve, and could inform detailed policy recommendations (**green growth opportunity 5)**. This report complements an analysis of traditional trade competitiveness with an analysis of NZ's green performance relative to its global rivals (sections 4.3, 4.4 and 4.6), indicating how NZ would fare if these production inputs were priced or regulated in more countries over time.

NZ's demonstrated ability to innovate in a sector could indicate the prospects for longer-term success. Companies and industries are dynamic and countries' comparative advantage decades ahead is difficult to predict. One of the features of technology and equipment providers, and especially of innovative activity, is that it is often linked to dense agglomerations, with deep markets of firms and people with the relevant skills and proximity to large markets (Audretsch and Feldman 2004). NZ may succeed in sectors where it has or can acquire comparative advantage but there will be other sectors where it will not attract capital. A current ability to produce high-value innovations (as indicated through patents) is likely to provide some indication of future ability to innovate within a field. Conversely, the absence of patents to date in a field not in its infancy would indicate that NZ would face difficulties in gaining a large share of the future global opportunities in that area.

Box 2. **The green economy, green jobs, and two key questions about green employment**

The size of the green economy and the number of green jobs are difficult to measure accurately, even once the meanings of the terms have been clearly defined. Measuring the green economy and green employment is challenging because the provision and use of goods and services which improve environmental quality and resource efficiency can be found across virtually all parts of the economy, from commercial buildings to agriculture to emissions-intensive manufacturing. This is reflected in the OECD/Eurostat definition of the environmental goods and services industry (OECD 1999:9) as consisting of:

'activities which produce goods and services to measure, prevent, limit, minimise or correct environmental damage to water, air and soil, as well as problems related to waste, noise and eco-systems. This includes cleaner technologies, products and services that reduce environmental risk and minimise pollution and resource use.'

A less formal definition along similar lines is provided by the International Labour Organisation (ILO 2012) and researchers for the Brookings Institutes' recent survey of the green economy in the US adopted a similar approach (Muro et al. 2011).

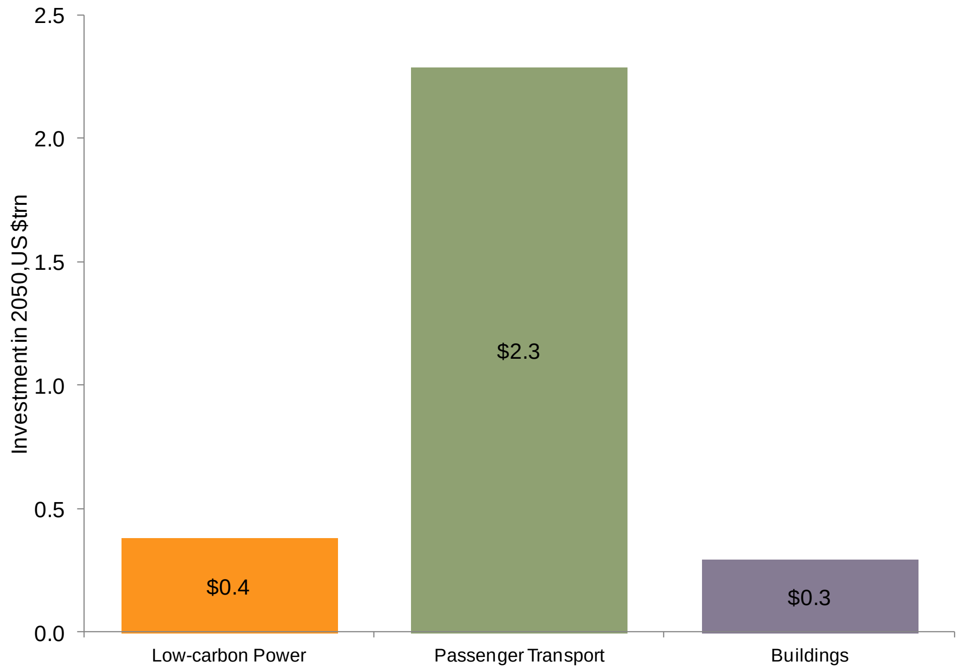
Two questions are frequently raised in the public debate on green jobs. The first is about the relative quality of green jobs (are they more highly skilled and better paid than average?). The second is about the number of jobs available in a greener economy.

On the first, the sheer diversity of green jobs, from installing insulation in residential buildings to designing better solar panels, would suggest that, green jobs as a whole would be unlikely to be more or less skilled or rewarded than others. Reviewing recent work on the skill requirements of green jobs, the OECD (2012a) found that as green jobs were very heterogeneous in terms of skill requirements, pay levels and working conditions, the shift to a green economy would be unlikely to much ameliorate or exacerbate concerns about job quality. However, systematic differences may be visible in individual sectors and for some groups of workers. In the US, Muro et al. (2011) found that, the clean economy offered more opportunities and better pay for low- and middle-skilled workers than the economy as a whole.

On the second question, it is, important to distinguish between *gross* and *net* job creation as a result of any government policy or structural change. When there are spare resources in the economy, such as during a recession or depression, government policies such as fiscal stimulus can raise employment relative to the situation without the intervention, creating an increase in *net* employment. In contrast, broad-based policies to achieve ambitious environmental goals such as carbon pricing work by shifting demand towards goods embodying fewer emissions over the longer term, resulting in a gradual move from more to less-polluting production processes over time. While the demand for clean technologies and services will increase, expanding employment in those fields and sub-national regions that produce them, such policies are projected to have a modest adverse impact on the aggregate economy including on rates of economic growth (see for example OECD 2012a). The impact on the growth rate does not take into account the environmental and longer-term economic benefits of the policy. This illustrates the importance of (a) judging policies against their impact on overall wellbeing as well as on the distribution of that impact across the economy and (b) well-designed policies to support workers and firms in industries affected by environmental policies (OECD 2012a).

Globally, the market to supply low-carbon power, transport and building technologies could be worth more than $3 trillion by 2050 (IEA 2010; Figure 1). The overall opportunities in low-carbon power could be around $380 billion, spread across a range of technologies (Figure 2).[7] Of these, current patenting indicates that NZ could be well placed to take advantage of expanded investments in geothermal power. Dechezlepretre and Martin (2010) survey the distribution of high-value patents for 15 low-carbon technologies over 1980-2007.[8] NZ appears in the list of the top 15 innovative nations only for geothermal. This geothermal opportunity, along with other opportunities for exporting goods and services associated with power generation and for improving the domestic grid, are discussed in detail in the case study in section 5.1.

Figure 1. **Investments in low-carbon energy could exceed three trillion dollars in 2050 with most of the opportunity in passenger transport**



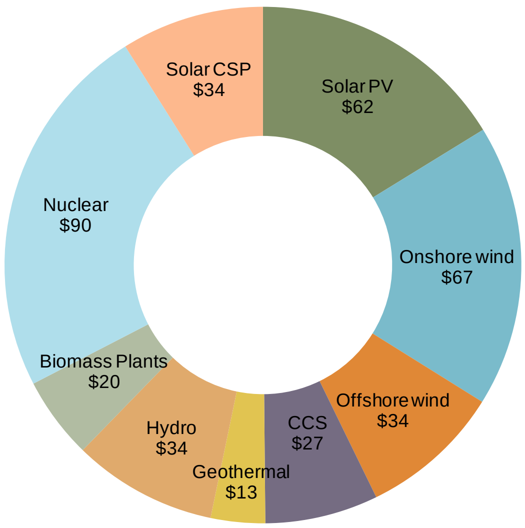
Note: projected additional annual investment (in 2008 USD) required in 2050 to achieve emissions reductions in the IEA's BLUE scenario, which achieve a 50 per cent reduction in energy-related CO_2 emissions by 2050.

Source: Vivid Economics based on IEA (2010).

[7] These projections were made prior to the Japanese earthquake and nuclear disaster of 2011 and the rate of nuclear deployment is likely to be lower than that projected.

[8] The technologies are: electric and hybrid vehicles, fuel injection, biomass, geothermal, hydro power, marine energy, waste to energy, wind power, solar CSP, solar PV, solar thermal, heating, cement, insulation, lighting, methane destruction, batteries, nuclear, fuel cells. As the value of patents is very variable and many are of little commercial value, in order to examine only higher value patents, the authors examine inventions where a patent has been filed in at least two countries. See Dechezlepretre and Martin (2010:8) for further discussion.

Figure 2. **The transition to a low-carbon power system will require large investments across a range of technologies**

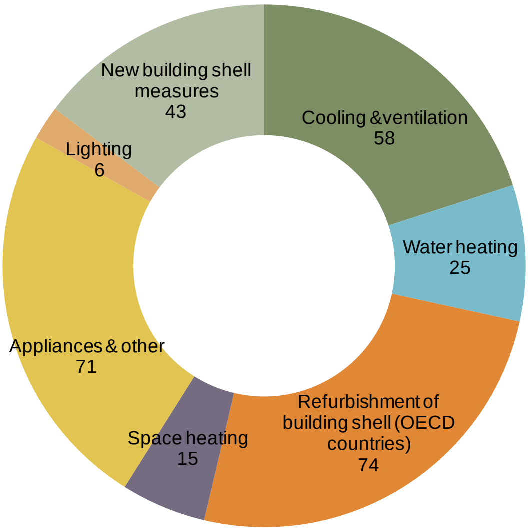


Note: projected additional annual investment (in billions of 2008 USD) in low-carbon power in in 2050 in the IEA's BLUE scenario by technology.

Source: Vivid Economics based on IEA (2010b).

While there are some very clear opportunities in sectors such as transport and power, green growth opportunities for the NZ building sector may be less apparent or more complex. Of the $300 billion per year potential global opportunity in buildings, it would seem challenging for NZ to become an important player in any of the key technologies or processes identified by the IEA (Figure 3), and the lack of strong domestic standards creates relatively little domestic demand from which an export industry might be built. The case study in section 5.2 discusses policies for improving the energy efficiency and comfort of NZ's domestic building stock which would contribute to domestic demand for more efficient buildings. While becoming a leader in the global market for building technologies would be challenging, the potential size of the opportunity in liquid biofuels is similar to that in building technologies (Figure 4). NZ could capture some of this global market by developing liquid fuels from forest waste (see the case study in section 4.7 for a detailed discussion).

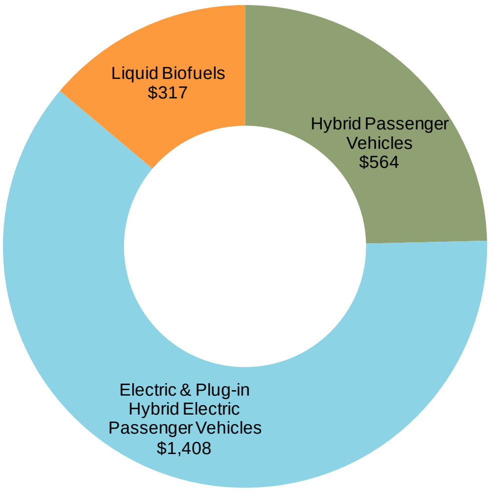
Figure 3. **Globally, opportunities to supply low-carbon technologies to buildings could be worth $300 billion in 2050**



Note: *projected additional annual investment (in billions of 2008 USD) in energy efficient building technologies in the IEA's BLUE scenario by technology.*

Source: *Vivid Economics based on IEA (2010b).*

Figure 4. **The substantial investments required in passenger vehicles and fuels in a low-carbon future are likely to be dominated by electric vehicles**



Note: *projected additional annual investment (in billions of 2008 USD) in passenger transport in the IEA's BLUE scenario by technology.*

Source: *Vivid Economics based on IEA (2010b).*

Long-run projections indicate opportunities in greening agriculture and food production. It is extremely difficult to project global business as usual investment in these sectors 40 years ahead, let alone the additional investment opportunities from a shift to a more sustainable global economy (Hawksworth 2010). PWC's estimates for the WBCSD suggest the 'broad order of magnitude' of sustainability-related investment opportunities in natural resource sectors, see Figure 5. They show the potential for global opportunities in areas in which NZ has strong current comparative advantage: food and agriculture, ($1.2 trillion per year in 2050), and forestry, ($200 billion per year in 2050).

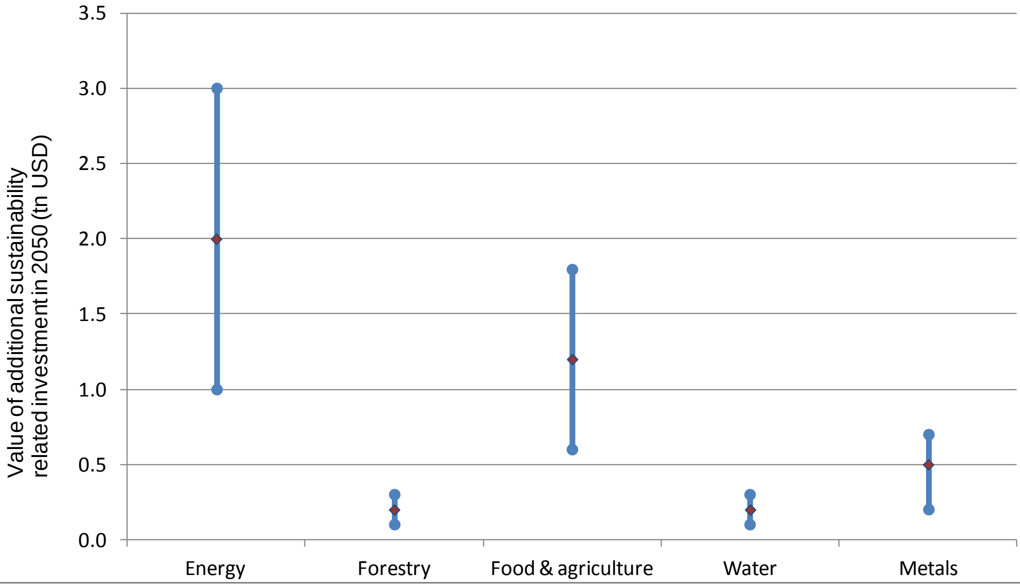
A major trend in food markets globally is an increase in food demand driven by per capita income and population growth: a ten per cent increase in income is estimated to lift food expenditures by between 3 and 7.5 per cent. Demand for meat, dairy and fish all increases faster than average food demand (Seale, Regmi, and Bernstein 2003). This increase in demand can have environmental consequences, though the conversion of land to agricultural land, through habitat destruction and pollution as a result of intensification, and through the consumption of fresh water. A factor in the trends is that the foods which are most responsive to increases in income include some of the most water-intensive in production.

Driven by food demand, water withdrawals for irrigation could be up to 57 per cent higher in 2050 according to de Fraiture and Wichelns (2010). This in itself might trigger an adjustment in the pattern of food supply, since trade in food is expected to be able to relieve this pressure, potentially completely. One group of researchers has suggested that optimal investment in food production and trade could reduce the level of additional irrigation water withdrawals by 90 per cent, see Figure 8. The availability of water in New Zealand and the efficiency of New Zealand's farmers in using it, could come to be a comparative advantage, and increase the value of New Zealand's agricultural exports. Improvements in domestic water policy and efficiency which would raise wellbeing and improve environmental quality in NZ could also assist with participation in global market for water saving products and services across agricultural, industrial and residential sectors.

NZ's ability to innovate in sustainability-related agriculture is underscored by its very strong relative performance in high-value biotechnology patents (Figure 6).[9] Given the additional investment in agriculture necessary to feed a global population of around 9 billion by 2050, further developing NZ's innovative abilities in agricultural technologies could help NZ exports while improving nutrition and wellbeing across the developing world. The cumulative net investment in developing countries necessary to feed 9 billion people is estimated at $360 billion. Estimates of the composition of this investment in Schmidhuber, Bruinsma, and Boedeker (2009) show several areas of potential opportunity for NZ including investments in milk and meat production and soil conservation (Figure 7). Sustainability-related investment opportunities in food and agriculture could be worth more than one trillion in 2050. Detailed analysis of what these global opportunities mean for the NZ agriculture, forestry and fisheries sectors can be found in the case studies in sections 4.5, 4.7and 4.8.

[9] There has been a debate in NZ over whether previous investment or encouragement of biotechnology has been worthwhile (Callaghan 2011). The fact that NZ has a revealed comparative advantage in biotechnology patents cannot by itself answer the question of whether the benefits of investment in this sector exceeded the costs, however it does indicate that NZ has produced intellectual property that the inventors considered worth protecting at cost in multiple countries.

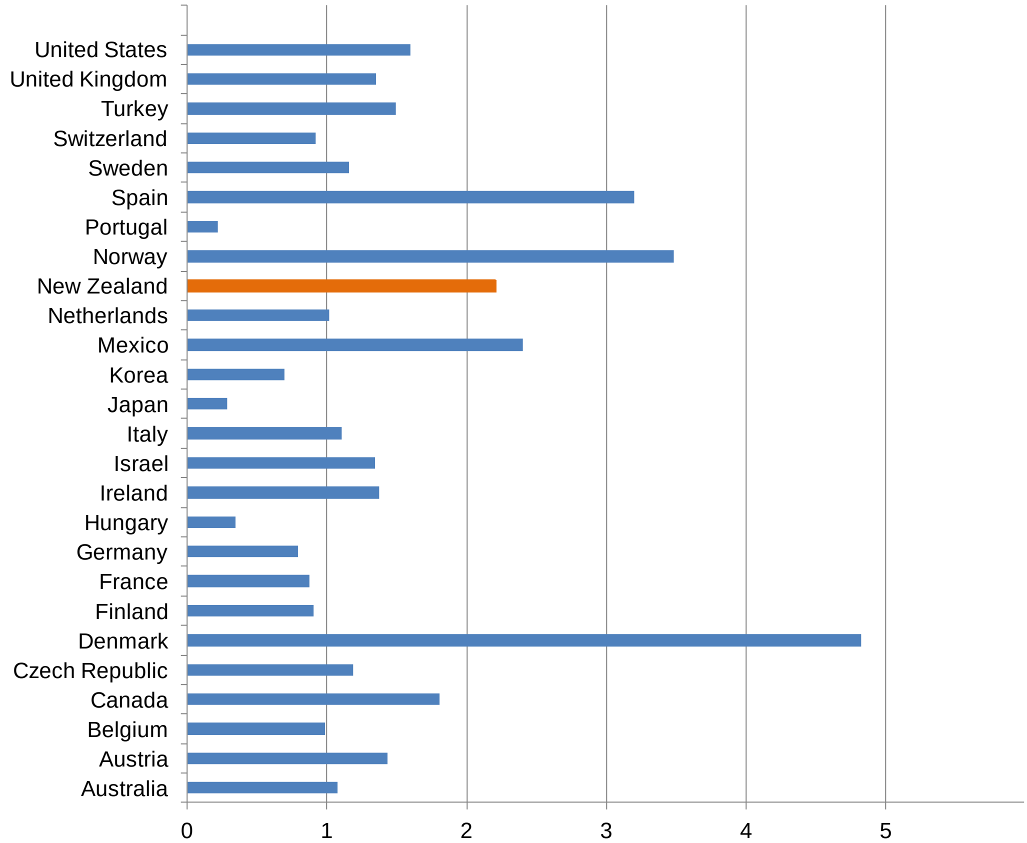
Figure 5. **Sustainability-related investment opportunities in food and agriculture could be worth more than one trillion in 2050**



Note: *projected value of annual investments in 2050 in trillions of 2008 USD under a sustainable path relative to a business as usual path. The red diamond indicates the central estimate and the top and bottom of the blue line show high and low estimates.*

Source: *Vivid Economics based on Hawksworth (2010)*

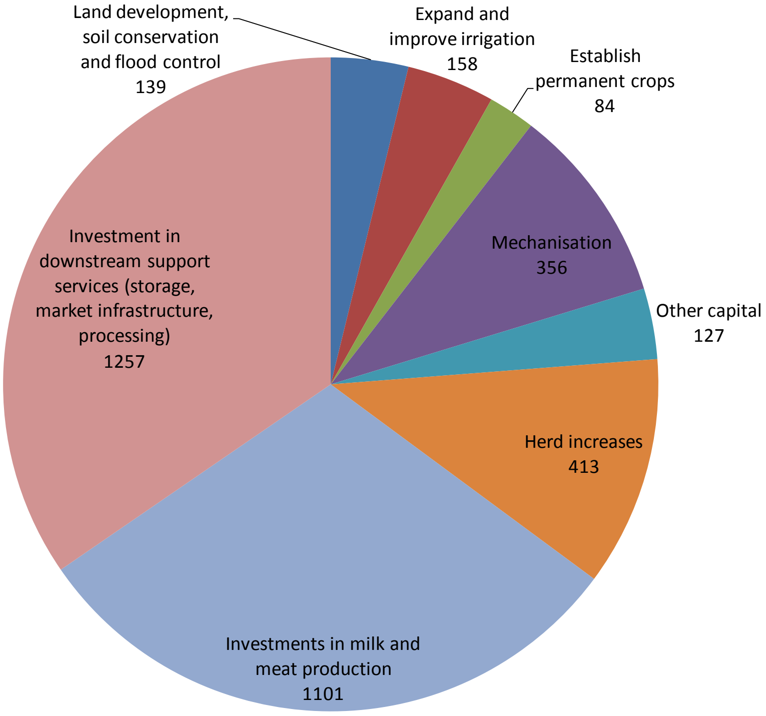
Figure 6. **NZ has a comparative advantage in biotechnology innovation**



Note: *Ratio of national share of biotechnology patents to national share of total patents by country. A value above one indicates a 'revealed comparative advantage' in biotechnology innovation. Average over 2005-2008 of 'triadic patent families (patents taken out at each of the European Patent Office, US Patent and Trademark Office and Japan Patent Office to protect the same invention). The value of the innovation embodied patents varies considerably and patents that belong to a family are typically of relatively high value OECD (2008).*

Source: *Vivid Economics, OECD (2012).*

Figure 7. **Improving nutrition and livelihoods in developing countries will require substantial investments across a range of agricultural sectors**



Note: *Estimated cumulative net investment over 2005/07-2050 in agriculture in developing countries required to feed a global population of 9 billion people in 2050. Figures in billions of 2009 USD.*

Source: *Vivid Economics based on Schmidhuber, Bruinsma, and Boedeker (2009).*

Figure 8. **Water consumption by crops could trigger changes in agricultural trade, raising the value of agricultural output in water-abundant areas**

Note: *in the optimistic scenario the optimal policy applied differs by region*

Source *Vivid Economics from data in de Fraiture and Wichelns (2010)*

This report will argue that the opportunities for the *green* aspects of growth come from external pressures to integrate environmental costs into businesses' financial costs. These external pressures may affect the international competitiveness of NZ industries. For this reason, one might ask:

How well do NZ's large, competitive merchandise export industries perform environmentally?

Are there 'champion sectors' which are both green and competitive?

One might then ask:

Do any of NZ's currently competitive sectors become uncompetitive when their environmental performance is taken into account?

How likely it is that environmental costs will be internalised in international trade?

This report looks makes progress in answering the first pair of questions. It stops short of converting physical measures of performance into value-based measures which can be translated directly into competitiveness and it leaves for another time the analysis of policy which might cause these costs to be internalised.

The areas of opportunity identified across this report have informed the list of 21 specific actions that could help NZ to take advantage of global green growth. This review of the sectoral detail of investment opportunities from global green growth has indicated opportunities for NZ in biotechnology and sustainable agricultural products and services, geothermal energy, forestry including second-generation biofuels, and in water efficiency.

Many NZ businesses are adept at surveying global markets for opportunities, meaning that it is unlikely to be simply a lack of awareness of opportunities which holds NZ back from capitalising on the opportunities from global green growth. As the case studies in this report show, barriers to taking up specific opportunities can be numerous and surmounting any one of them within a sector will often require both business and government action. The actions identified throughout the report focus on key aspects of high priority, feasible plans to improve NZ's environmental and economic performance.

1.3.1 The role of the state and markets

The authors of this report assert that the primary way in which green impacts or green performance will attract value in the future over and above the value they attract today is if state governments take action. In addition, consumers may express their preferences directly, through the purchase of goods with green credentials.

When governments prescribe production methods, tax polluting emissions or mandate ambient environmental standards, the effect is to increase the costs of production, raising prices. This increases the value added by firms which have greener production methods. The authors accept that consumers may choose to purchase products which are produced in a more environmentally responsible manner. There are a number of examples of this happening, the organic food movement being one. However, the greater part of the value and market opportunity for the main environmental impacts such as greenhouse gas emissions, water use, water pollution and biodiversity lies in the incentives created by state intervention. Where these policy interventions are made by the New Zealand government for the benefits of its own population, the costs and benefits are internal to its own affairs. Section 4 of this report looks at the influences outside New Zealand, and the effects on New Zealand's exports, while section 5 deals with environmental performance and opportunities in less- and non-traded sectors. While changes in the costs of imports are also potentially important, they lie beyond the control of New Zealanders, so they are not considered here. This study is outward facing but restricted to questions within the locus of domestic policy.

This assertion of state influence means that any consideration of the value of green growth action in New Zealand involves both market analysis and policy analysis. The market analysis shows how well placed New Zealand might be to benefit from changes in policy, and the policy analysis shows when, where and with what vigour policy might create new opportunities.

1.4 Green growth policy in New Zealand

Recent green growth discussions by Government and its advisors

1.4.1 Related published work

The New Zealand Government appointed a group of experts to explore and report on topics relating to greener and faster growth. The Green Growth Advisory Group, as it was known, published its findings in December 2011 (Green Growth Advisory Group 2011).

The Group took the OECD's analysis as its starting point. The Group was primarily concerned with policy rather than diagnostics or measurement, and it makes a number of policy recommendations, which we turn to shortly. In making these recommendations it has not built upon a particular credo for the role of government in the economy or environment, nor a particular belief about or interpretation of evidence on the origins of New Zealand's economic and environmental performance over recent decades. Nevertheless, the Group has felt able to make a number of recommendations.

Spanning all the individual recommendations is an overarching strategy. The strategy it espouses is to green policy in every area of government activity, rather than to pursue a separate green growth agenda, and to pursue economic growth in part through an increase in the role of contribution of exports to 40 per cent of GDP.

As in this report, the Group remarks that higher productivity is likely to create most new value in current economic activities rather than in areas outside New Zealand's current competency. The Group argues that improved environmental performance and net gains in biodiversity are integral to green growth.

It recommends the publication of green growth indicators every three years, setting out a dashboard of indicators that might be used. The Group would also like to see Government take several actions: provide access to better information on environmental performance; make it easier to comply with regulations and voluntary standards; promote collaborative action in resource management; invest more in public R&D; and, steer business decisions toward desired outcomes. The Group suggests reviews of resource rentals, royalties, emissions pricing and congestion pricing.

It champions quite a long list of individual policies many of which are related by three themes. The first is that NZ has a brand reputation associated with cleanness and a high quality of environment. The second is the presence of a system within which innovation occurs. The third is the capability of the business sector, particularly small and medium-sized enterprises.

1.4.2 Government policy

The New Zealand National Party published a major paper in March 2012 setting out the party's position on environmental policy (National Party 2012). It talks about economic growth together with environmental improvement. It describes willingness for New Zealand to make a fair share of greenhouse emissions reductions tempered by concern to see the economy grow. It remarks on the effect of the emissions trading scheme, which it declares is partly responsible for a shift from net deforestation to net afforestation from 2009.

Like this report, the National Party's paper draws comparisons between New Zealand and Nordic countries and cites the Yale and Columbia 2010 Environmental Performance Index. It offers sustained attention on environmental performance through a new Environmental Reporting Act and a new role for the parliamentary Commissioner for the Environment.

1.5 The contribution of this study

An understanding of New Zealand's relative environmental performance in sectors which add the greatest value through trade

1.5.1 Extending previous work

This study builds on others' previous work on trade, comparative advantage, and environmental performance. It continues the exploration of many of the themes and ideas set out in Pure Advantage (2012) and draws on publications by academics and multinational organisations including those developed in preparation for the United Nations Conference on Sustainable Development ('Rio+20'), in particular World Bank (2012b). The study also makes use of existing databases of trade compiled by the UN and of environmental performance collated by the OECD and applies them in new ways.

1.5.2 New findings

The study collects detailed analysis on green growth opportunities for a selection of industries of particular importance to NZ. It also shows for the first time who New Zealand's trade rivals are and how they compare with New Zealand on measures of environmental performance. It goes on to reveal where New Zealand is catching up with the leading performers in its export markets and where it is falling behind. This naturally leads to policy questions that might come after this study: Will future policy in these sectors create green opportunities? What value might they have? What policy action is justified, to best position New Zealand's firms, after accounting for the action those firms would freely take themselves?

1.5.3 Potential uses

The authors of this report believe that its value lies in three areas. First, in discussing the economic foundations of green growth which allows a rigorous discussion of green growth policy. Second, in helping to develop a measurement methodology for export activities, collating and presenting relevant evidence. Third, exploring potentially worthwhile areas of policy change in selected sectors.

The high-level competitiveness analysis is limited in scope to exports and by the high sectoral level of aggregation of international environmental performance data. In the future, and as more data become available, both these limitations might be addressed by further research. These limitations are partly overcome by the in-depth, NZ-specific analysis in the University of Auckland Business School case studies.

The authors hope that the report can inform a debate about green growth and public policy in New Zealand. In particular, both the high-level and detailed analysis and the 21 green growth opportunities identified have informed the development of Pure Advantage's seven Green Growth Initiatives.

2 A portrait of New Zealand's economy

Small, open and unique

Section Contents:

This section of the report gives an overview of the NZ economy using macroeconomic indicators to illustrate the structure and performance of the New Zealand economy in recent years. It sets the context for considering the challenges ahead and the opportunities for green growth.

'By and large, the New Zealand economy is based on the flow of services provided by its natural environment.'

2.1 Introduction

Investment and technical change

Economic growth is critical to the welfare of New Zealand's population. The connection between economic growth and well-being underpins recent government initiatives to close the so-called income gap with Australia and lift New Zealand's ranking within the OECD. Early models of economic growth defined economic growth as rising aggregate consumption or output (GDP) and recognised the fundamental forces of diminishing returns and technological progress (Solow 1956). The principal conclusion of the Solow growth model is that the accumulation of physical capital alone cannot account for the growth over time in output per person or for the geographic differences in output per person. In other words, observed differences in real income are too large to be accounted for by differences in capital inputs.

Beginning in the 1980s, a group of economists undertook empirical research under the banner of 'endogenous growth' (see for example Romer (2001). This research aimed at uncovering the private and public choices that cause the rate of growth to vary across countries. In particular, it showed that investment in human capital (for example, education), research and development, and innovation can make significant contributions to economic growth. The influence of institutions, in accounting for results that in the long run did not produce economic growth, is associated with North (1990). It should be obvious that the structure and performance of an economy reflects decisions made regarding R&D, innovation, adoption of new technology, institutional frameworks, and so on. The importance of these factors has been recognised in a recent report prepared by the Ministry of Economic Development (Proctor 2011).

Using the above themes, this section of our report is aimed at providing an overview of macroeconomic indicators. The indicators illustrate the structure and performance of the New Zealand economy in recent years, providing a context for considering the challenges ahead and the opportunities for growth that is consistent with the ecosystems upon which we depend.

2.2 Macroeconomic indicators

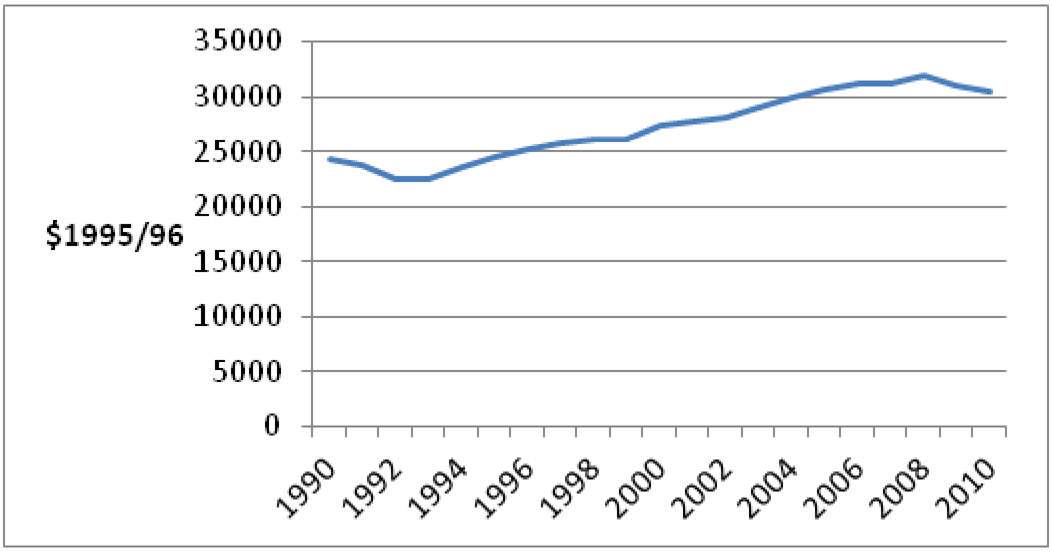
A well-educated, trading nation

The following economic indicators provide information about the structure and performance of the New Zealand economy from 2000. Cross country comparisons are provided where possible.

2.2.1 Gross domestic product

Gross domestic product (GDP) measures the market value of all final goods and services produced in New Zealand in a given period. Figure 9 shows New Zealand's GDP per capita in real terms ($1995/6) increasing over the period 1993 through 2006, levelling off and falling from 2008. Average growth in real GDP per capita over 1990-2010 has been around two per cent per year.

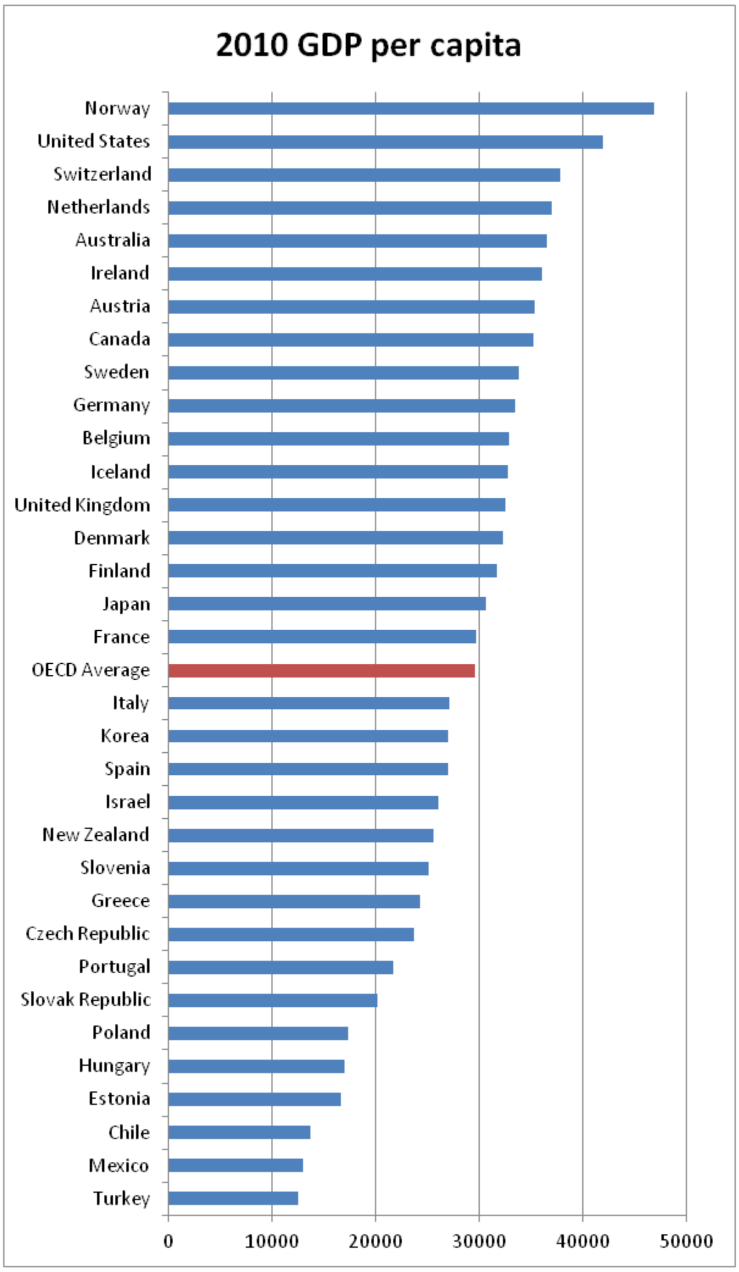
Figure 9. **Real gross domestic product per capita, New Zealand, 1990 to 2010**



Source *Statistics New Zealand*

Figure 10 shows New Zealand's performance relative to other OECD economies. In 2010, it sat below the OECD average at 22nd out of 34 OECD countries.

Figure 10. **New Zealand's ranking in GDP within the OECD, 2010**

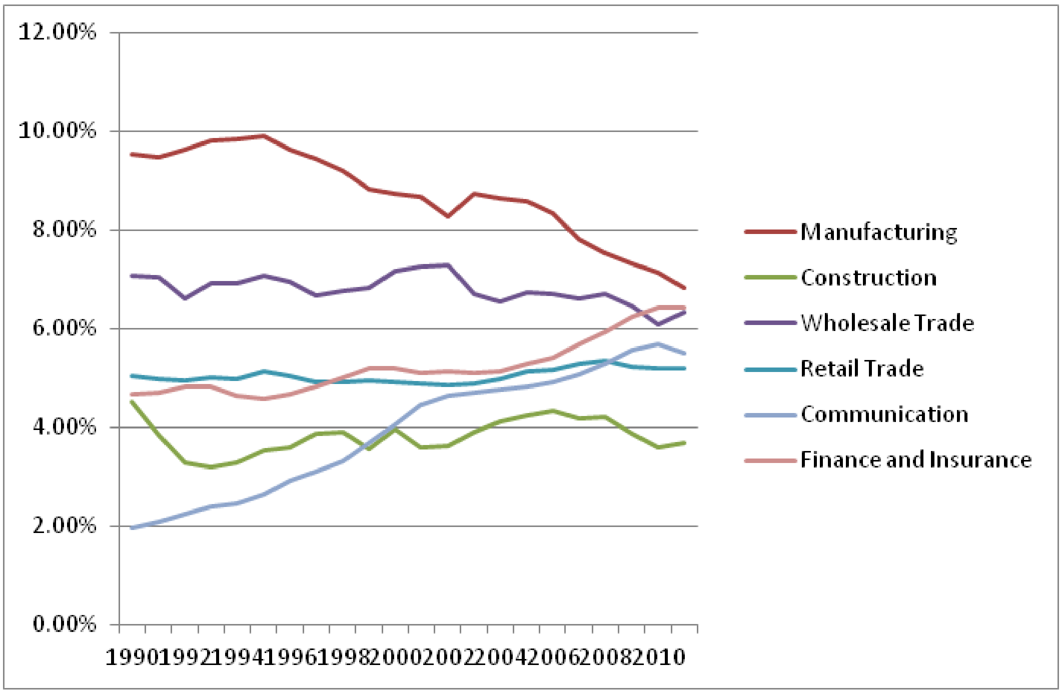


Source *OECD Statistics*

GDP has a number of limitations as an indicator. As discussed further in section 3, while rising GDP per capita indicates that economic activity has increased, it does not necessarily follow that the standard of living has improved. Additional indicators are required to reveal changes in personal income, income distribution, health, and so on. Furthermore, it is quite plausible that the quality of New Zealand's natural assets – for example, water, biodiversity, and air – can be falling as GDP per capita rises. Similarly, while the utilisation of stock resources – such as coal, oil and gas – contribute to GDP, changes in the quantum of reserves are not accounted for; the rate at which we use stock resources has implications for economic growth in the future.

Better insights into economic growth are obtained by looking at sector level trends. Property and Business Services – which includes scientific research; technical, legal, accounting, marketing and business services - contribute around 30 per cent of GDP. Figure 11 excludes Property and Business and illustrates trends in sector-level contributions to GDP. The contribution of Manufacturing to GDP has fallen, almost continuously, since 1990. Communication, Finance and Insurance, increased over the period. Wholesale, Retail, and Construction have remained relatively constant.

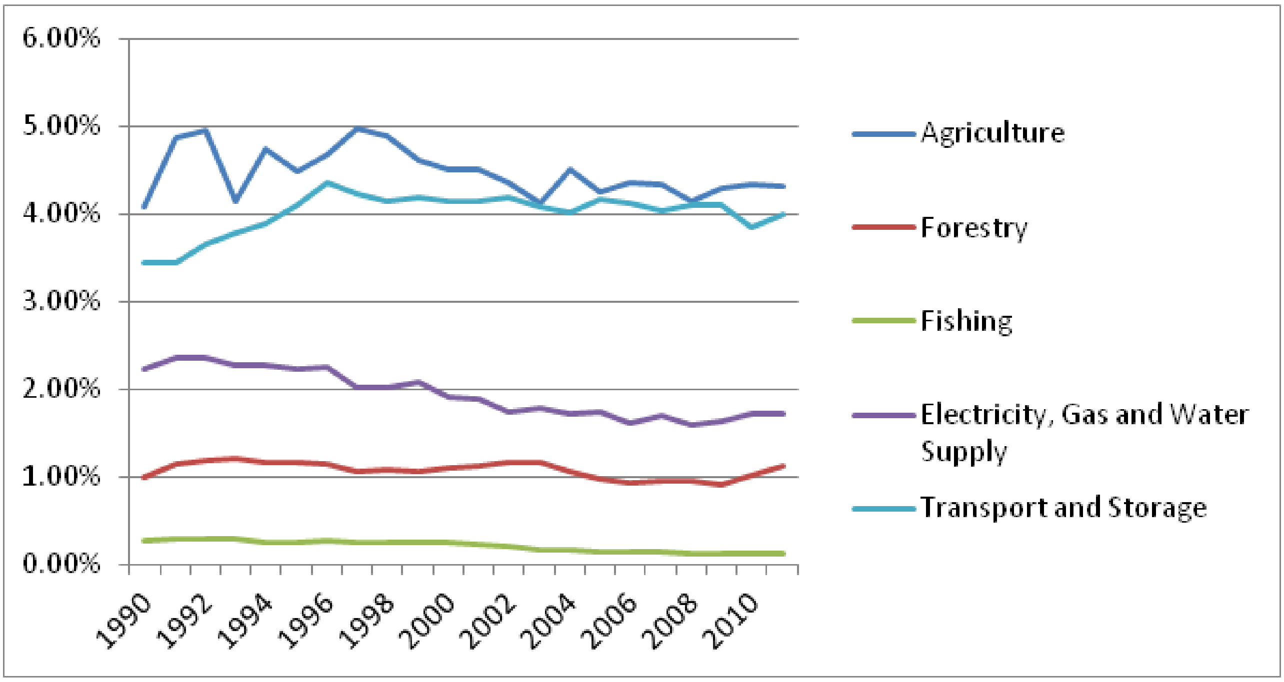
Figure 11. **Sector level contributions to GDP in New Zealand, 1990-2010**



Source *Statistics New Zealand*

The share of GDP contributed by the remaining market sectors are illustrated in Figure 12. When interpreting the trends shown in Figure 11 it is important to bear in mind that contributions to GDP are measured as value added. Thus any processing, for example milk produced at the farm level, is accounted for in another sector, such as manufacturing in the case of milk processing.

Figure 12. **Sector level contributions to GDP in New Zealand, 1990-2010**

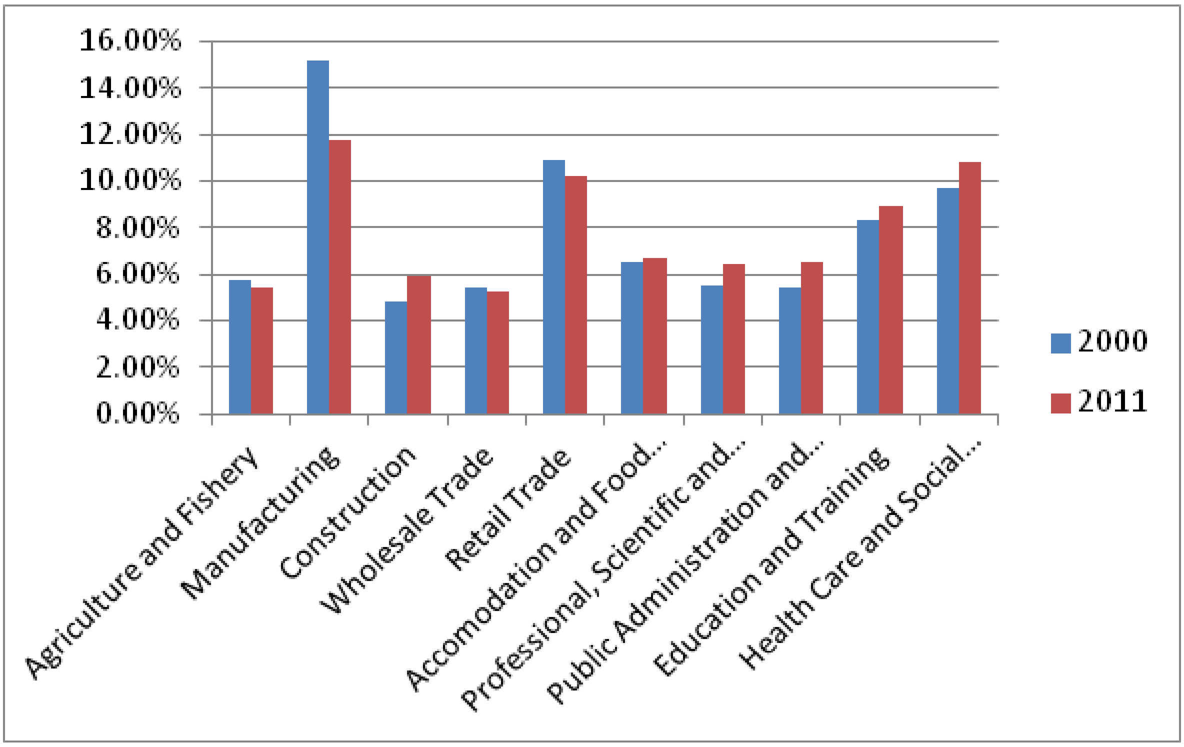


Source *Statistics New Zealand*

2.2.2 Employment

Total employment shows a similar trend to GDP per capita, increasing to 2008 and then falling off. As with GDP data, we can gain more insights by looking at changes in employment across sectors. Employment in Manufacturing shows the greatest decrease, from around 15 per cent to below 12 per cent of total employment, shown in Figure 13. Employment gains are shown for Construction, Professional, Scientific and Technical Services, Public Administration, and Education and Health Care Services.

Figure 13. **Employment composition by sector in New Zealand, 2000 and 2011**



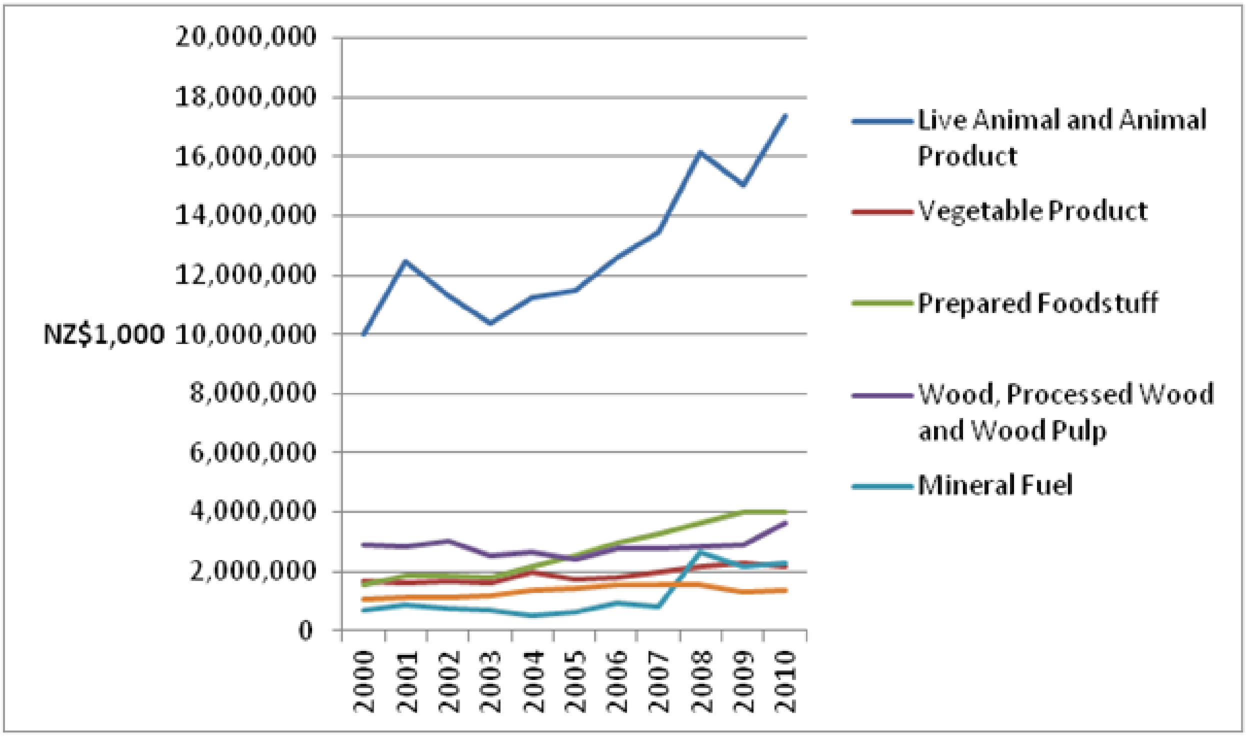
Source Statistics New Zealand

In summary, New Zealand's performance within the OECD in terms of GDP per capita explains the desire to lift value added. Trends in employment show a levelling off in absolute employment from 2008 and a change in the composition of the workforce away from manufacturing to service sectors in the economy.

2.2.3 Exports and imports

Given New Zealand's relatively open economy the role of trade in economic growth is significant. It is clear from Figure 14 that export receipts are dominated by resource-based products. Bearing in mind the importance of conditions in overseas markets and the exchange rate, the success of agriculture is obvious. Whether or not diminishing returns, without gains in resource efficiency and product development, will dampen this impressive contribution to the economy is moot. Regulations aimed at improving environmental standards could also limit the contribution from agriculture.

Figure 14. **Nominal value of exports from New Zealand 2000 to 2010**



Source: Statistics New Zealand

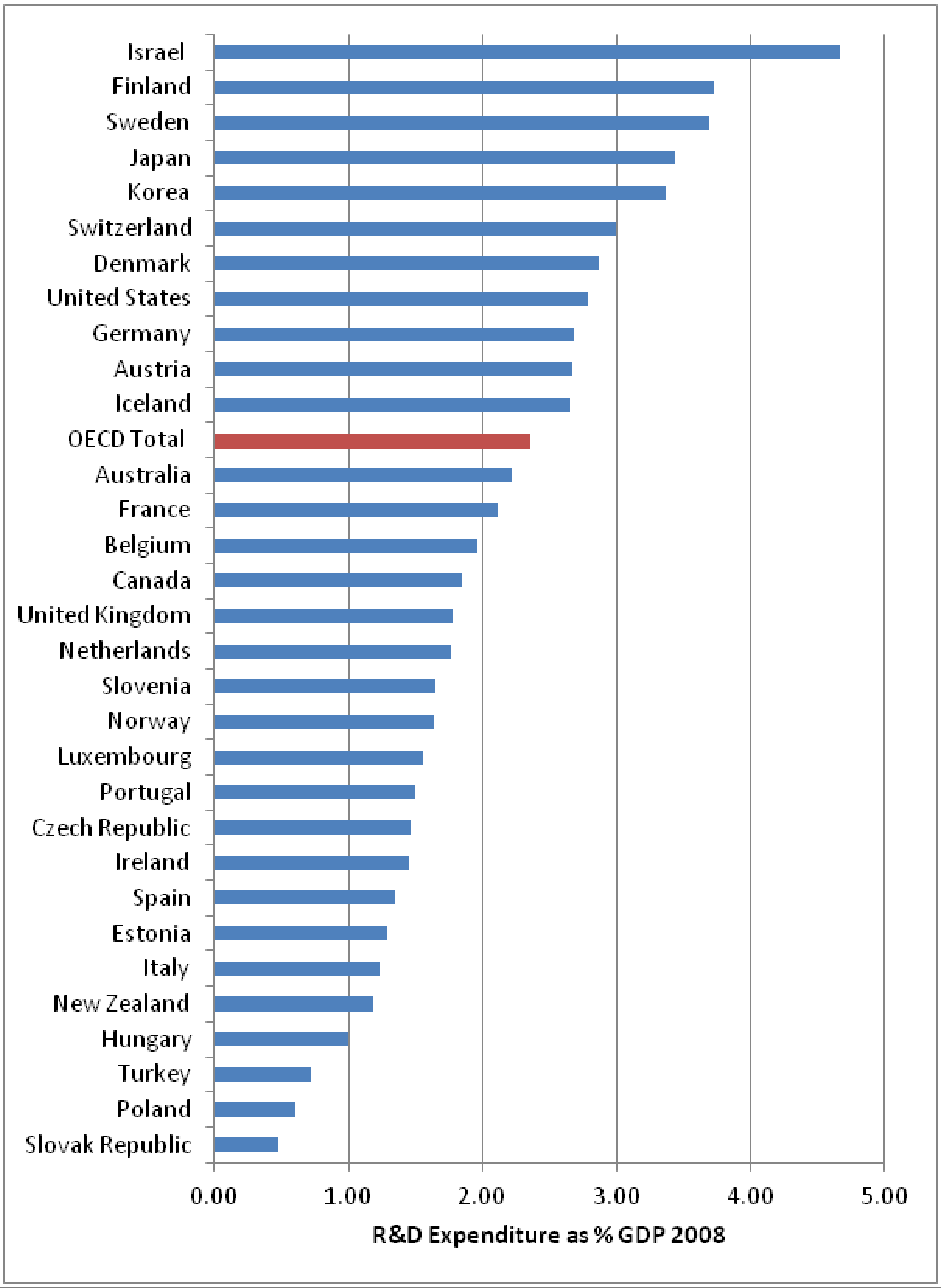
Although exports of mineral fuels have decreased in recent times they are New Zealand's leading import. Minerals fuels, machinery and road vehicles are the three top imports by value.

2.2.4 Research, development and innovation

The OECD defines research and development (R&D) to include creative work undertaken on a systematic basis in order to increase the stock of knowledge. Empirical research has established a strong and robust relationship between measures of innovation – such as R&D investment and patent registrations – with firms' market value (for example, see Griliches 1981). Firm productivity has been found to be positively correlated with innovative output (patents leading to commercial application) and that innovative output is, as expected, related to R&D (Crepon, Duguet, and Mairesse 1998). More recently there has been a focus of agglomeration benefits – for example, knowledge spillovers – flowing from externalities associated with spatial clustering of business, underpinned by factors such as infrastructure. The empirical evidence in favour of agglomeration benefits is mixed and Gardiner and Martin (2010) are of the view that spatial agglomeration may not boost national growth. In advanced economies, Krugman (2009) finds that agglomeration may not be a primary source of growth enhancing increasing returns.

A great deal has been written about innovation in NZ over the past decade, and two recent reviews (OECD 2007; Raine, Teicher, and Reilly 2011) provide an understanding of the strengths and weaknesses of current policy and a range of detailed recommendations for improving performance. R&D intensity, measured by expenditure on R&D as a percentage of GDP, is often used as an indicator of an economy's relative investment in generating new knowledge (OECD 2011d). Figure 15 shows New Zealand sitting fifth from the bottom of countries reporting their expenditure in 2008. In 2010 total R&D expenditure in New Zealand was NZ$2,444m, around 1.3 per cent of GDP, an increase of 13 per cent from 2008.

Figure 15. **Expenditure on R&D as a percentage of GDP, 2008**



Source OECD Statistics

According to the latest survey conducted by the Ministry of Science and Innovation and Statistics New Zealand, the business sector spent $1,013 m (an increase of 10 per cent over 2008), slightly over 40 per cent of the total spent on R&D. The greatest area of growth in the business sector was in services which increased by 18 per cent over 2008; driven by a rise in the spending on computer and other service industries (Statistics New Zealand 2010a). By way of contrast, the business sector accounts for around 70 per cent of R&D performed in OECD economies (OECD 2011d), a much higher figure than in New Zealand. Spending on R&D by the government sector was NZ$629m, or 25 per cent of the total, approximately equally split between basic (roughly, 'blue sky'), applied (targeted), and experimental development. Seventy-two per cent of R&D expenditure fell under what was described as 'applied and experimental development' in 2010.

Innovation, as defined by Statistics New Zealand, includes the development or introduction of any new or significantly improved activity for the business (Statistics New Zealand 2010a). This includes products, processes, and methods that the business was the first to develop and those that have been adopted from other organisations. Innovation rates, defined as a percentage of firms in a sector undertaking innovation, is summarised in Table 1. With the exception of firms in the industry classified 'professional, scientific and technical' the innovation rate in 2009 has dropped from 2007. Overall, the innovation rate remains at 46 per cent.

Table 1. **Innovation rates (percentages)**

Industry	2007	2000	Change
Total agriculture, forestry, and fishing	34	32	↓
Total manufacturing	58	57	↓
Total wholesale trade	57	56	↓
Total information media and	65	60	↓
Total financial and insurance services	59	51	↓
Total professional, scientific, and technical	48	50	↑
Overall	46	46	–

Source: Statistics New Zealand (2010a)

Table 2 shows that most innovations are developed within the business entity, with confidentiality agreements being the main means of protecting intellectual property. It also appears that New Zealand business tends to favour organisational and process innovation over product innovation.

Table 2. **Innovation type, percentage**

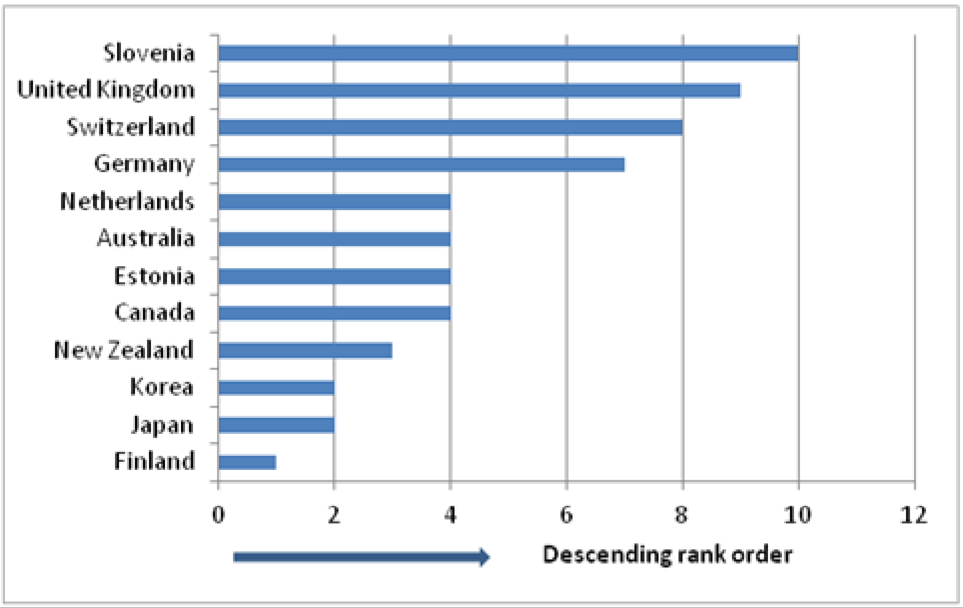
	Developed by the business		Developed by business in partnership with others		Obtained from others and significant improvements made		Obtained from others and no significant improvements made	
	2007	2009	2007	2009	2007	2009	2007	2009
Product	56	58	27	27	17	17	19	15
Process	61	56	25	23	19	24	14	12
Organisational	68	66	24	23	15	17	7	7
Marketing	52	62	36	35	15	13	14	8

Source: Statistics New Zealand (2010a)

2.2.5 Education

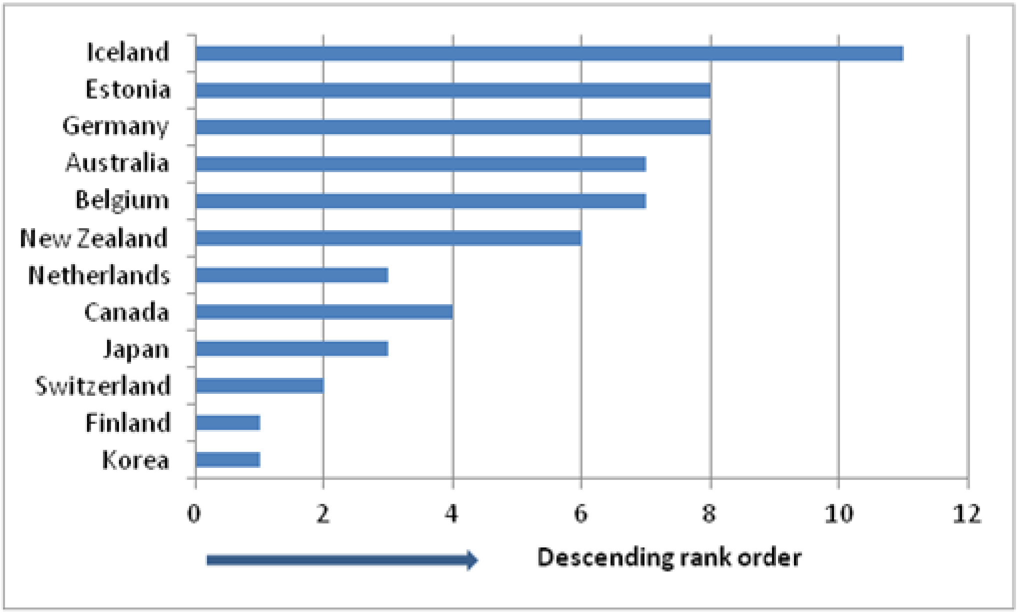
Drawing on the idea that human capital contributes to economic performance we use Figure 16 and Figure 17 to highlight the standards achieved in science and mathematics in NZ. Relative to a selection of countries in the OECD, New Zealand scores very well in science and well in maths.

Figure 16. **Performance in science**



Source: OECD Statistics

Figure 17. **Performance in mathematics**



Source: OECD Statistics

2.2.6 Income distribution

Comparisons with other OECD countries use generally the Gini coefficient; a score of 100 indicates perfect inequality and a score of zero indicating perfect equality. The most recent OECD comparison (from 2004) gives New Zealand a score of 34, indicating higher inequality than the OECD median of 31 and a ranking of 23rd equal out of 30 countries. New Zealand’s Gini score was below that of the United States (38), very close to those of the United Kingdom (34) and Ireland (33), a little above those of Canada and Japan (32), and a little further above that of Australia (30). Denmark and Sweden had the lowest income inequality with Gini scores of 23.

2.3 Concluding comments

An economy whose trading position is built upon ecosystem services and whose people are increasingly engaged in business services

Growth models provide an understanding of important elements of growth and the aim of this overview is to characterise the outcomes of New Zealand's economy. Indicators such as GDP per capita show an upward trend in the order of two per cent a year. Since 2000 there has been major shift away from manufacturing, both in terms of contribution to GDP and employment. Data show that the Property and Business Services sector, by far, dominates in terms of contribution to GDP. Data on exports show the large, sustained contribution of products from agriculture and resource-based industry. Bearing in mind the decline of Manufacturing, this should raise questions about the capacity of the primary sector coupled with the Property and Business Services Sector to increase GDP and contribute to wellbeing. Imported petroleum products and manufactured goods, including vehicles, dominate imports, meaning that NZ is exposed to changes in oil prices.

In terms of R&D, Innovation and Education, it would appear, on the surface at least, that the quality of our educated population is not being transformed into activities linked to R&D and Innovation. There is an opportunity to build on recent reviews of innovation in NZ by targeting an average share of R&D in GDP and adopting policies for green innovation **(green growth opportunity 1)**. The government's plan to develop a 'unified, cross-government innovation plan based on the OECD's model of innovation policy' (Ministry of Science and Innovation 2012:10) is a positive step and the plan could draw on the recommendations from these recent reviews. Green innovation could be a focus of any overall plan.

These observations suggest that an accelerant for economic growth lies in the value adding part of production, utilising our talented scientists and technical skills. There are limits associated with increased output from resource-based enterprise. New Zealand has a finite land resource, access to water in some areas is now limited, and there is growing concern over the off-site impacts associated with intensive agriculture. The above indicators do not measure these affects, which are discussed further in the agricultural case study in section 4.5.

By and large, the New Zealand economy is based on the flow of services provided by its natural environment. Agriculture, fisheries, forestry, tourism depend on the quality and well-functioning of the natural assets that underpin economic activity. For tourism in particular, New Zealand's 'clean, green' image is a crucial part of its marketing to overseas visitors (Ministry for the Environment 2001). Just as importantly, the health and well-being our individuals and communities depend on the quality of the environment.

The economy is relatively open and depends to a large degree – for its primary industries, at least – on the functioning and integrity of its unique ecosystems. Global economic activity is dynamic and increasingly interdependent, as evidenced by the recent global downturn. By way of illustration, the dairy industry, as a major exporter, makes a significant contribution to the New Zealand economy. The contribution of dairy farming to economic welfare depends inter alia on international markets, access to water (natural capital), fertilizer and energy (manufactured inputs), managerial skill (human capital), and irrigation and milking systems (manufactured capital). Welfare also depends on the (unintended) impacts of production on local ecosystems, such as ground water, and natural habitats. Concerns over the contribution of emissions to climate change are evidenced by the proposed inclusion of agriculture in the ETS. Dairy farming in not unique in this regard because similar reasoning, involving different dimensions, applies to most forms of economic activity be they production or consumption.

Economic and environmental outcomes associated with production and consumption are closely related to policy and the institutions of society. For many years now New Zealand has embraced the competitive market model, removing subsidies from production and adopting light handed regulation. The removal of subsidies that distort the allocation of resources is consistent with green growth (OECD, 2011). In order to sustain and further enhance economic growth it is becoming increasingly evident that we must focus on the natural and environmental resources that underpin our welfare, and the welfare of future generations. The focus on green growth will bring into light contemporary challenges, and the institutions and policies that serve us well and those that require attention. One key message from macroeconomic growth models is that human capital and innovation, which underpin technological progress, have a key role to play in green growth (Brock and Scott Taylor 2011).

3 Green growth concepts and measurement

The foundations for the interpretation of data

Section Contents:

Introduction

A conventional economic growth framework, centred on a concern about wellbeing, can be improved by extending it to cover changes in capital assets, and goods that are not traded in markets. This turns it into a green growth framework.

Good environmental policies in New Zealand enhance wellbeing for its nationals, measured under a green growth framework, except when the environmental impacts cross international boundaries. In doing so, they reallocate resources across uses and over time.

The shift from conventional to green growth introduces considerable measurement challenges, so some, but incomplete progress can be made with the data that is available. It gives an indication of how resources might shift if there were to be a movement of policy from conventional growth towards green growth, and in particular whether the gains that New Zealand enjoys from trade might be enhanced or diminished.

'A good quality growth metric has to take into account capital and contributions to wellbeing that are not traded in markets.'

3.1 Introduction

The structure of this section

Section 1.2.3 introduced the working definition of green growth used in this report, namely ‘growth which maintains or improves wellbeing while staying within ecological constraints’. This section sets out the ideas behind green growth, describing the relationship between consumption and wellbeing, and between the environment, production and wellbeing. It also comments on the role of trade.

The section goes on to lay out the parameters of green growth, and selects a set of sectors which will be the primary focus for later analysis. These are sectors in which New Zealand has comparative advantage and therefore contribute a large proportion of value added from exports.

3.2 Conceptual framework

The economics of green growth

3.2.1 Introduction

The purpose of policy is to protect and enhance the wellbeing of people. In order to achieve those ends, it is necessary to understand how wellbeing is created, how improvements in wellbeing come about, and what the role of the state (and policy) is in enhancing outcomes. Standard economics is at hand to help us. Here is the standard economic treatment, in a nutshell.

Wellbeing is the result of consumption of many goods, some bought in markets. The goods purchased in markets are all ultimately bought with income arising from wages (labour), payments to owners of the land and physical capital used to produce output, or the consumption of natural capital.

Now it happens that the productivity of labour is enhanced by combining it with capital, and also that workers like to save to spread their consumption over their lifetimes. Hence the joined practices of investment and saving form part of the system. The formation of capital that results turns out to be important.

Just as the current generation (in most countries) benefits from capital endowments that are natural as well as manmade, passed on from previous generations, so it passes on an endowment to the next generation. If each generation passes on more capital (per capita) to the next, the fortunate later generation can apply its labour and realise greater output and income. In this way, the consumption and wellbeing of subsequent generations grows over time and is raised above that of the previous generation.

This elegant mechanism of raising welfare, driven by the laying down of capital, applies equally to goods traded in markets and those that are not. Let us call these latter type non-market goods: they include family relationships, social networks, environmental goods, and so on. While it is usual to measure rising output of market goods and call it 'growth', now let us extend the measurement to encompass environmental goods and call it 'green growth'.

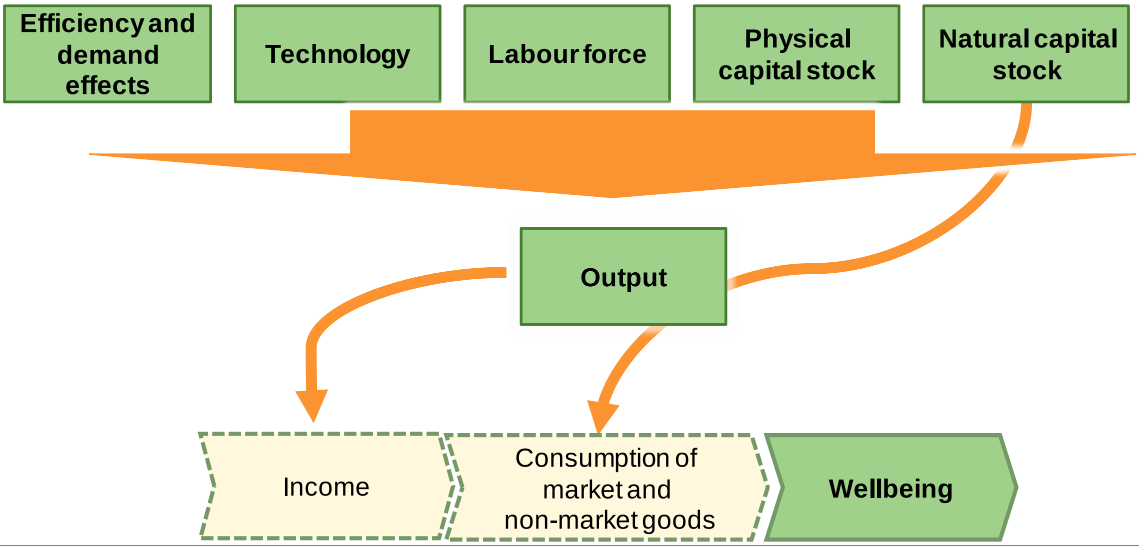
3.2.2 Consumption and wellbeing

This mechanism can be written down formally, mathematically, but it will be more useful here to represent it in pictures, and to draw assurance from the fact that there is mathematical rigour behind it. The discussion here draws on the presentation in Hallegatte et al. (2011) and World Bank (2012b).

The building blocks of this framework must include labour and capital. To make the effects of green growth policies explicit, capital is divided into physical capital and natural capital (not made by people), and to be explicit that the way in which labour combines together, and combines with capital is described by the technology available, and the way in which markets, the state and the economy as a whole organise themselves to produce output.

Labour and services from physical and natural capital are combined in a particular way and with a particular level of efficiency and produce output, and it is the consumption of part of this output (the rest being put aside and saved) that translates into one part of wellbeing. This is the first part of the framework, Figure 18.

Figure 18. **The contributions to consumption and wellbeing**



Source *Vivid Economics*

This framework gives us the basic components, but the aspect of central interest here is the contribution of the environment to wellbeing, so the next step is to build that into the framework. This is quite easily done.

3.2.3 The five influences on production

The environment comes into play in several ways. Most directly, it produces environmental goods that are consumed directly, such as water, fish, landscape and so on. Indirectly, it affects the people's preferences between work and leisure (the quality of leisure opportunities), their availability to participate in employment (health), the amenity benefits of the environment and the availability of natural goods and capital as an input to production. Putting aside the production effects, which will be elaborated further in a moment, this furnishes a list of environmental consumption effects, namely:

– amount and quality of leisure;
– health benefits (other than those captured in output);
– other amenity benefits.

These effects can be important, but because markets cannot be relied upon to take them into account (for example, because some are public goods and others are externalities), the state often intervenes to secure an acceptable outcome. When the state intervenes, it does so by issuing rights, setting prices, prescribing processes and so on. The effect is to change the pattern and level of consumption. In the short and medium term the pattern of consumption shifts towards goods with lower environmental production costs, meanwhile some consumption is exchanged for investment, with income funding capital to raise environmental efficiency or expand natural assets. From these routes arise associated, second order impacts on the organisation of the economy, with their own repercussions for consumption.

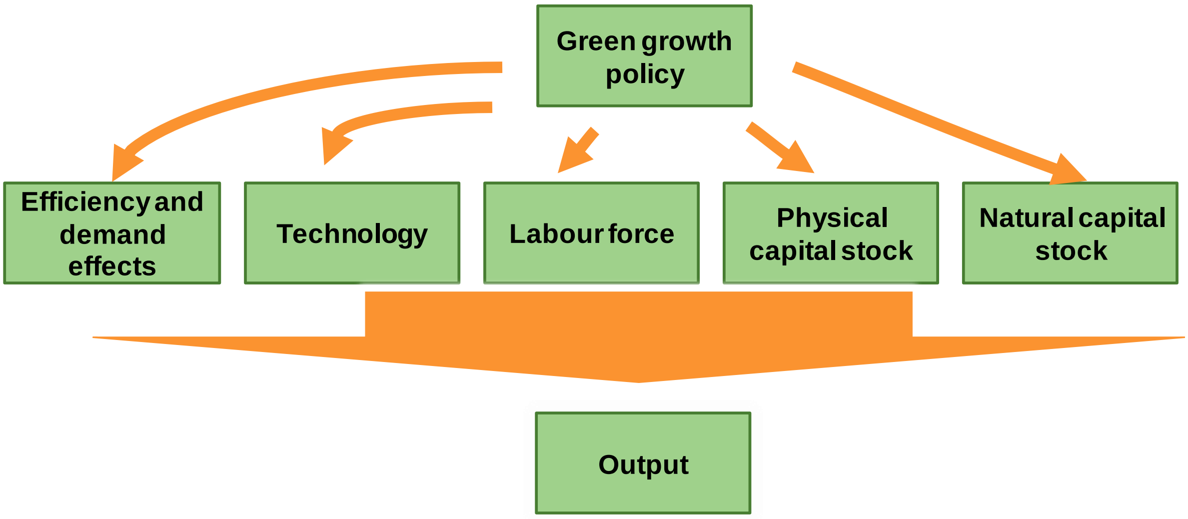
It will be easier to understand the effects of state intervention after seeing some examples. Examples of the direct effects of green growth policies on natural assets include energy efficiency policies which reduce greenhouse gas emissions and fishing quotas which increase the number and size of fish. Examples of the indirect effects of green growth policies on the other four aspects of production include the effect of:

- climate change mitigation policies on the physical capital stock, which can be negative in the short run as investment is diverted into emissions reductions, but positive in the medium term, for example if mitigation maintains the productivity of agricultural capital;
- environmental policies that raise urban air quality on human health, which can affect the labour force by reducing days lost due to illness;
- environmental policies on technology and intellectual capital, for example if carbon pricing enhances incentives for the development and deployment of low-emissions technologies;
- green growth policies that create efficiency and demand effects, such as energy efficiency policies that raise resource efficiency across the economy and green fiscal stimulus policies which raise overall employment and output if there is spare capacity in the economy.

The overall effect of a green growth policy depends on the relative size and duration of the positive and negative effects. The effects total five in number, as shown in Figure 19, namely:

- an effect to raise or diminish the natural capital stock;
- a change in the allocation of investment across physical capital stock;
- a change in the availability and propensity to work of the labour force;
- adjustments to the technology with which the inputs of production are combined;
- improvements in efficiency for a given level of other inputs and technology or increases in short-run demand (caused for example by an effective ‘green stimulus’ program).

Figure 19. **The five influences of environmental policies on production**



Source: Vivid Economics

So, in summary, there are a number of non-market effects such as health and amenity, some of which might be difficult to measure and harder still to monetise, and a set of market effects which may be no easier to measure, but straightforward to monetise.

Economists agree among themselves that a necessary condition for non-declining wellbeing per person is that the stock of capital per person does not fall over time. Their views differ over whether and how much some forms of capital can be substituted for one another, for example whether or not increases in human capital can substitute for reducing stocks of non-renewable fossil fuels. However, there is agreement that no suitable substitutes exist for some types of environmental capital, such as a liveable climate, and so these must be maintained over time.

3.2.4 The role of trade

So far, the discussion has been implicitly as if the country, New Zealand, is a closed economy, without any links overseas. Since New Zealand is a trading nation, let us now show how this framework applies in an open economy. There are several preliminary points of understanding.

First, the overall balance of payments of New Zealand, which is made up of two sub accounts for consumption and investment goods, must always be zero, so any purchase made from New Zealand by a foreigner must be balanced by a purchase by a foreigner from New Zealand. It does not matter whether these purchases are of consumption goods or investments.

Second, trade matters to the wellbeing of New Zealanders because the price of imported goods may be lower than the cost of goods produced at home, and the same logic induces foreigners to purchase New Zealand's goods and services. It matters to New Zealand that it can produce *some* goods and services at a lower cost than its trade partners, in order that it may purchase *other* goods and services in return. The corollary of trade is specialisation. Trade contributes to growth, or higher wellbeing, by obtaining more wellbeing for the endowment of labour and capital resources that New Zealanders possess.

How does this change when viewed through the lens of green growth? It changes insofar as the costs of production would be changed by policy, so that the aggregate benefits from trade are changed by the subtraction of higher or lower costs, or insofar as depletion of capital might attenuate the opportunities for production in the future. For example, if a carbon charge is levied on imports by an overseas consumer, it reduces the value added by the export of that good and as a consequence less investment and employment will be channelled into the production of those goods for export. For another example, if forest stocks diminish, the future timber production capacity will be lower.

A final example of looking at trade through a green growth lens is the example of oil imports. Greater self-sufficiency in energy supply might bring macro-economic benefits to New Zealand. A benefit arises because wealth that is not spent on imports can be spent on own-produced goods and services instead, boosting the domestic economy. The benefit will be greater and more immediate the greater the proportion of the wealth that is spent on consumption goods and services produced in New Zealand. A longer term benefit will be seen if some of it goes to internal investment.

As this report will stress, whether this is of benefit to wellbeing not just production is a different matter. A policy proposal to reduce imports of a consumer good with the aim of producing it domestically instead would generally encounter opposition for the reason that this would simply result in the good being produced less efficiently at home, lowering the overall consumption possibilities available to NZ residents. There is one thing that makes fossil-based energy special in this regard: the social costs of greenhouse gas emissions.

These benefits have been estimated in Europe. The specific analysis concerned changes in energy taxation in Europe, resulting in shifts away from energy and from fossil fuels in particular (see Vivid Economics. 2012a). The estimates reveal a difference between countries which extract fossil fuels and those others which do not. Those such as Spain who rely heavily on imports experience an expansion of their economy as energy consumption contracts and is replaced by an increase in consumption of own-produced goods and services. Those countries such as Poland for whom imports are a much smaller share of supply miss out on these benefits because they substitute one domestically-produced good, energy, for other goods. In all cases the effects persist for a number of years before dissipating as relative prices adjust. This evidence suggests a macro-economic benefit can be harvested by cutting consumption of fossil fuel imports in exchange for greater domestically-produced power.

3.2.5 Policy conditionality

Let us continue with the theme of changes brought about if a policy were introduced. The effects would depend upon its strength (how severe or lax it is) and who introduced it. First, consider the effects that policy action taken by others might have. For example, foreign states might impose sanctions or charges on imports coming from countries whose environmental policies they deem inadequate, such as the border carbon adjustments included in some of the bills proposing an emissions trading scheme in the United States. It need not be governments that act: firms purchasing inputs could demand higher environmental standards as a condition of purchase, as has happened with some large food retailers. Alternatively, consumers might incorporate environmental performance into their purchasing preferences, by demanding organic food and other differentiated products. Second, contemplate the effects of policy made in New Zealand, such as its emissions trading scheme. These might raise the production costs of some goods in New Zealand relative to others. One can imagine a number of combinations of policies within and outside New Zealand, with a myriad of costs and benefits across sectors, affecting the mix of outputs which New Zealand produces.

Indigenous policies within New Zealand, if they are chosen well, will enhance wellbeing. Policies introduced by foreign governments, if they reduce (enhance) the value of New Zealand goods in overseas markets, would reduce (increase) wellbeing in New Zealand. An example is shown in 3.2.6. Any policies of foreign or New Zealand's own government that divert resources into capital formation may exchange wellbeing today for greater wellbeing in the future. One would hope that New Zealand's own policies would in aggregate over time enhance wellbeing.

These arguments show that any policies could contribute to or detract from green growth and the attribute which differentiates green policies from others is solely that they affect those aspects of wellbeing that are captured under a green account of consumption but omitted from its conventional version.

Table 3. **The benefits and costs of NZ's environment policies**

World	**New Zealand**	
	Acts	**Does not act**
Does not act	Benefits to NZ: lower financial costs from improvements in energy efficiency; improved health and amenity from reductions in urban air pollution Costs to NZ: increased input costs without sizeable environmental benefits given NZ is small proportion of global emissions	Costs to NZ (and world): likelihood of severe damages from dangerous climate change
Acts	Benefits to NZ: all of the above, along with reduced risks of severe damages from dangerous climate change; possible comparative advantage in growing low-carbon markets	Benefits to NZ: reduced risks of dangerous climate change Possible costs to NZ: effects resulting from other countries' mitigation policies, such as reduced access to markets and reduced demand for NZ's emission-intensive export goods

Source: Vivid Economics

3.2.6 Perspective

The perspective taken in the discussion above and in the following analysis is across the whole economy. There may be changes in wellbeing and the balance of output between sectors as a result of policy, but not changes in overall employment. To be more precise, permanent changes in overall employment levels would only come about in rather restricted circumstances (other than a change in the working age population), one of which is by altering the way in which the employment market responds to employers' demands and the other through a change in individuals' propensity to work. Other effects, such as a fiscal stimulus, are likely to have a temporary effect on employment levels.

3.2.7 Time horizons

There is one more dimension to be brought into the analysis, and that is time. Since output involves the utilisation of capital, choices about the type and amount of capital investment affect the profile of consumption over time.

For example, the short-run effect of some pollution mitigation policies can be to increase the capital stock as surplus is diverted into mitigation, and consumption is reduced, so that employment in some industries may grow less quickly than without mitigation action. However, over longer time horizons, wellbeing is expected to be higher with good quality mitigation policies than without.

3.2.8 Summary

In summary, the benefits of green growth policies do not always show up rapidly as higher growth, and higher short-run growth should not be a necessary criterion for a good green growth policy. This is because conventional measures of growth do not measure the state of the economy's stocks of wealth, and many valuable environmental outcomes are not traded in markets, so improvements do not appear as growth. A green account addresses these deficiencies.

The channels through which benefits accrue and their timing describe where and in what form people may expect to see benefits from environmental policies. They ought not to expect green growth policies to be always directly additional for the economy as a whole, because in some cases, such as climate change, the benefits lie outside New Zealand and are contingent on the actions of others. Nor ought they to expect additional jobs except in specific circumstances, since many of the effects will be to change the allocation of resources around the economy rather than to create additional employment.

3.3 Parameters to be measured

Economic accounts are transformed into green accounts

The purpose of this section is to concisely re-cap how standard economic accounts, in particular the GDP measure of output whose movement is usually described as ‘economic growth’, can be transformed into green accounts. It replays the conventional definition and then defines two extensions which together make up the transformation.

3.3.1 Conventional market output

Conventional economic output is already reported in national accounts as gross domestic product (GDP). This measure describes the sum of all production activity in the economy. This sum is identical to the sum of all final expenditures within the economy, or can instead be described as the sum of all income generated by production within the economy. GDP is not a direct measure of welfare. It does not show to whom the income is due: it does not subtract that amount which goes overseas and nor does it add the income received from overseas. Once those adjustments are made, the figure is known as gross national income (GNI). Further adjustment can be made by subtracting the capital used up in production. This yields the equivalent net figures, net domestic product and net national product.

3.3.2 First extension: non-market goods and services

The conventional accounting measures already encompass *non-market* services such as public education, defence and health care, albeit by measuring the cost of production rather than the value of services produced. However, these conventional figures omit completely the consumption of non-market services for which there are no market costs of production. Examples include the consumption of atmospheric climate regulation services through the emission of carbon dioxide (which has only recently become a market-traded good in some countries) or pollution of water resources. Principal among these non-market goods are environmental goods. If these can be measured, which they often can, then they can stand alongside as a complementary description of output. Moreover, if they can be valued, which is less common, then they can be incorporated into the conventional output measures to create a green output measure.

3.3.3 Second extension: natural capital

Onto this sum, one can add natural capital stocks that contributed to wellbeing. There is a broad consensus that indicators for green growth and sustainable development should measure natural capital, as part of a capital- or wealth-based approach to sustainability, for example see (Stiglitz, Sen, and Fitoussi 2009; OECD 2008b; OECD 2011a). The way of going about measuring the stocks of natural capital remains an open question. The World Bank constructs a single measure which allows the value of a country’s physical, human and natural capital to be compared in monetary terms (Bolt, Matete, and Clemens 2002), while Stiglitz et al. prefer a ‘dashboard’ of sustainability indicators (Stiglitz, Sen, and Fitoussi 2009). European countries follow the dashboard approach, drawing from a wide range of sustainable development indicators, some relating to natural capital. The most parsimonious European country uses only 16 indicators, while the most profligate has chosen to have 163 (United Nations Economic Commissions for Europe 2009).

In this study, the stocks and changes in stocks of important natural capital resources are identified and where possible recorded. They are supplemented by indicators of the efficiency with which key natural materials are used. New Zealand’s principal natural capital assets and their uses are:

- hydrocarbon reserves (energy supply);
- atmospheric greenhouse gas stock (temperature regulation);
- marine fisheries (fish protein);
- biodiversity (agriculture, tourism and leisure);
- forest cover (wood products);
- other landscapes (tourism, agricultural production; amenity values for residents, and so on).

3.4 Choice of metrics and comparators

New Zealand's revealed advantage and the greenness matrix

3.4.1 A selection of comparator countries

New Zealand's environmental performance is compared against other countries in two groups. The first group is a selection of OECD countries, chosen because of their similarity in size or agricultural specialisation. The second group is a collection of countries which are known to be rival exporters to New Zealand's main export markets. The rivals are listed in tables in the Appendix.

3.4.2 The measurement of comparative advantage in conventional market terms

Comparative advantage is defined as the degree of specialisation in the production of a good for export. In this report, the measurement of conventional comparative advantage and environmental performance uses existing and new approaches and takes into account current performance and trends. The approach is explained here.

The measurement of comparative advantage is well established. The conventional measurement of comparative advantage is applied to NZ's merchandise export industries but it cannot be applied to services exports due to lack of data. Instead, an overview of the services sectors is provided. In contrast, the measurement of green competitiveness is here is new, for there is no standard technique for assessing the environmental impacts of industries.

Before describing the measurement of comparative advantage in more detail, it is important to understand the subtle distinction between this, relatively easy-to-measure metric, and the more commonly discussed, more-difficult-to-measure term, competitiveness. The term competitiveness is not always well understood. Competitiveness describes 'margins' (that is, the excess of revenues over input costs) at the firm or industry level. Moreover, in sectors where the goods are homogenous and there is a single price, high competitiveness equates to low costs, especially costs for an additional unit of output. This is a firm-level concept which does not translate easily or well to country level. For this reason, and because it is hard to measure, let us focus on comparative advantage.

Comparative advantage is relevant only at country level. It identifies sectors that are more productive relative to their international rivals when compared with other New Zealand sectors and their peers. A country's degree of specialisation in an industry is a measure of the sector's comparative advantage within the economy, when compared to its international rivals.

There are many reasons why countries can have a comparative advantage in making a product. Examples include differences in production technologies and resource endowments between countries, and the ability to produce at scale lowering the unit cost of production. These advantages are generally reflected in higher exports for that good relative to country's overall share of world trade. This means that an index of trade specialisation can be used to measure the comparative advantage of NZ industries and the index chosen here is the Balassa Index.

The Balassa Index (BI) of revealed comparative advantage was developed by the economist Bela Balassa in 1965. It is a simple index. For any country, the index measures the proportion of exports from a sector relative to the country's overall share of world trade:

- if a country's share of the global market for that sector is larger than its share of overall world trade, the BI is above 1 for that sector, indicating that the country specialises in it;
- the higher the BI, the more specialised the country is in a sector;
- a country can produce a lot of something and not specialise in it: this occurs if the *absolute* amount of exports from the sector is large, but the country's market share in the sector is smaller than the country's share of world trade averaged across all sectors.

Other measures of specialisation exist, such as the Michaely index, which would give similar results for New Zealand, but the BI is the most commonly used. Nevertheless, the BI has two limitations. First, results from different countries cannot be directly compared: a country with a BI of 4 is not twice as specialised as a country with a BI of 2 for the same commodity. Second, changes in the BI over time will not always reflect changes in specialisation. Here, the index is constructed for a single year, so its stability over time is not an issue. The results are shown in section 3.5.

3.4.3 The measurement of competitiveness in services

As mentioned above, as the set of countries reporting data on services trade in COMTRADE is smaller than that for merchandise trade, robust Balassa indices cannot be constructed, and yet, services are important with data from Statistics New Zealand in 2011 showing that services accounted for 21 per cent of NZ exports, a fall from a level of 28 per cent in 2006. These service exports include international tourist expenditure in New Zealand (54 per cent of service exports) and non-residents' passenger and freight transport (20 per cent).

Without suitable world trade data, one can refer instead to indices constructed by others. For example, the World Economic Forum (WEF) publishes a cross-country measure of competitiveness for the travel and tourism sector. WEF's Travel and Tourism Competitiveness Index has a broad range of sub-indicators and covers 139 countries. It is available for 2011, 2009, 2008 and 2007. It aggregates a large amount of information related to countries' attractiveness as tourist and travel destinations, ranging from ATMs accepting Visa cards to the effect of HIV/AIDS on business. This is structured under three headings addressing: first, regulations, policy and safety; second, infrastructure and price; and lastly, education and training, natural and cultural resources. The results from this index are presented in section 3.4.2.

3.4.4 The measurement of green competitiveness in merchandise exports

The next area of the assessment is environmental performance or green competitiveness. This is a measure of absolute performance, hence it is a measure of competitiveness rather than comparative advantage. It is estimated at sector level. The assessment of environmental performance involves four steps and the analysis is applied to dairy, livestock, fruit and nuts, forestry and fish, since these are four of the largest sectors contributing to GDP and to exports, see Figure 12.

The green competitiveness analysis is performed in three steps, selecting the rival countries, identifying the key impacts and choosing indicators for those impacts. There is no need to proceed beyond physical measurements because economic valuations are not available.

– The first step is to select rival countries. The selection comprises the eight largest exporters to New Zealand's main export market or 75 per cent of the global market, whichever is larger. The rivals are identified using trade data at a high level of disaggregation (the three-digit Standard International Trade Classification level). For example, one sector is defined as the 'production of cheese and curd' rather than aggregated to the 'production of dairy products'. Thus the rivals identified are sure to be genuine competitors in NZ's export markets.

– The second step is to identify key environmental impacts for each industry, restricting coverage to the main impacts of each industry.

– In step three, suitable indicators of those impacts are chosen, taking into account what indicators are available for New Zealand and its rivals. The indicator values are analysed in step four, for each industry and indicator over time and the result is a matrix of New Zealand's environmental performance against its rivals, see Table 4.

This matrix ranks New Zealand against its rivals. Each indicator in each sector is assigned to a position in the matrix. There are four positions in the matrix, which for ease of recall have been named as follows:
– *green*: high and steady or improving environmental performance relative to rivals;
– *green with risks*: high but declining performance;
– *not green, could worsen*: poor and deteriorating performance;
– *not green, may improve*: poor but improving performance.

The rows in the greenness matrix below assess NZ's environmental performance relative to its industry rivals and the columns assess New Zealand's performance over time. Two tests are applied which allow indicators to be assigned to one of the four positions. First, if New Zealand is ranked in the top third of rivals on that indicator, NZ is labelled 'relatively green' on that indicator. Second, if the change in the indicator between the last two observations is improving or steady, NZ is 'improving or steady' on that indicator. The annual time series are smoothed so that this assessment is based on the trend in performance rather than year-to-year variation. The Appendix contains details of the indicators and rivals for each industry, and a worked approach using an example indicator.

Table 4. **The greenness assessment matrix**

NZ performance relative to rivals	**Change in absolute performance**	
	Deteriorating	**Steady or improving**
Relatively green	Green with risks	Green
Not relatively green	Not green, may worsen	Not green, may improve

Source: Vivid Economics

Data availability limits the precision of some of the agricultural indicators. In particular, water and fertilizer use cross-country data are only available for agriculture as a whole. Where this is the case, variations between New Zealand and its rivals in a sub-sector could be due to either the differences in the composition of agriculture between the two countries or the relative efficiency of resource use within an agricultural sub-sector. The more similar the composition of agriculture is between the two countries, the more likely it is that variations in the indicator reflect differences in resource efficiency in a particular sub-sector, and thus the more reliable the indicator.

3.5 Revealed comparative advantage

New Zealand's specialisation in agriculture and tourism

3.5.1 Manufacturing

The Balassa Index indicates that the production of agricultural goods has the greatest comparative advantage in New Zealand. The five largest sub-sectors in which there is a revealed comparative advantage are also within the agriculture sector, see Table 5. These together made up 44 per cent of merchandise exports (around one third of total exports) in 2009. A range of manufactured goods also exhibit comparative advantage.

Table 5. **New Zealand's dairy and meat industries exhibit the strongest comparative advantage**

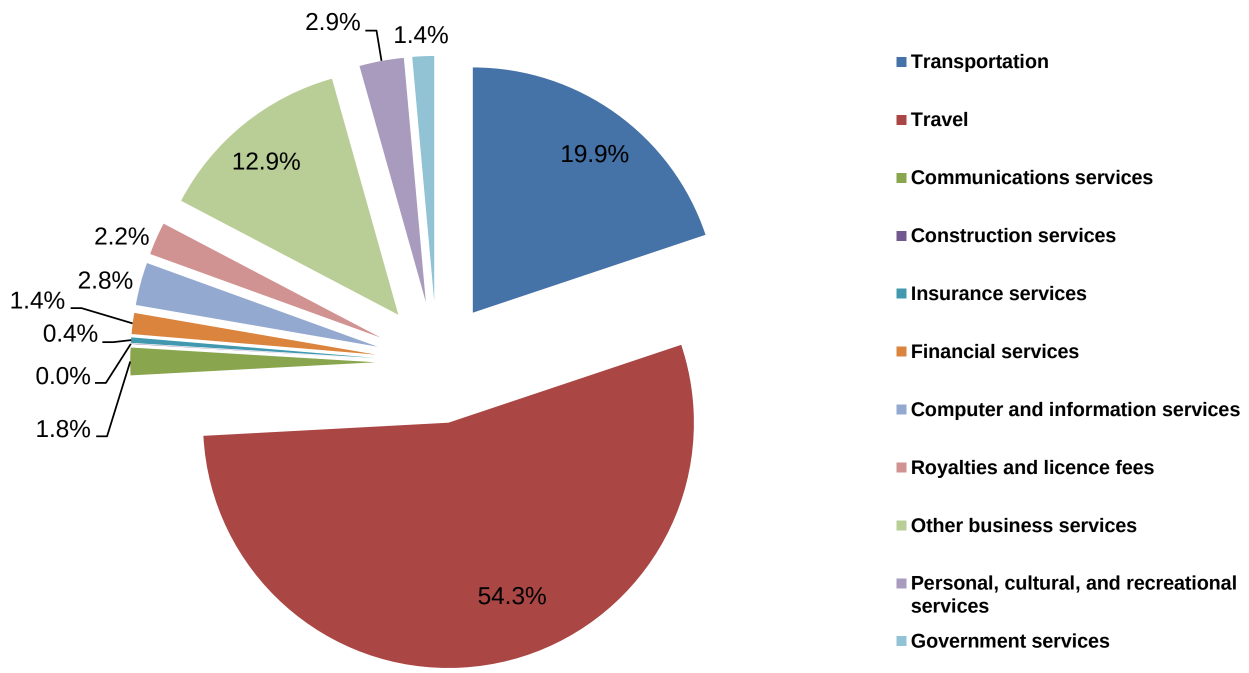
Sub-sector	Proportion of exports, percentage	Balassa Index
Milk and cream and milk products other than butter or cheese	13.1	58.4
Other meat, meat offal, fresh, chilled, frozen (for human)	8.4	19.6
Meat of bovine animals, fresh, chilled or frozen	4.5	19.5
Fruit and nuts (not including oil nuts), fresh or dried	4.0	7.8
Butter and other fats and oils derived from milk	3.8	99.3
Edible products and preparations, not elsewhere specified	3.5	9.2
Cheese and curd	3.4	18.8
Alcoholic beverages	2.8	6.0
Starches, insulin and wheat gluten; albuminoidal substances; glues	2.7	18.9

Source: Vivid Economics analysis based on UN COMTRADE database

3.5.2 Services

Transport and travel contribute three quarters of the value of services which New Zealand exports, see Figure 20. There are very few other service exports other than some miscellaneous business services.

Figure 20. **Three quarters of service exports are transport and travel, 2011**



Source Statistics New Zealand, imports of services data

New Zealand's clean, green image is a critical part of its marketing to international tourists and for ecotourism in particular.[10] While constructing estimates of the monetary value of the brand is difficult the Ministry for the Environment's (2001) made a detailed attempt, estimating the financial impact of a perceived deterioration in NZ's environment on the dairy, international tourism and organic food sectors. Estimates of the value of the clean green attributes of the brand to NZ tourism were derived from a survey of outbound tourists from Australia, the US, UK, Japan and Korea. Respondents were asked how a deterioration in environmental quality would affect their decision to visit NZ and the duration of their stay, with the responses translated into expected losses to the tourism sector should such a perceived deterioration occur. While the responses vary by nationality and purpose of visit, the survey provides quantitative support for the

[10] For a definition of ecotourism and profile of ecotourists in NZ, see Higham, Carr, and Gale (2001). While some research indicates that ecotourists spend more than mainstream tourists (for example Wight (1996)), research of the relative profitability of different types of tourism does not appear to be well developed.

proposition that overseas perceptions about the quality of NZ's environment are important for tourism: a sharp deterioration in perceived environmental quality was estimated to result in reduced expenditure of NZ$780m (in 2001 NZD). By way of comparison, total expenditure by international tourists in 2008 was NZ$7,166m (Statistics New Zealand 2012a).

Given the importance of this brand to NZ it would seem worth updating this research and investigating how brand value has changed over time. Research could also illuminate whether there are cost-effective opportunities for leveraging this brand further, particularly in fast-growing Asian markets **(green growth opportunity 3)**. Government and business leaders can also play a proactive international role in in defending NZ's clean green brand and improving performance and policies where there is a mismatch between perceptions and reality **(green growth opportunity 4)**. NZ's clean green image may be important for service and merchandise experts. In some cases, international perceptions may be less favourable than actual performance, for example, NZ's emissions on a per capita basis are high when measured gross and lower on a net basis. In other cases, perceptions of under-performance could be accurate and damage the brand. Within the set of welfare-improving environmental policies, prioritise policy improvements in areas where the gap between actual policy and that expected by key international stakeholders is large and commercially important. An example might be the overall level of NZ's 2020 emissions reduction targets.

There is no data available on revealed comparative advantage of travel and tourism, but the international comparison provided by the World Economic Forum's Travel and Tourism Competitiveness (TTCI) Index offers those readers who would like to explore this topic further some insights. The TTCI and its components are scored from 1 to 7, with a higher number denoting a better outcome. Scores are derived from quantitative data and responses from the World Economic Forum's *Executive Opinion Survey*, reflecting the forum's membership. Hence the index results reflect the preferences of the population which the World Economic Forum samples in its survey. Between 2009 and 2011, New Zealand improved its overall rank and score in the TTCI. NZ's ranking improved across all three sub-indices, as shown in Table 6.

Table 6. **New Zealand scores highly on the Travel and Tourism Competitiveness Index**

	Overall country rank[a]	Score	T&T regulatory framework rank[b]	Score	T&T business environment and infrastructure Rank	Score	T&T human, cultural, and natural resources rank	Score
2011	19	5.00	13	5.60	25	4.80	22	4.60
2009	20	4.94	14	5.55	30	4.62	25	4.65

Note: [a] *ranks are out of 139*

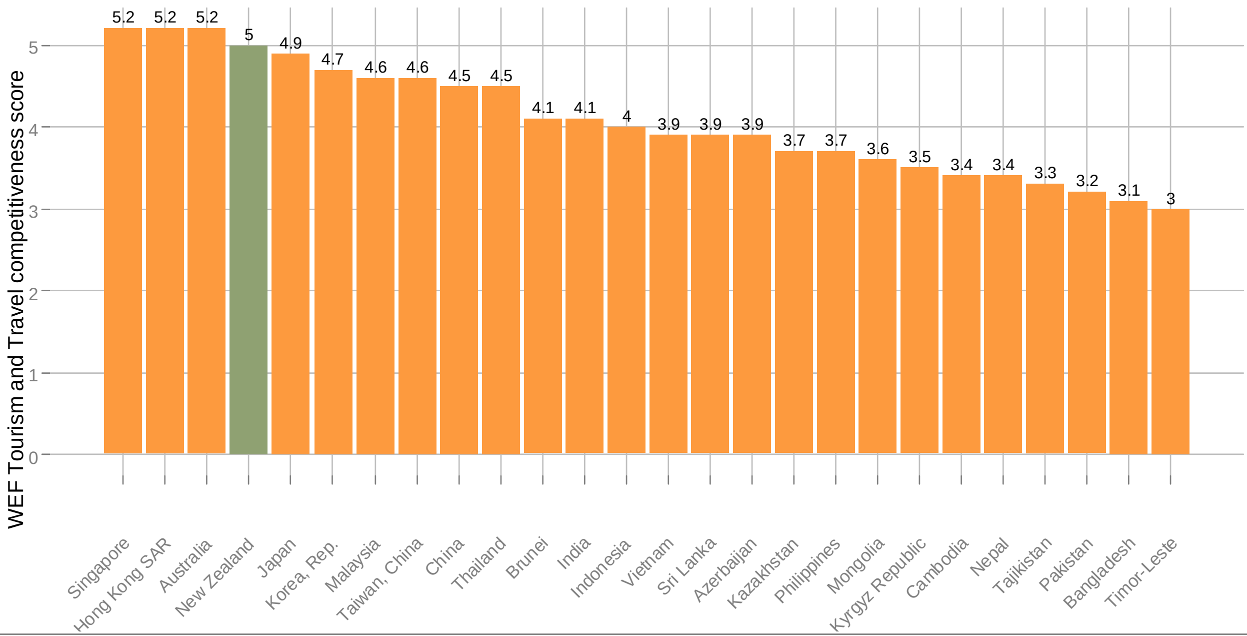
[b] *two new indicators were added to this sub-index in 2011*

Source: Blanke and Chiesa (2011)

New Zealand scores highly within the Asia-Pacific region. The regional leaders are Singapore, Hong Kong and Australia. Internationally, the highest ranked country in 2011 was Switzerland, with a score of 5.68 overall.

Aside from their innate value to New Zealanders, NZ's environmental assets and biodiversity are primary attractions for overseas visitors. These are public goods and so belong to and are managed by the state. Public investments in NZ's natural capital which support sustainable private sector tourist investment, including NZ's biodiversity, could be identified through collaborative research **(green growth opportunity 20).** Government could work with industry to develop a register of the assets that are or could become important to tourism and their condition and performance, and identify how these compare to NZ's rival tourist destinations. A review could also identify assets suitable for environmentally sustainable tourist development which lack supporting infrastructure, and consult on its provision.

Figure 21. **New Zealand ranked fourth in the regional TTCI in 2011**



Source *Vivid Economics based on WEF Tourism and Travel Competitiveness Index 2011*

4 An evaluation of New Zealand's performance

Above average but neither leading nor consistent

Section Contents:

New Zealand exports in those sectors which have comparative advantage. The most important in value terms are in agriculture (for merchandise exports) and in travel and tourism (for service exports).

This section compares New Zealand's performance in the agricultural sectors with those of its export rivals and provides in-depth analysis of the sectors through case studies. The comparisons with rivals show that New Zealand has no particularly weak areas of environmental performance in its agricultural exports but neither does it have any champion leading sectors. The fact that it avoids poor performance and yet does not achieve leadership is likely to reflect its policy and management strategy. This high-level competitiveness analysis is complemented by detailed University of Auckland Business School case studies of the agricultural, forestry and fisheries sectors and their green growth opportunities.

'The dairy sector greatly outperforms sheep in its methane emissions performance per head compared with rivals'

4.1 Introduction

A presentation of environmental indicators over time and in comparison with export rivals, and case studies

This section presents comparisons of environmental indicators over time for a selection of sub-sectors that are important to New Zealand's export activities as well as in-depth case studies for the sub-sectors.

After a whole economy review, the individual sectors covered are dairy, meat, forestry and fisheries. There is little data available on travel and tourism or horticulture, which would otherwise feature in this list.

In each sector, improvements or deterioration of the environmental indicators over time is recorded, and New Zealand is classified either as a good performer (in the top third of the sample of countries examined) or a poor performer (in the bottom two thirds). The countries chosen as comparators are the smaller of the eight largest exporters or 75 per cent of the global export market in that sector, and so include all New Zealand's main export rivals in those sectors.

Data for this exercise are drawn from a range of sources including the OECD, World Bank and Food and Agriculture Organisation. Data sources are listed in the Appendix.

4.2 Whole economy performance

Mixed: better than average environmental performance but in the bottom half of OECD rankings on gross domestic product

4.2.1 Introduction to the comparator countries

In the rest of this section, New Zealand's whole of economy environmental performance is assessed relative to OECD countries with similar incomes, as well Australia and Canada (Table 7). In 2010, New Zealand's GDP per capital was just under US$30,000 at purchasing power parity and New Zealand was ranked 21st out of 32 in the OECD. This is just under 90 per cent of the OECD average and around 73 per cent of Australia's. The rankings are shown in Table 7.

Table 7. **New Zealand's GDP per capita is similar to that of Italy or South Korea**

Country	GDP per person, US$ 2010	OECD rank
Australia	40,644	6
Canada	38,989	11
OECD average	33,898	-
France	33,835	17
Japan	33,771	18
Spain	32,076	19
Italy	31,563	20
New Zealand	**29,865**	**21**
South Korea	29,004	22

Note: *GDP is measured in exchange rates adjusted for purchasing power*

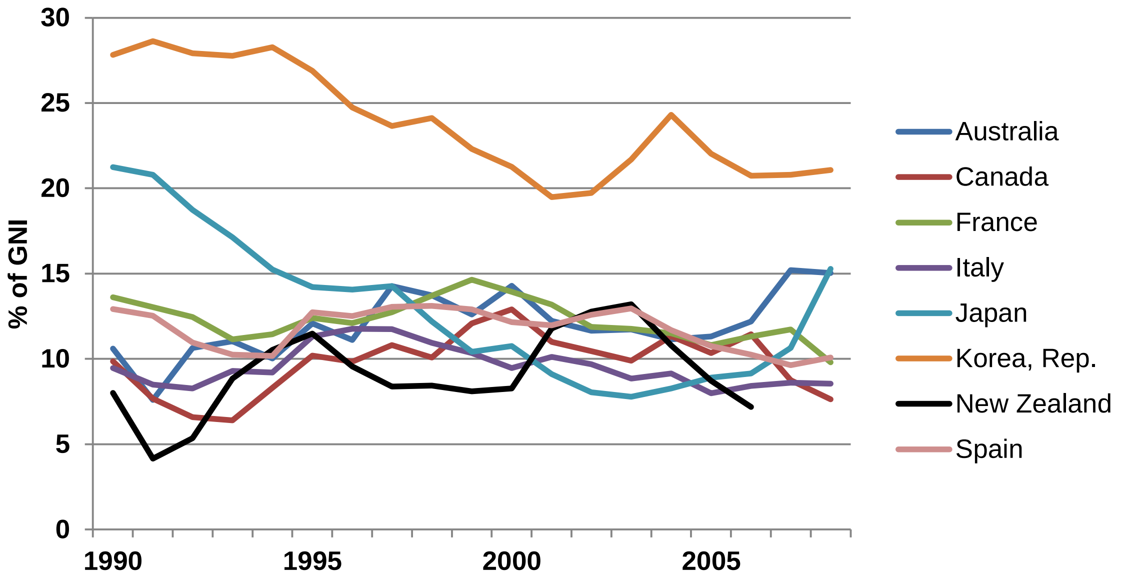
Source: *OECD Statistics*

4.2.2 Extending the measures of economic success

GDP is one of the few metrics which is commonly available. For a broader measure which is closer to green output, let us turn to the World Bank's calculation of green net national income. This measure extends the conventional measurement of economic output to cover (non-market) environmental goods and capital stocks. To be more specific, the genuine savings measure adjusts gross savings for depreciation of physical capital, investments in human capital, reductions in natural capital through depletion of non-renewable resources, the over-exploitation of renewable resources, and finally damage due to air pollution from suspended particulates and CO_2 emissions. The resulting composite indicator shows whether the overall capital stock is rising or falling over time. It is not a perfect indicator, see Neumayer and Stiglitz for a discussion of its limitations (Neumayer 2003; Stiglitz, Sen, and Fitoussi 2009). In particular, if markets do not optimise resource extraction over time then the valuation of reserves will be incorrect, if externalities are not corrected then prices will be incorrect, if the computation of resource rents uses average cost rather than marginal cost then then the estimates will be biased, and if resource discoveries are valued at their discovery costs, they will also be wrong. All these problems afflict the World Bank's genuine savings calculations.

The calculation shows that NZ, in common with developed countries generally, has positive genuine savings, meaning that it may be possible to increase wellbeing over time. It also indicates greater potential for future growth in some countries, such as South Korea and Australia than New Zealand, who respectively have similar and higher GDP per capita than New Zealand, see Figure 22.

Figure 22. **NZ has a low rate of genuine savings compared to its peers, accounting for pollution damage**



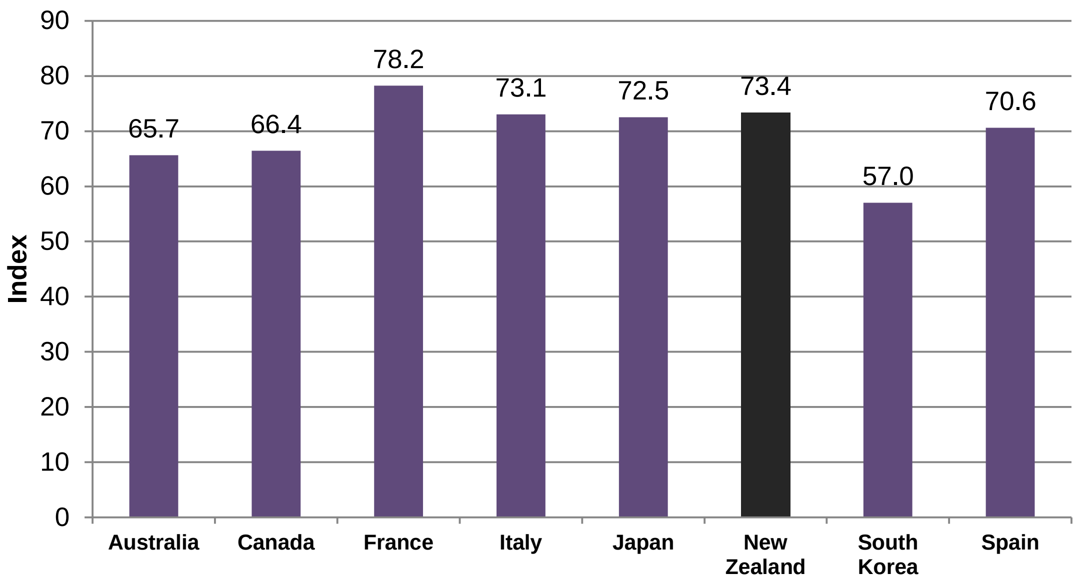
Source *World Bank (2011b)*

4.2.3 Composite environmental performance

Although New Zealand enjoys a lower level of conventional economic output, it is performing relatively well on an environmental index compiled by Yale and Colombia Universities (Yale Center for Environmental Law & Policy and Center for International Earth Science Information Network 2010) . Their Environmental Performance Index is intended to reflect national environmental performance for a broad set of countries. Wherever possible, it describes the state of the environment, using pressure or impact variables as a fall back. The individual components each receive a percentage score, reflecting the proportion of attainment of a target value, taken from an international treaty, standard, value from the scientific literature, or expert opinion. The individual components are aggregated using subjective weights chosen by the university authors. Those weights change between 2008 and 2010.

In this index, New Zealand achieved a ranking of 15th overall in 2010, or second among the selected peer group shown in Figure 23.

Figure 23. **NZ was ranked 15th overall and second among its comparator countries in 2010**



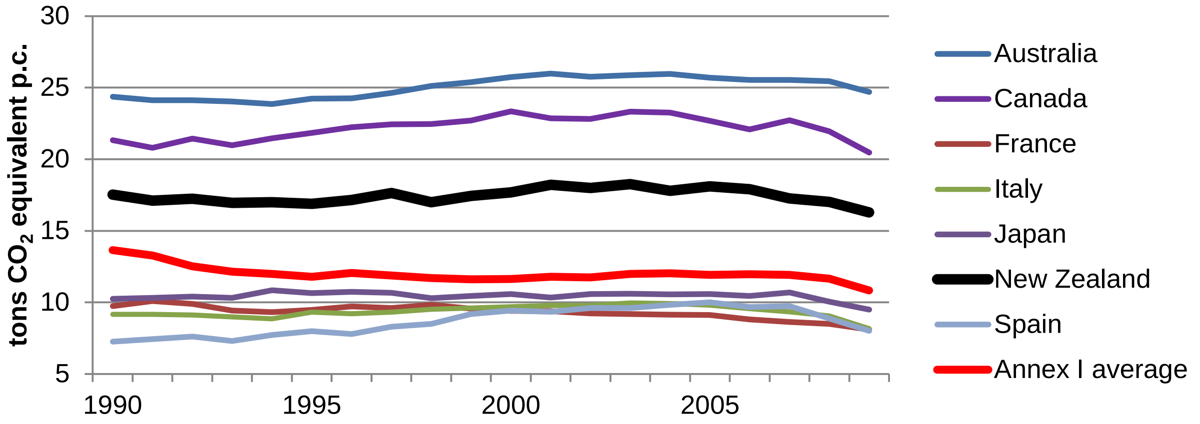
Source Yale Center for Environmental Law & Policy and Center for International Earth Science Information Network (2010)

4.2.4 Individual elements of environmental performance

Just as it is possible to drill down into the conventional economic data, it is also possible to decompose the environmental data into its constituent parts. Some of the most important data are on greenhouse gas emissions intensity, size of populations of key species and air pollution.

When measured on a gross basis before including net removals from forestry, New Zealand's emissions of greenhouse gases per capita are higher than the other developed countries in this group, with the exception of Australia and Canada: roughly twice as much as France or Spain. The emission rate has declined a little over the last 20 years whereas it has declined by more across the broad group of Annex 1 countries which took emissions targets under the Kyoto Protocol.

Figure 24. **Greenhouse gas emissions per capita *ex*cluding LULUCF are higher than the Annex 1 average**

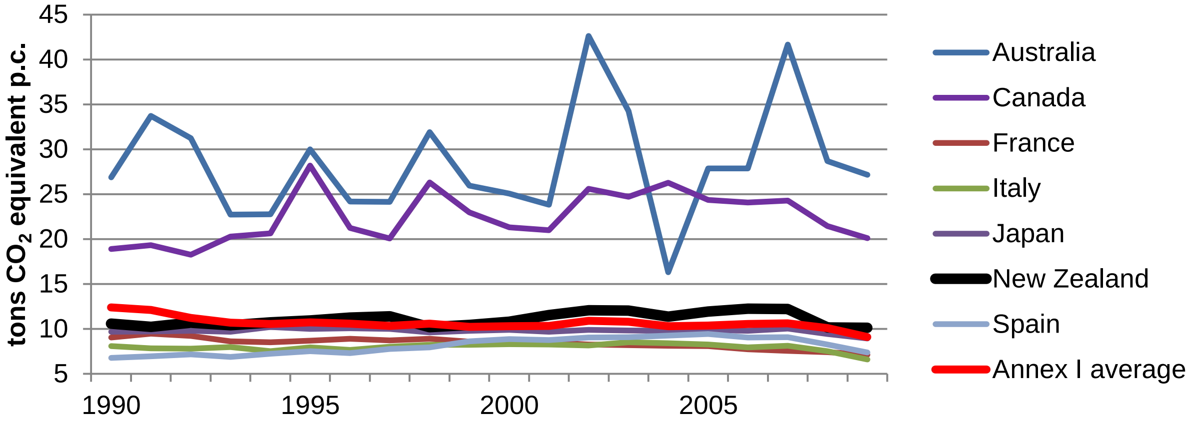


Note: Land Use, Land-Use Change and Forestry; Annex I countries have emission reduction targets under the Kyoto Protocol

Source GHG emissions from United Nations Framework Convention on Climate Change (2011), population data from International Energy Agency (2011b)

New Zealand can claim a substantial credit for storing carbon in its forestry sector, so that if this is factored in, its performance in terms of emissions per capita is much closer to that of its Annex 1 peers. Yet, even with this adjustment, it remains slightly above its peers and has made no clear progress over the last 20 years.

Figure 25. **Greenhouse gas emissions per capita *in*cluding LULUCF are higher than the Annex 1 average**

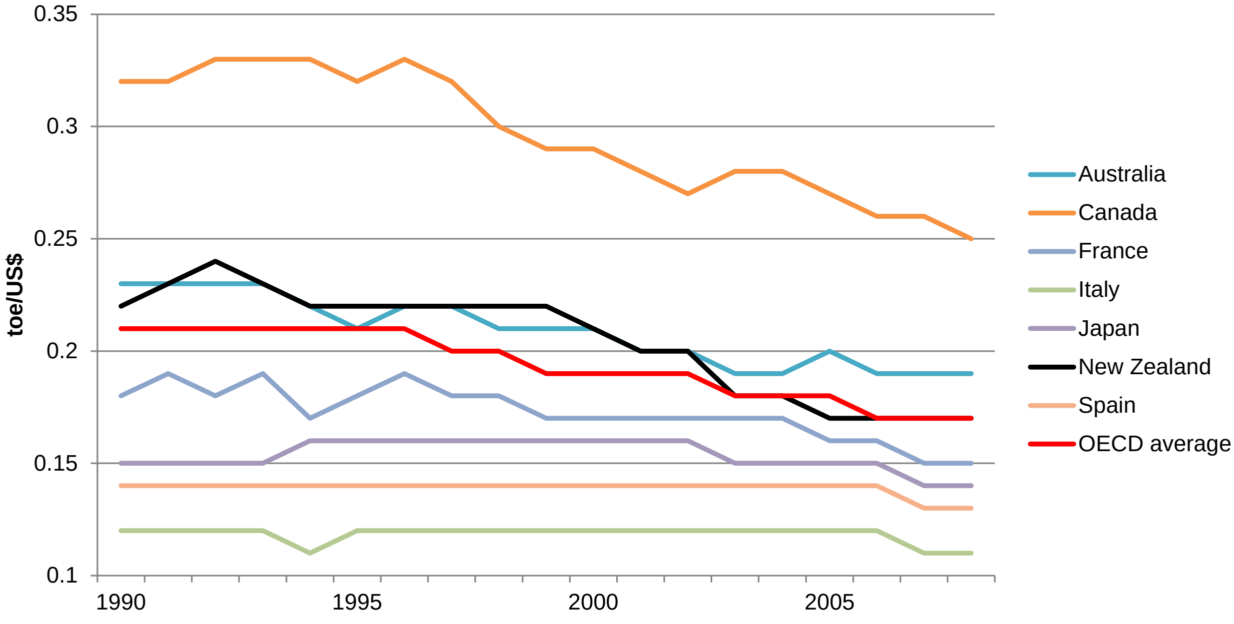


Note: *Land Use, Land-Use Change and Forestry; Annex I countries have emission reduction targets under the Kyoto Protocol*

Source *GHG emissions from United Nations Framework Convention on Climate Change (2011), population data from International Energy Agency (2011b)*

While per capita emissions have remained static for a couple of decades, New Zealand's economy has grown and become less energy intensive. It has caught up with OECD average emissions per dollar of output and for the last decade has outperformed Australia on this metric.

Figure 26. **New Zealand's energy intensity is similar to the OECD average and both have improved over time**



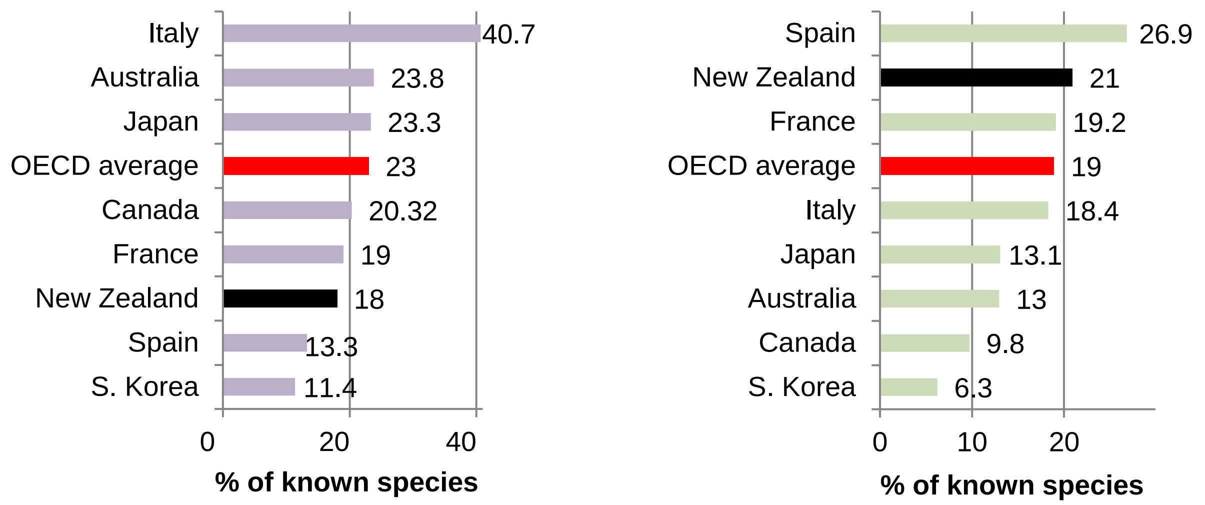
Note: *tons of oil equivalent per thousand 2000 USD of GDP calculated at purchasing power parity (PPP) exchange rates*

Source *OECD (2010b)*

This improvement in emissions intensity has been achieved almost entirely through energy efficiency. There has been little structural change in the economy to explain it. The country's energy efficiency has gone up by a creditable 1.0 per cent per annum (Department of Climate Change and Energy Efficiency 2010). This is a better than average performance relative to peers: Australia merely achieved 0.1 per cent. However, it has not been a leader in the field, with Canada, the United States and Germany all achieving significantly faster rates of improvement, closer to 1.5 per cent per annum. To improve performance, NZ could review each of the IEA's 25 recommended energy efficiency policies which NZ has not yet implemented, prioritising the IEA's recommended cross-sectoral measures to support private sector investment **(green growth opportunity 2)**. Well-designed energy efficiency policies achieve low-cost emissions reductions, deliver financial savings and improve energy security. In a review of each IEA member country's performance, the IEA (2009) noted that, despite the strength in NZ's performance there were several areas for improvement, particularly in buildings, transport and cross-sectoral policies to support private sector investment in energy efficiency. More specific opportunities in the areas of transport and buildings are discussed in the University of Auckland Business School case studies in section 5.

Turning to biodiversity, a picture emerges from the wildlife indicators compiled by the OECD. These do not lend themselves to easy interpretation. Nevertheless, the pattern which emerges is of a relatively well-managed marine fishery, with some threatened marine mammals, and with terrestrial flora that are generally thriving but a terrestrial fauna whose amphibians are under high levels of stress. These positions are shown in Figure 27 and Figure 28.

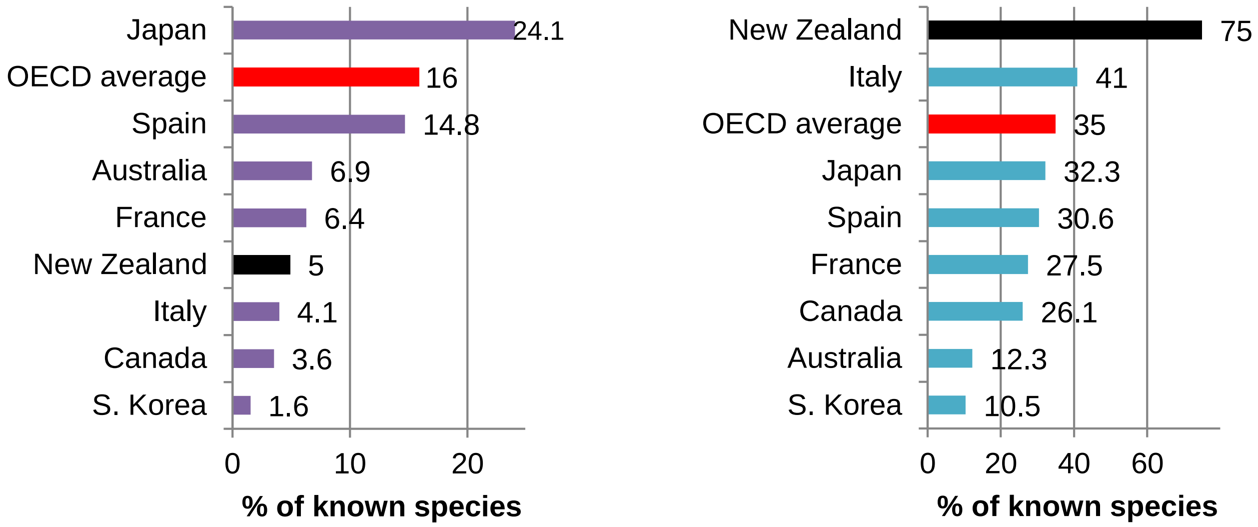
Figure 27. **NZ's birds are no more or less threatened than the OECD average (right hand chart), and its mammals (almost all marine) (left hand chart) are relatively protected, percentage of species that are threatened**



Note: data are latest available year (not specified, varies by country)

Source OECD Statistics

Figure 28. **New Zealand's vascular plants are generally thriving (left hand chart), but its amphibians are under stress (right hand chart), percentage of species that are threatened**

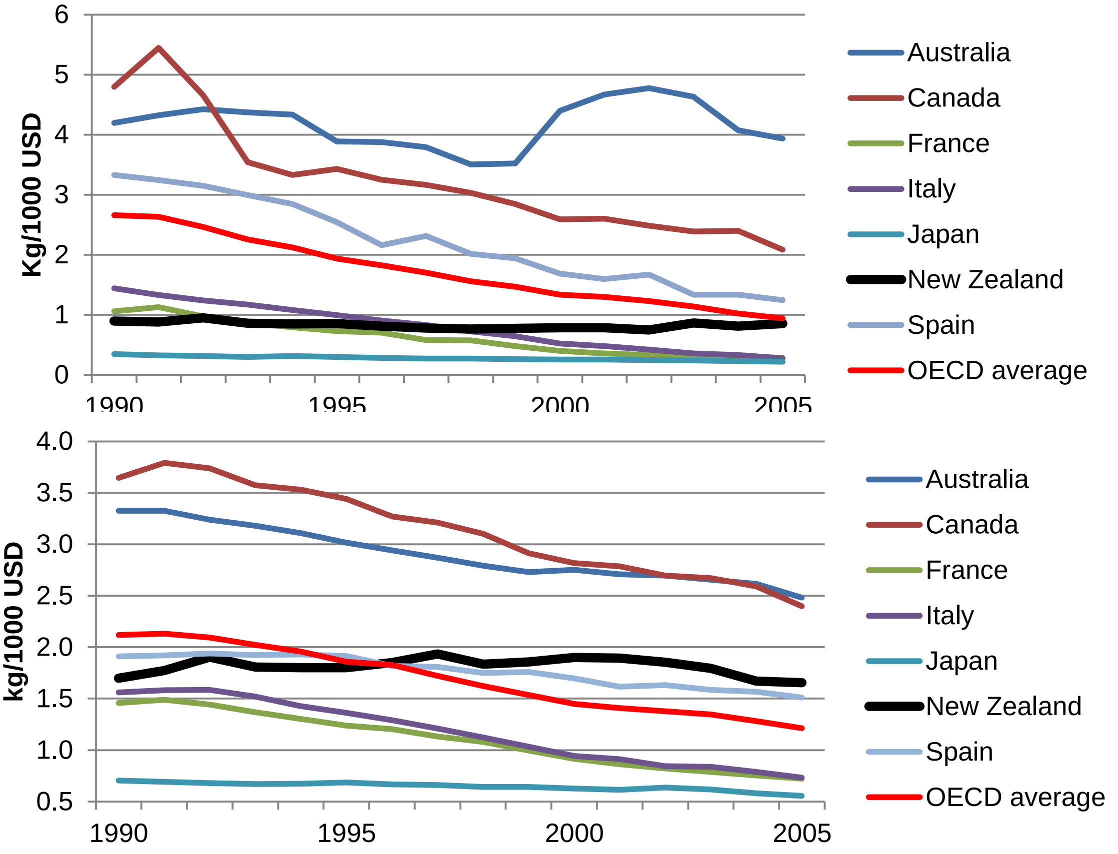


Note: data are latest available year (not specified, varies by country)

Source OECD Statistics

New Zealand has historically had much lower emissions of transboundary and local air pollutants than many of its peers, and the OECD average, but those peers have been catching up over the last 20 years while New Zealand's performance has barely changed. As a result, it is now at the OECD average level for sulphur oxides and well above it for nitrogen oxides, although on both counts it comfortably outperforms Australia and Canada.

Figure 29. **Emissions of transboundary and local pollutants to air, mass of SO_X (top graph) and NO_X (bottom graph) per unit of GDP**

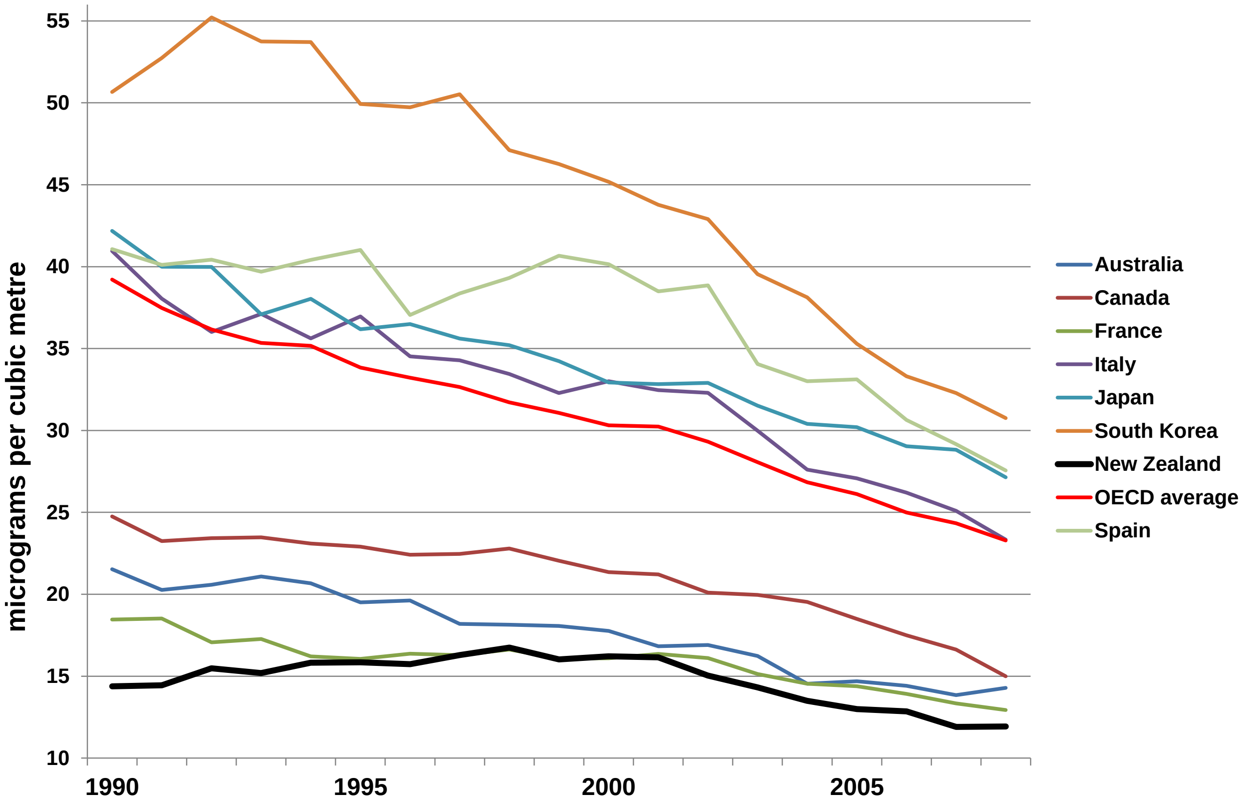


Note: GDP at PPP exchange rates, 2000 USD

Source OECD Statistics (SOx and NOx emissions), International Energy Agency (2011b) (GDP)

This declining position in terms of emissions intensity may not be noticed by New Zealand's residents and visitors because its air quality, at least in terms of particulates, remains outstandingly good relative to peers, at around half the OECD average. This is shown in Figure 30.

Figure 30. **New Zealand's air quality is relatively very good, population-weighted PM10 (micrograms per cubic metre)**

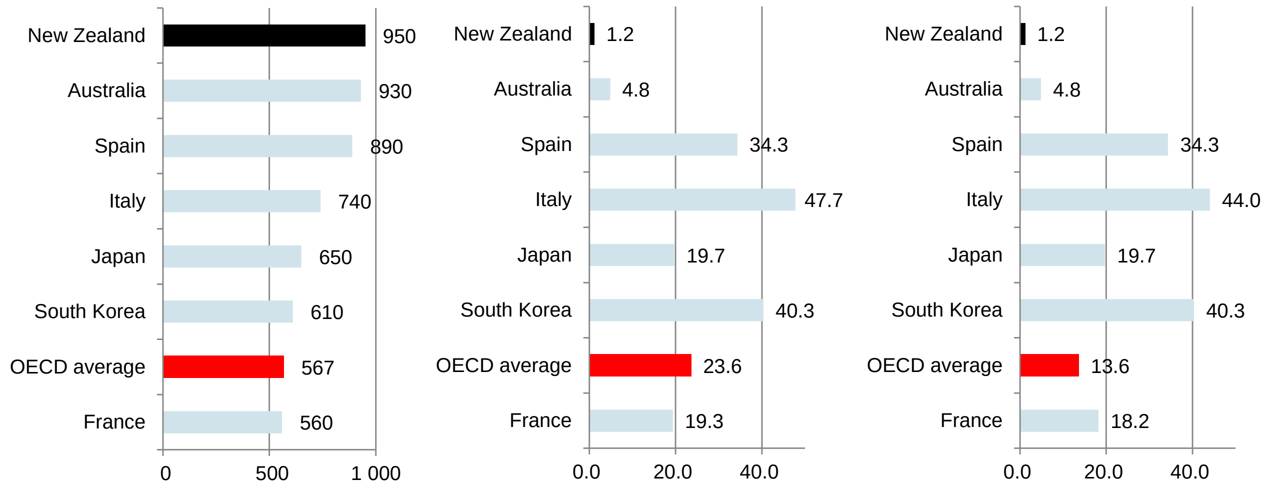


Note: *PM10 are fine suspended particulates less than 10 microns in diameter. Levels are weighted by the urban population in residential areas of cities with more than 1million residents*

Source *World Bank (2011b)*

New Zealand is a high consumer of water per person relative to other countries, but it taps a very small proportion of its renewable internal resources and the high per capita water use is explained by its relatively large agricultural sector. At a national level the indicators appear comfortably sustainable, although these mask local pressures in some areas (see section 4.5).

Figure 31. **High water extraction per capita is mitigated by abundant local resources, volume of water use per capita (million m³), percentage of internal resources, percentage of renewable resources**



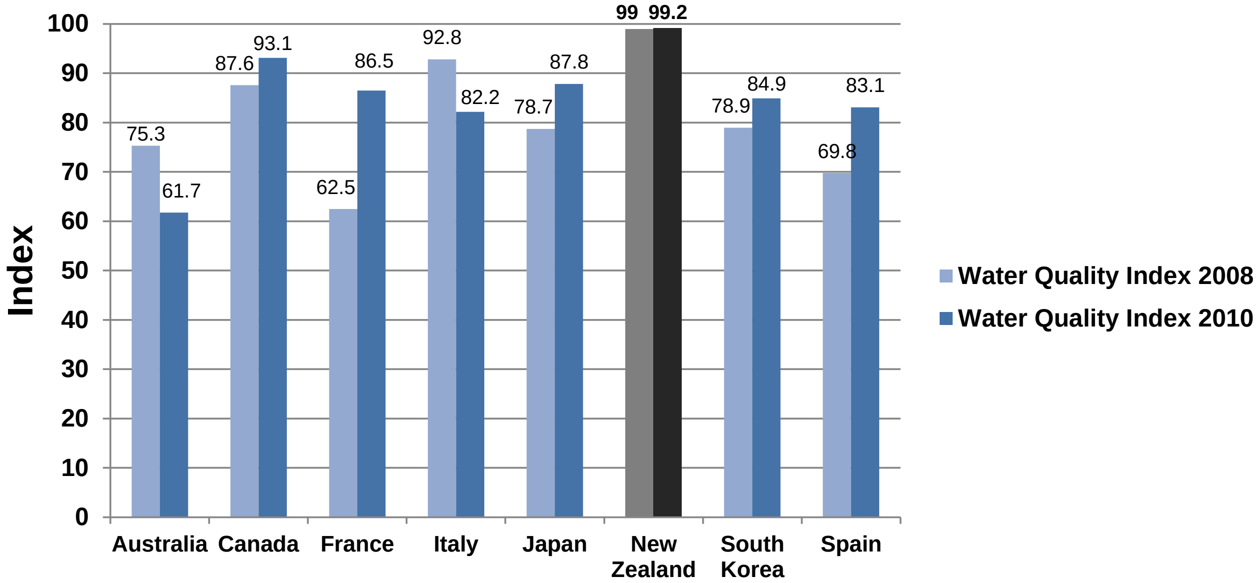
Note: *internal resources are precipitations minus evapotranspiration; renewable resources are internal resources plus inflows from neighbouring countries*

Source *OECD Statistics*

4.2.5 Water quality

At a national level, NZ water quality is high and stable, however this masks variations between individual catchments (see section 4.5)

Figure 32. **New Zealand has excellent water quality**



Note: *The Water quality index measures five parameters (dissolved oxygen, pH value, electrical conductivity, total nitrogen and total phosphorus)*

Source *Yale Center for Environmental Law & Policy and Center for International Earth Science Information Network (2010; 2008)*

4.3 Dairy and general agriculture competitiveness analysis

Leading methane emissions performance

4.3.1 Dairy

NZ performs well relative to global rivals through its efficient use of liquid fuels and low methane emissions per head of dairy cattle, see Table 8.[11] There is a less favourable picture in its use of water and fertilizer, which are all used more intensively than its rivals. While the use of fertilizer is showing improvement, with its use per dollar of output in decline from its historic peak, water use is rising faster than output, which means that the efficiency of its use is deteriorating. New Zealand has abundant water, so in aggregate this is not a concern, but it is causing damage in some local areas (see section 4.5.2).

The metrics which are poor or declining are all measured for agriculture at the aggregate level so tell us little about the performance of the dairy sector itself but are helpful in understanding the pressures which agriculture might be imposing on the environment. These can be found in the Appendix. In contrast, the methane emissions metric has the great advantage that it is specific to dairy cows, so it is worth exploring in more detail. The agricultural case study in section 4.5 complements this high-level cross-country analysis by providing detailed analysis with a particular focus on the dairy sector.

Table 8. **The dairy industry performs well on methane emissions per dairy cow**

Performance relative to rivals	Performance deteriorating	Performance steady or improving
Relatively green	*green with risks*	*green* • methane emissions per dairy cow
Not relatively green	*not green, could worsen*	*not green, may improve*

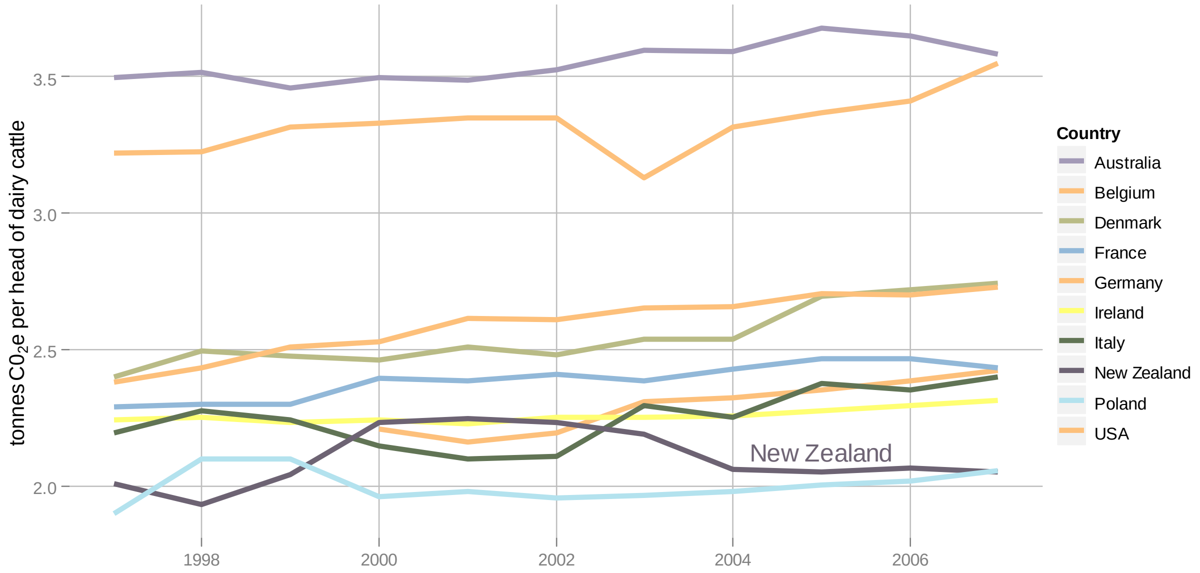
Source: Vivid Economics

New Zealand has world-leading performance in methane emissions from dairy cows. It has held this position for most of the past decade. Indeed, emissions per dairy cow have fallen in the five years to 2007 while those of many rivals have risen, see Figure 33. This echoes the results of a detailed comparison of energy and

[11] Emissions per unit of milk or meat are the product of emissions per head of cattle or sheep and the inverse of yield per head. Large differences in yields per animal across countries could result in differences in rankings by emissions per unit of output and by emissions per head.

emissions in the New Zealand and UK dairy industry: Saunders and Barber (2007) find that the NZ performs significantly better than the UK in terms of the overall emissions from dairying.

Figure 33. **New Zealand has maintained a market-leading position in methane emissions per dairy cow for much of the last decade**



Note: *data for the Netherlands are unavailable*

Source *Food and Agriculture Organization (2011a)(for heads of dairy cattle); the United Nations Framework Convention on Climate Change (UNFCCC) for methane emissions from dairy cattle*

4.4 Meat competitiveness analysis

Relatively good emissions performance in cattle production is not matched by good emissions performance in sheep production

New Zealand farms mainly cattle and sheep for meat. It is less competitive in emissions from animals in the meat industry than in dairy. It is close to the top-performing third of countries for methane emissions from non-dairy cattle but lags some way behind the best performers in sheep production.

Table 9. **The meat industry performs well on methane**

Performance relative to rivals	Performance deteriorating	Performance steady or improving
Relatively green	*green with risks*	*green*
Not relatively green	*not green, could worsen* • methane emissions per head of sheep	*not green, may improve* • methane emissions per non-dairy cow

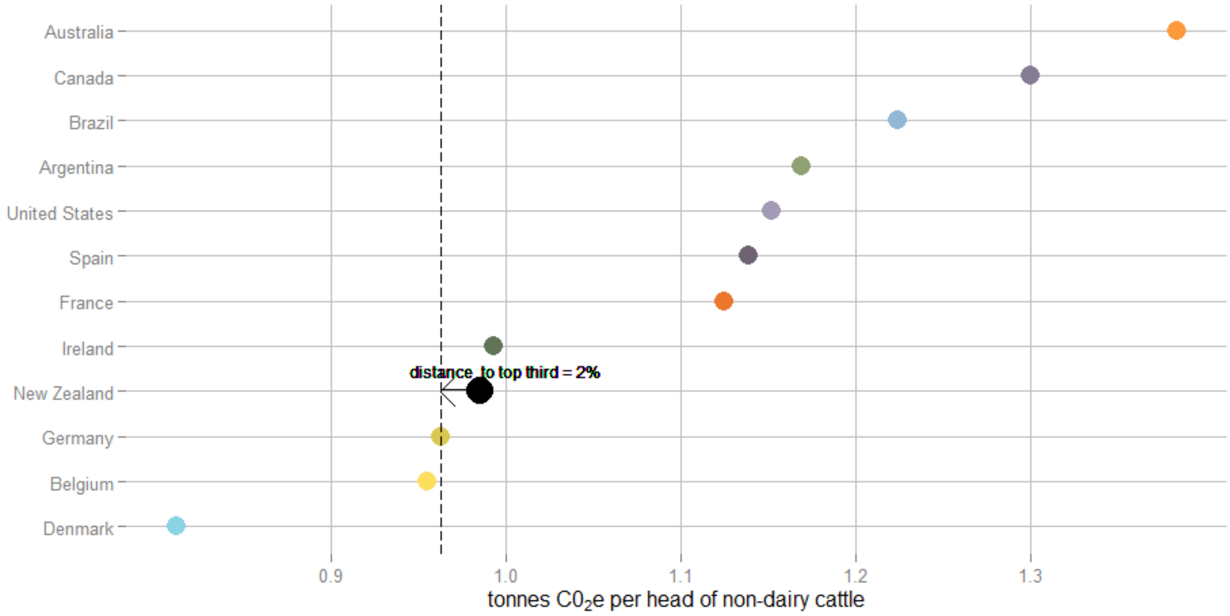
Source: Vivid Economics

New Zealand's methane emissions per head of non-dairy cattle compare quite well with global rivals, see Figure 34. New Zealand is just 2 per cent behind the top third of countries in the global market and with some further improvement could become a leading performer. Denmark leads the field in this area.

New Zealand's methane emissions performance in sheep production is far behind its performance in cattle. It has had consistently high emissions per head of sheep relative to global rivals and the metric has worsened by 21 per cent from 1990 to 2009 such that New Zealand would have to reduce methane emissions per head of sheep by 27 per cent to reach the top third of comparator countries, see Figure 35.[12]

[12] This results is not comparable with Saunders, Barber, and Taylor (2006), who compare NZ and UK lamb production in detail but calculate emissions from energy use only.

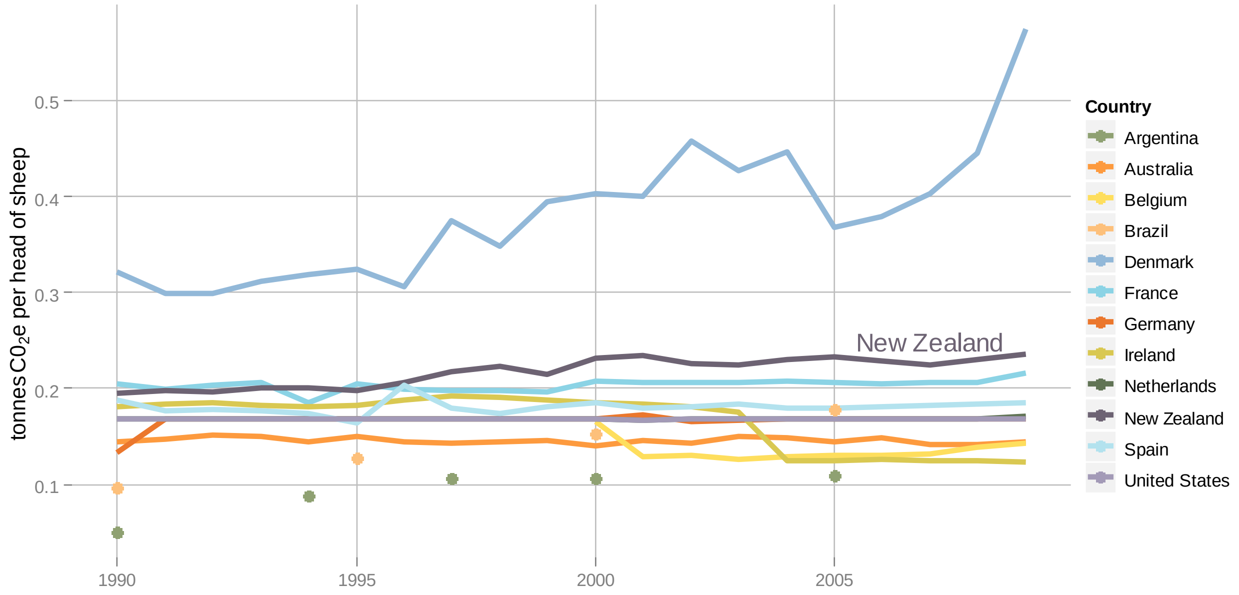
Figure 34. **New Zealand is close to the top third of performers in emissions per head of non-dairy cattle, 2006**



Note: *these data are a three year moving average (2005-2007). 'Distance to the top third' is calculated for rivals in the global meat market. Countries (in this case, only Canada) which are rivals in NZ's main export market but not the overall global market are included in graphs of results but not in the 'top third' calculation*

Source *FAO (2011) and the UNFCCC (2011), various sources for methane emissions for Brazil and Argentina (see Appendix)*

Figure 35. **New Zealand lags behind the main group of its rivals in emissions per head of sheep**



Note: *dots represent the data points for Brazil and Argentina, countries for which time series data are unavailable*

Source: *FAO (2011) and the UNFCCC (2011), various sources for methane emissions for Brazil and Argentina (see Appendix)*

4.5 Agriculture case study

NZ might maintain and enhance its advantage with green growth initiatives

4.5.1 Introduction

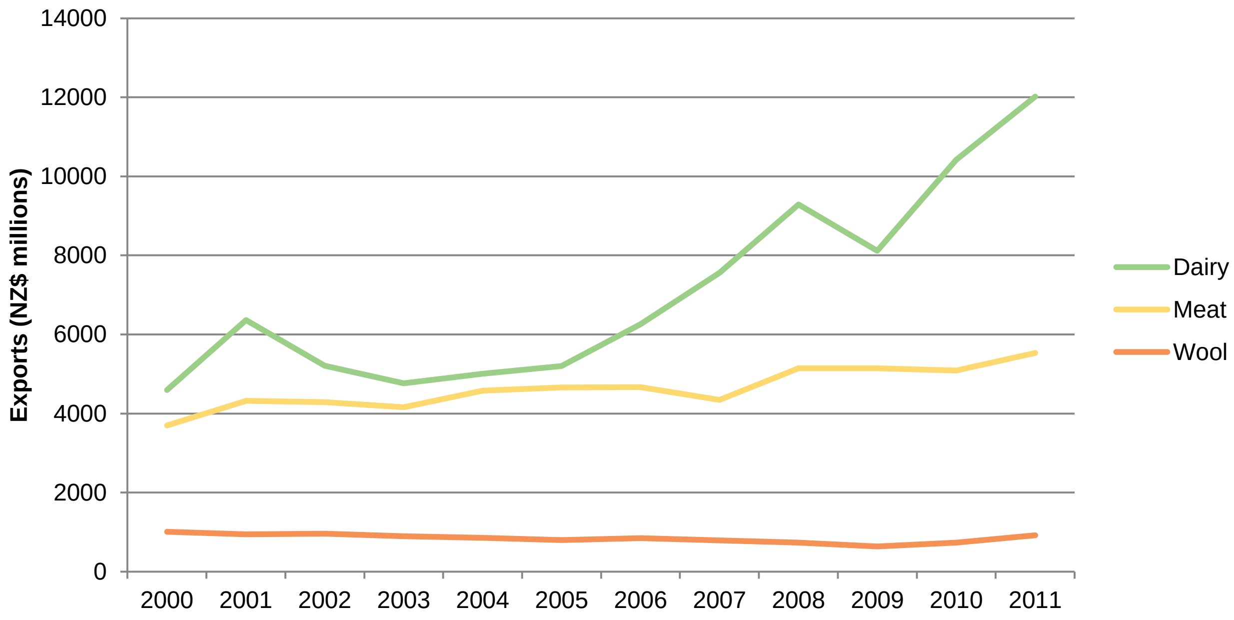
The aim of this case study is to highlight the pivotal role agriculture plays in the New Zealand economy, issues around its sustainability, the challenges facing contemporary agriculture, and the opportunities for green growth. NZ is recognised as a world leader in pastoral agriculture where its enterprise is based on favourable climate, soil and land. Productivity is augmented by the use of fertilizers, water, energy, and innovation. With this in mind, the case study underlines the prospects for green growth emerging from the agricultural sector and related industries. Exports from the sector have dominated NZ's export earnings for decades. Recognising that the bulk of agricultural production is exported, the first section provides an overview of NZ agriculture, including export volumes and values are described for the period 2000-10, and an overview of agricultural production, resource use and other issues related to sustainable agriculture. The next section sets the global scene in respect of production, trade, and factors affecting future supply and demand. Using the dairy sector as an example, the final section identifies risks and highlights opportunities for further economic growth.

4.5.2 New Zealand agriculture

New Zealand's economy is heavily dependent on pasture-based agriculture to generate export receipts. In 2011, NZ exports totalled NZ$46 billion. Australia was the largest customer, China being the second largest. The importance of export products based on pastoral agriculture is evidenced by dairy products (namely milk powder, butter and cheese) accounting for almost 25 per cent, and meat products 11 per cent, of the total value of exports. Figure 36 illustrates rates the remarkable growth in dairy exports; beginning at around NZ$4.6 billion in 2000 and increasing to over NZ$12 billion in 2011. Over the same period, the value of meat exports increased NZ$3.6 billion to NZ$5.5 billion, and the value of wool exports has remained at around NZ$1 billion.

Nearly 58 per cent of NZ's total merchandise export receipts in the year 2011 came from agricultural and horticultural products, within which, the dairy sector alone accounted for 52 per cent (New Zealand Ministry of Agriculture and Forests 2012). The NZ dairy industry is predominantly an export business, with less than five per cent of production consumed domestically. It is the world's largest exporter of dairy ingredients, accounting for more than a third of the international traded market. The need to compete against low cost producers in a volatile international market means that NZ's dairy farmers must remain focused on resilient farming systems, with relatively low fixed costs and high productivity (DairyNZ 2009).

Figure 36. **Dairy has been the major growth area in New Zealand agriculture**

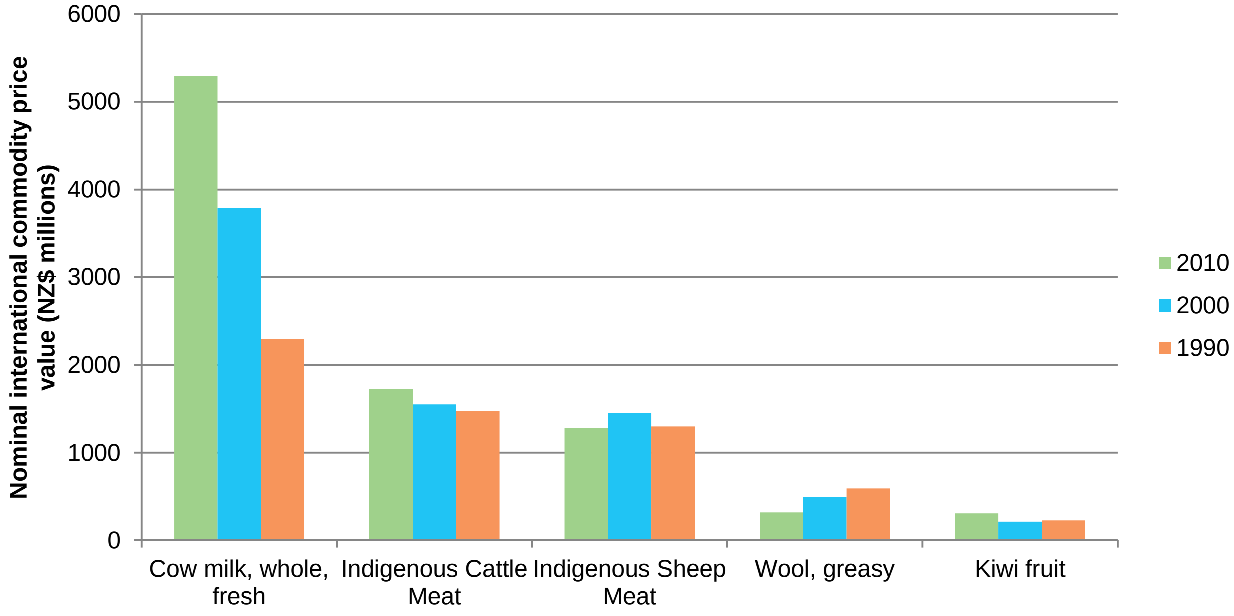


Source: Statistics New Zealand

Pastoral agriculture

Figure 37 provides an overview of trends in the value of production according to commodity group. Dairy production, both in terms of level and growth, dominates all other outputs from pastoral agriculture; including Kiwi fruit, which is not pastorally based.

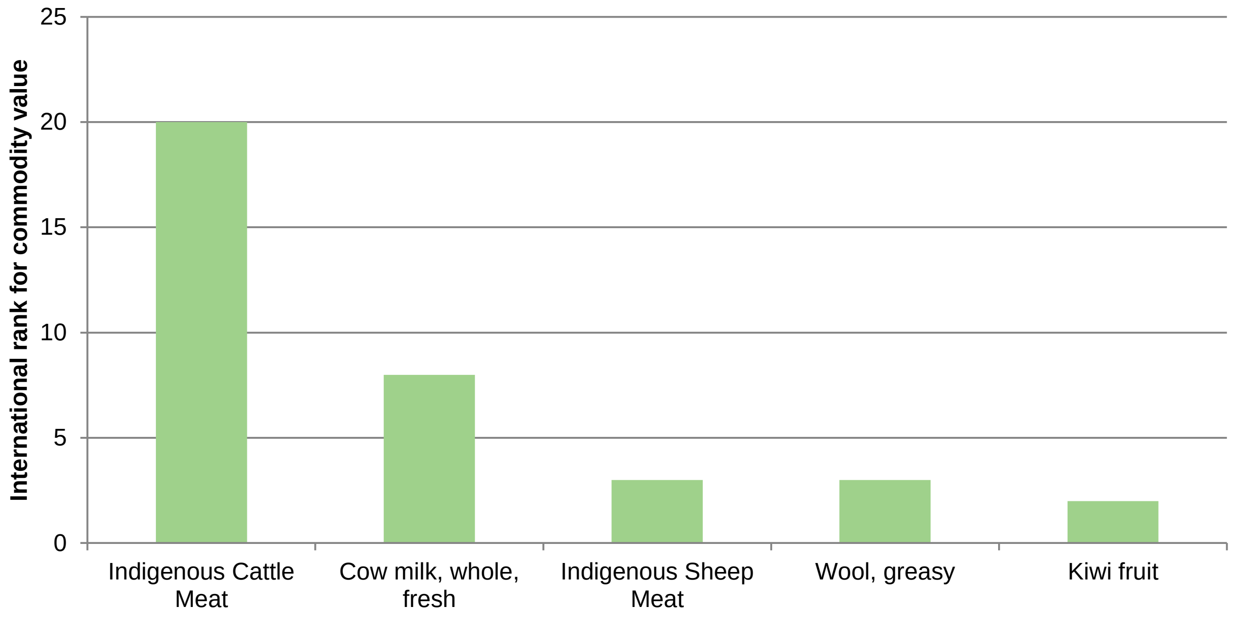
Figure 37. **Dairy dominates all other outputs from pastoral agriculture**



Source: Food and Agriculture Organization Statistics

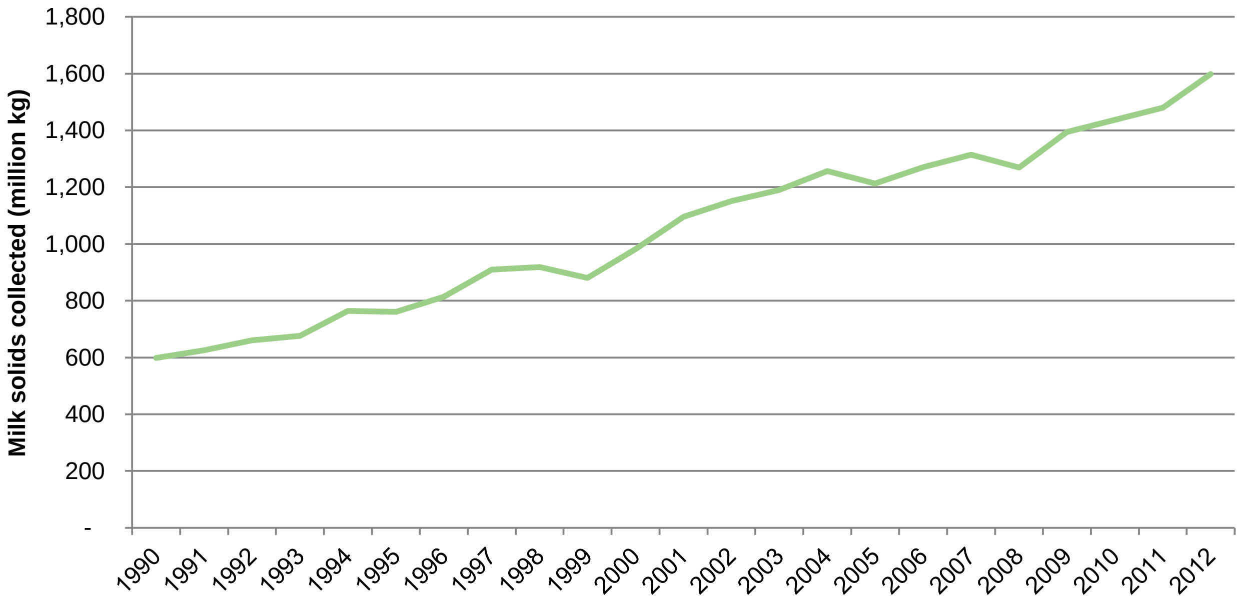
Figure 38 illustrates NZ's international ranking, by commodity grouping, based on commodity value. Dairy products are ranked eighth, sheep meat and wool products are ranked third.

Figure 38. **Dairy products have a higher international ranking for commodity value than meat or wool**



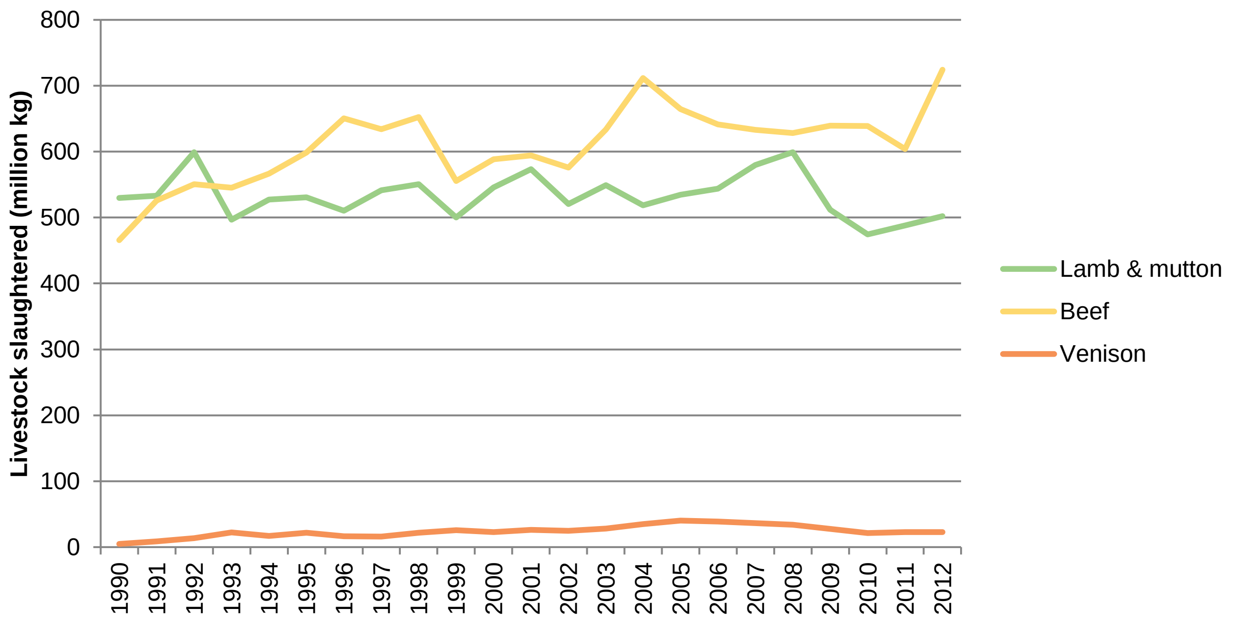
Source: Food and Agriculture Organization Statistics

Figure 39. **The weight of milk solids collected has been steadily increasing**



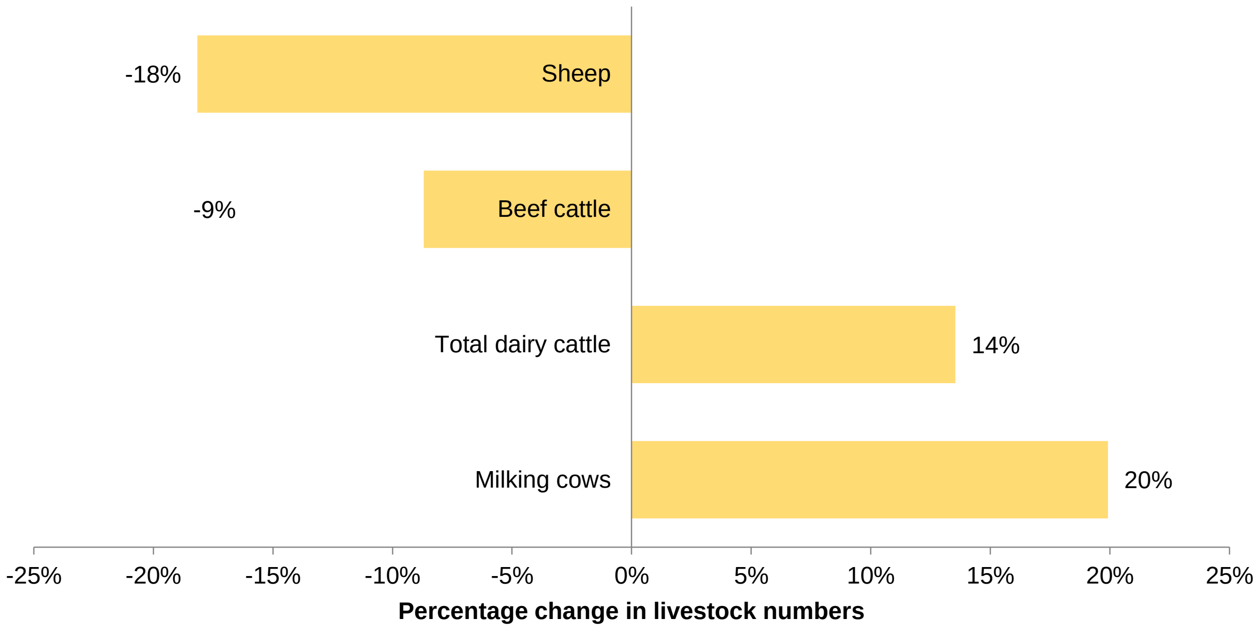
Source: New Zealand Ministry for Primary Industries (2012)

Figure 40. **Livestock slaughtered has stayed constant**



Source: New Zealand Ministry for Primary Industries (2012)

Figure 41. **There has been significant increase in number of dairy cattle, particularly milking cows**



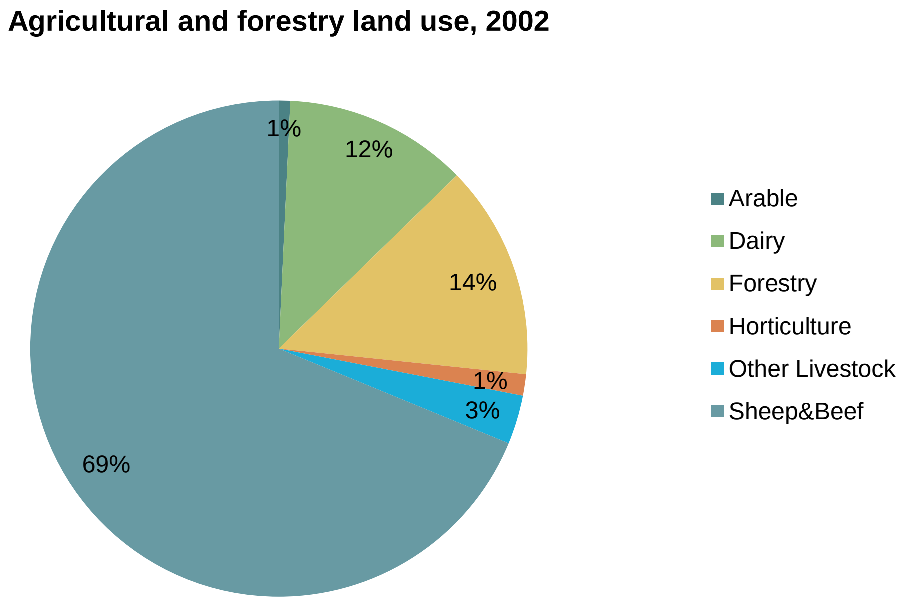
Note: Vertical axis shows percentage change in livestock numbers between 2002 and 2009

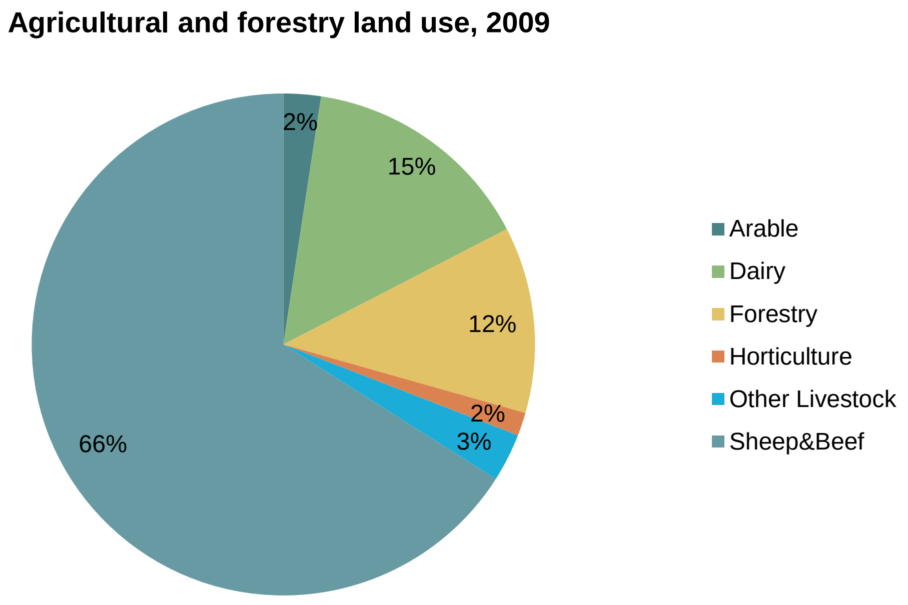
Source: New Zealand Ministry for Primary Industries (2012)

Land use

Figure 42 shows an increase in land used for dairy farming and a decline in land used for sheep and cattle farming between 2002 and 2009.

Figure 42. **The proportion of land used for dairy has increased since 2002**



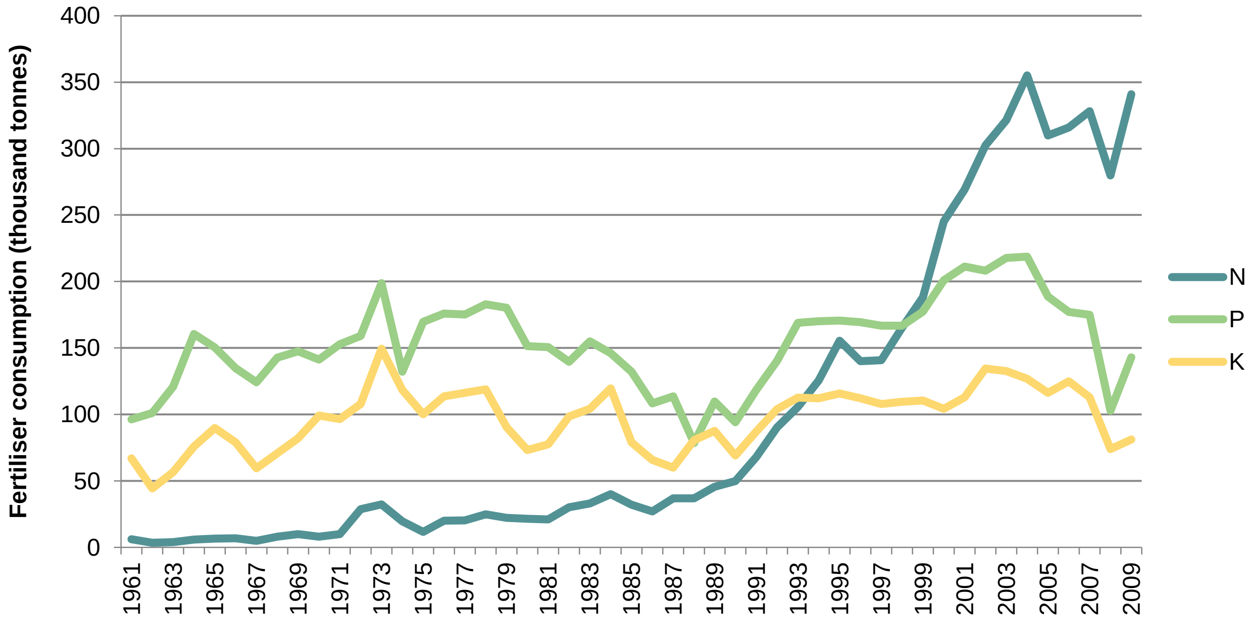


Source: New Zealand Ministry for Primary Industries (2012)

Nutrient use

Figure 43 shows national fertilizer use of nitrogen (N), phosphate (P) and potassium (K) from 1961 to 2009. There is a dramatic increase in nitrogen use beginning in the late 1980s. The use of phosphate appears to stay within the range of 100,000 to 200,000 tonnes per annum. Annual use potassium varies around 100,000 tonnes per annum.

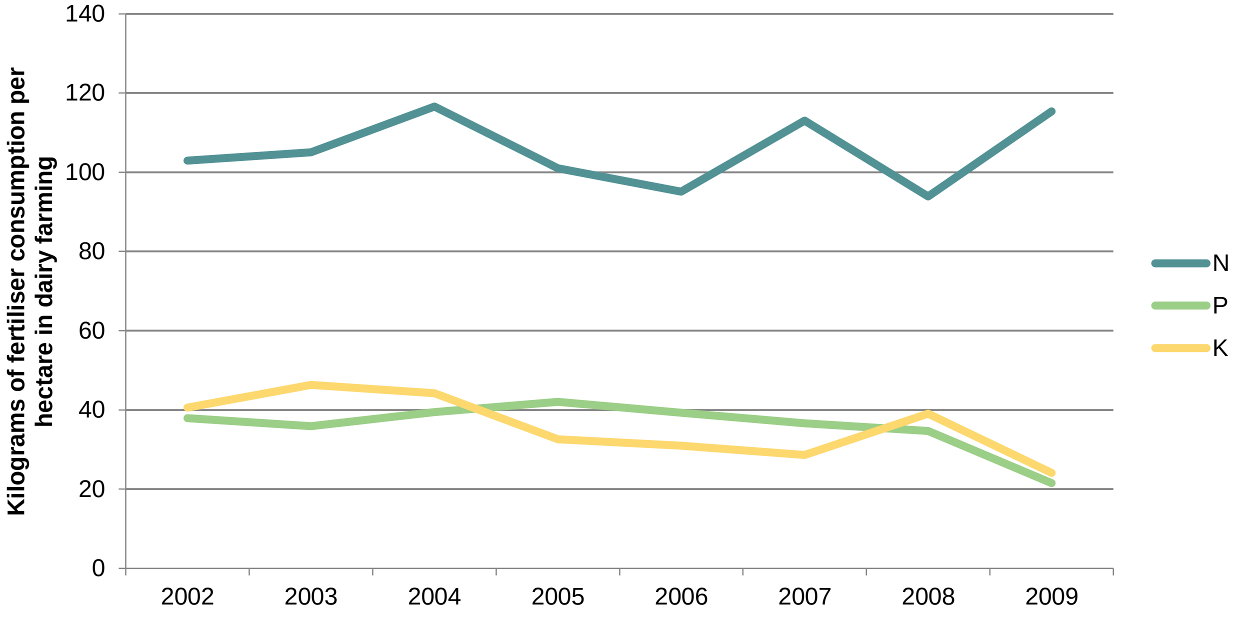
Figure 43. **Nitrogen consumption has greatly increased over the last two decades**



Source: Fert Research (2010)

Fertilizer use can be further broken down into use per hectare and use per unit of output. Figure 44 shows nitrogen use per hectare for dairy falling to between 100 and 120 kilograms per hectare. Phosphorous and potassium use per hectare have remained around 40 kilograms per hectare, dropping off to 20 kilograms per hectare in 2009. Measured in terms of output in 2002 relative to output in 2009, nitrogen use increased from 0.14 kilograms per kilogram of milk solids to 0.16 kilograms per kilogram of milk solids. Phosphorous decreased from 0.05 kilograms per kilogram of milk solids to 0.03 kilograms per kilogram of milk solids. Potassium also decreased from 0.06 kilograms per kilogram milk solids to 0.03 kilograms per kilogram milk solids (New Zealand Ministry for Primary Industries 2012).

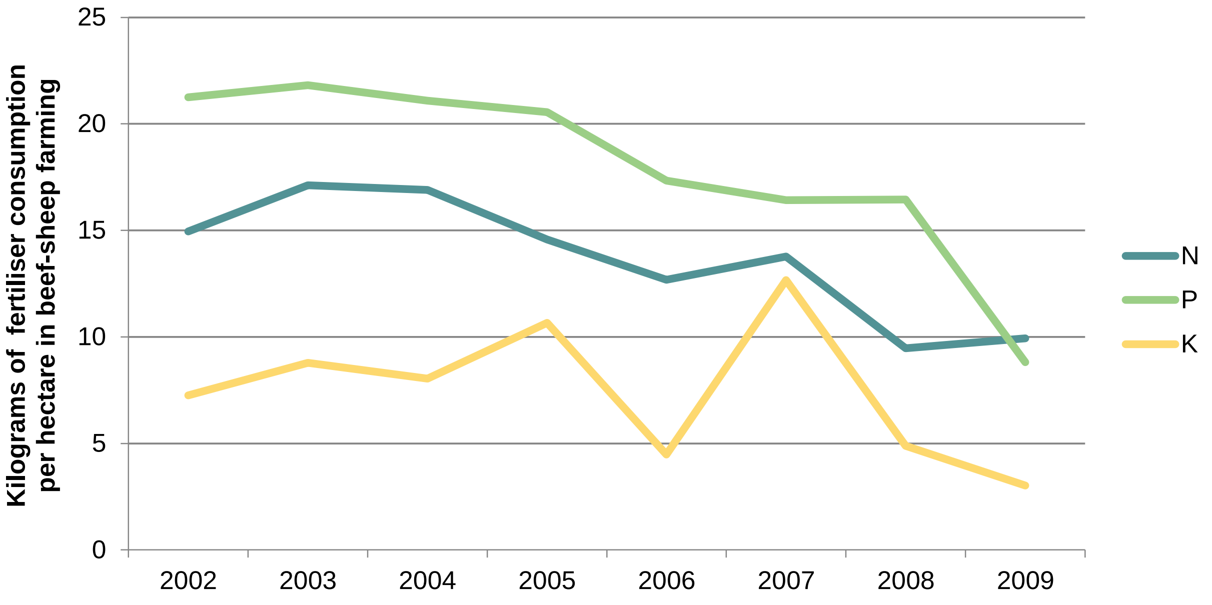
Figure 44. **Use of phosphate and potash per hectare has almost halved since 2002**



Source: New Zealand Ministry for Primary Industries (2012)

Figure 45 shows per hectare fertilizer use by beef and sheep farming declining from 2002. Per unit of output, the series shows decreasing use of nitrogen, phosphate and potassium per kilogram of beef and lamb output.

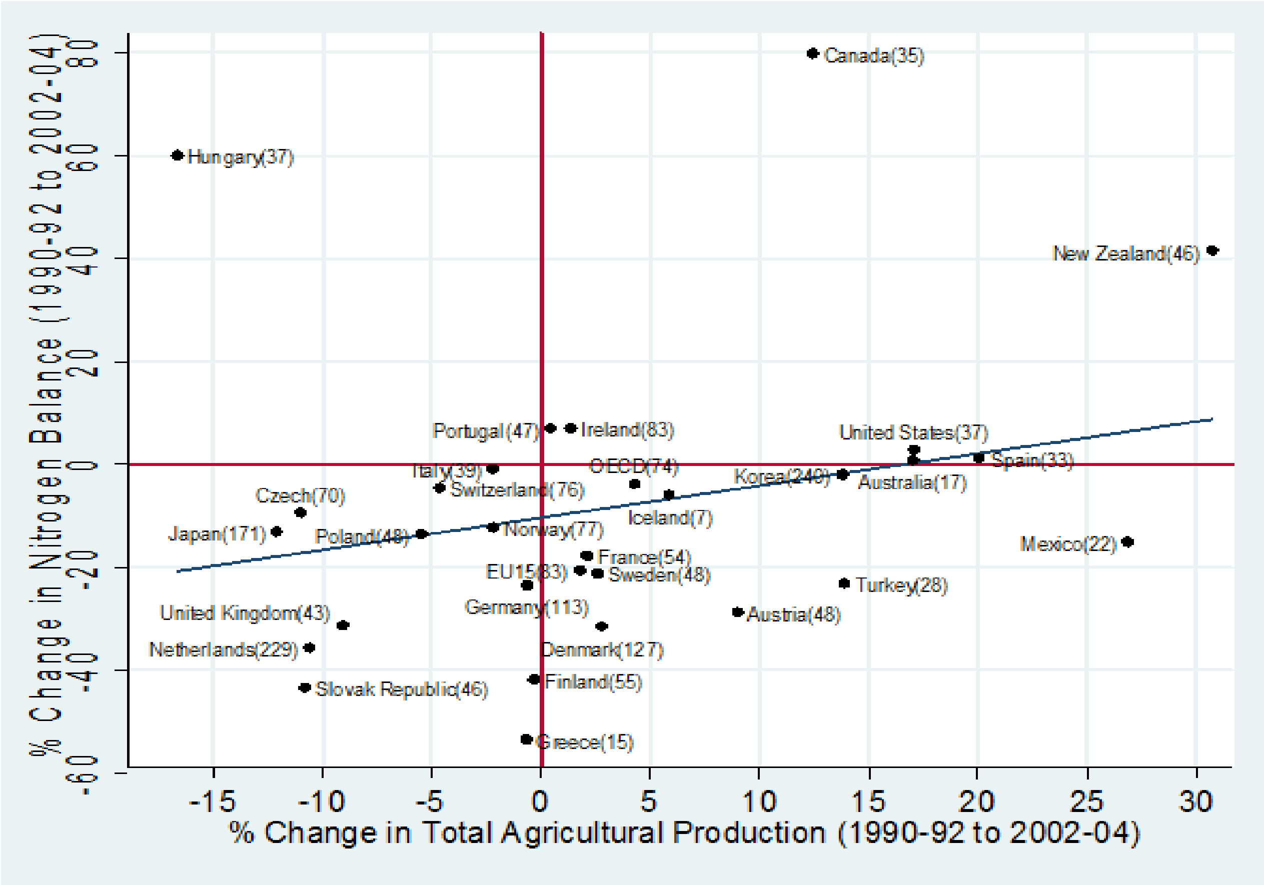
Figure 45. **Beef-sheep per hectare fertilizer use has been declining since 2002**



Source: New Zealand Ministry for Primary Industries (2012)

Figure 46 and Figure 47 show that the impressive growth in production is associated with percentage increases in both nitrogen and phosphorous balances. Land use changes from sheep and beef farming to dairy is associated with a 40 per cent increase in nitrogen and 120 per cent increase in phosphorous. The average difference between nitrogen (phosphorous) being used in production and what leaves the farming system is 46 kilograms per hectare (14 kilograms per hectare).

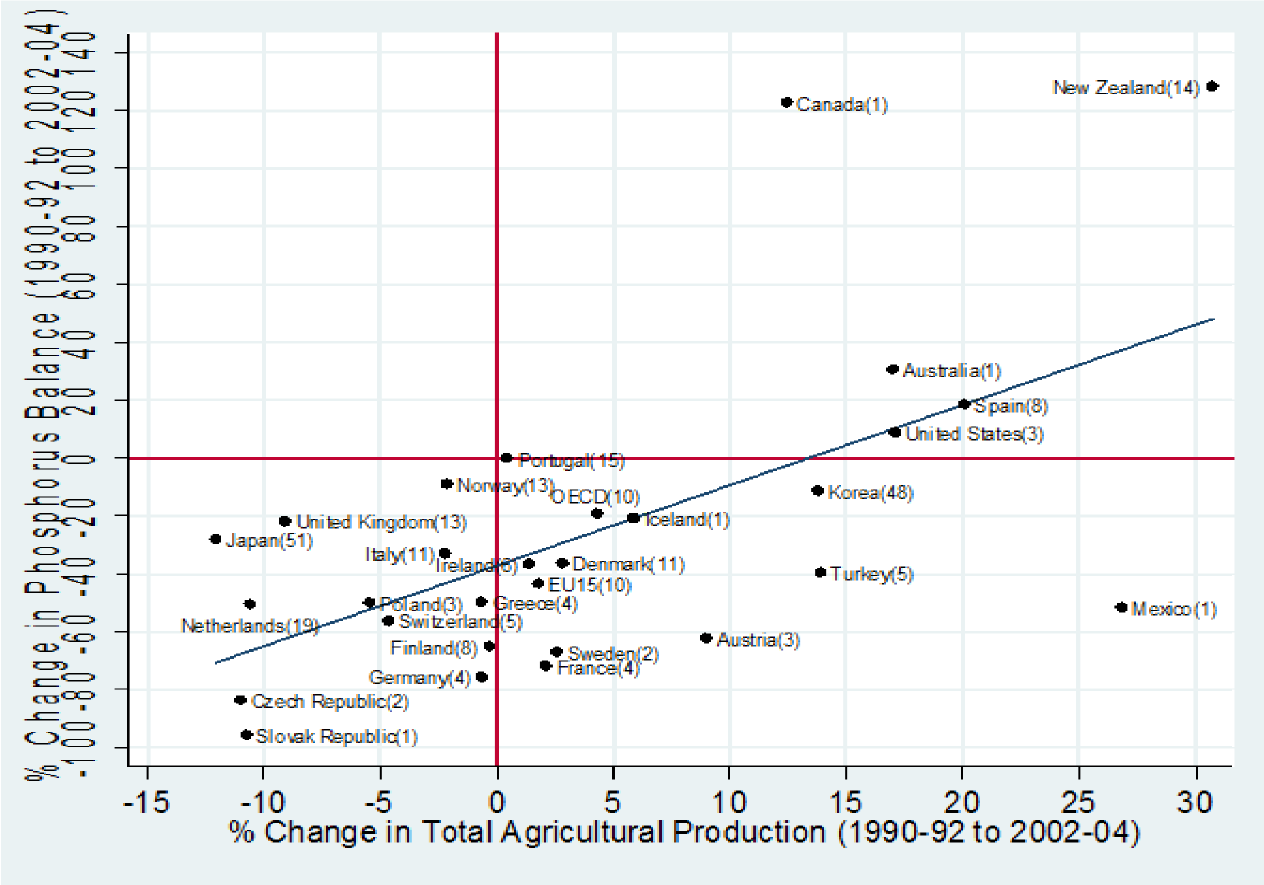
Figure 46. **The increase in agricultural production has been accompanied by an increase in the nitrogen balance**



Note: The values in brackets indicate the average nitrogen balance (in kilograms per hectare) in 2002 to 2004. Gross nitrogen balance is the difference between nitrogen input entering a farming system and nitrogen output leaving the system.

Source: OECD (2008b)

Figure 47. **The phosphorous balance has also greatly increased**



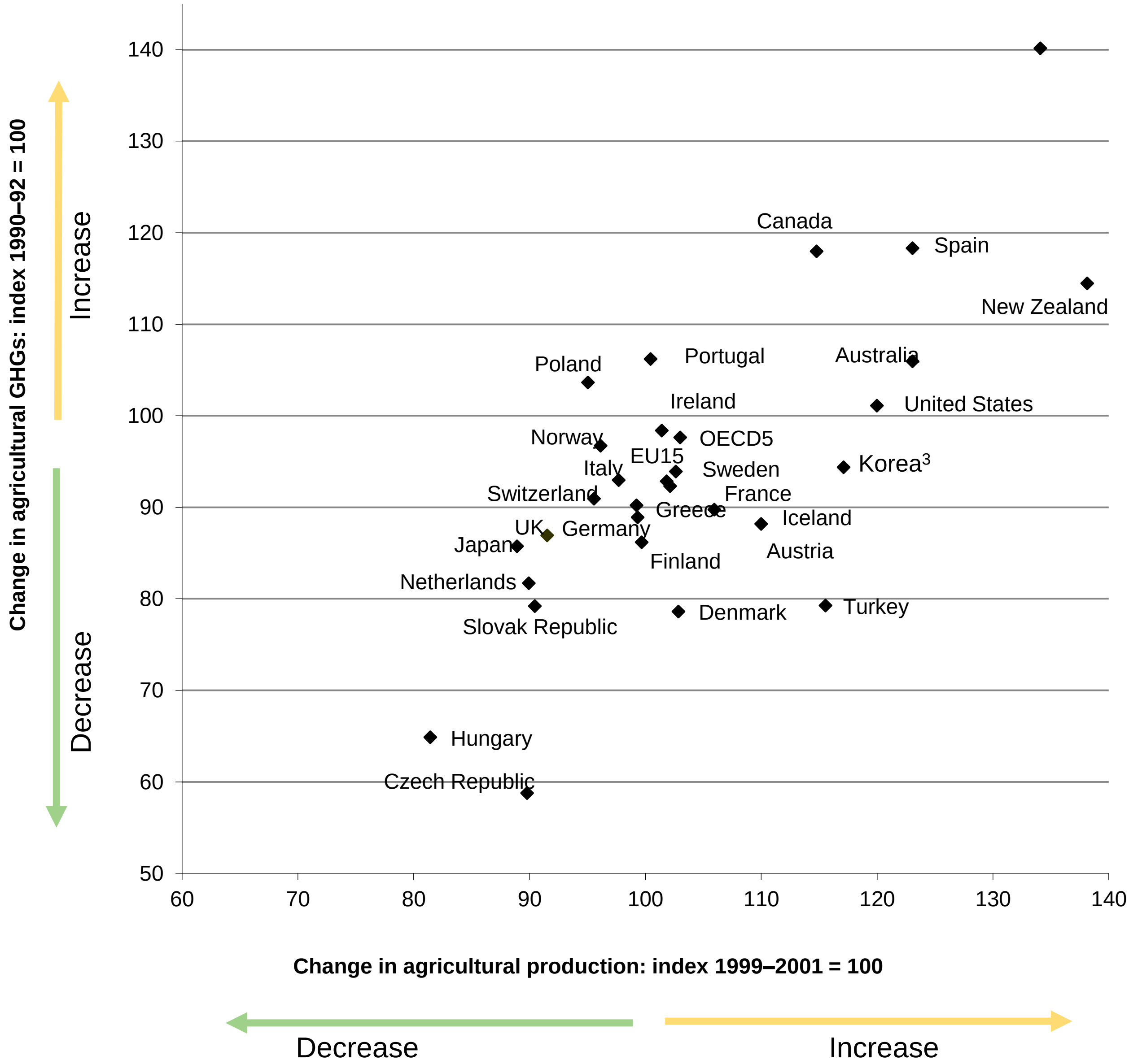
Note: *The values in brackets indicate the average phosphorous balance (kilograms per hectare) in 2002 to 2004. The gross phosphorus balance is the difference between phosphorus entering a farming system and phosphorus output leaving the system.*

Source: *OECD (2008b)*

Greenhouse gas emissions

Figure 48 shows that greenhouse gas emissions from NZ agriculture have increased roughly in line with the change in production, from a base standardised to 100 in 1990 to 1992 to slightly over 110 in 2001 to 2003.

Figure 48. **The increase in agricultural production has been accompanied by an increase in emissions**



Note: *The Agricultural Production Index is a volume index of total crop and livestock production. The data included in the figure are averages for 2002 to 2004, with 1999 to 2001 as the base period. Data for the period 2001-03 refer to the years 1999 to 2001 for agricultural greenhouse gas emissions. Data for the period 1990-92 and 2001-03 refer to the year 1990 and 1998 for agricultural greenhouse gas emissions.*

Source: *OECD (2008c)*

In its report to the United Nations, the Ministry for the Environment noted that the average annual growth in total emissions between 1990 and 2010 was around 0.9 per cent per year (New Zealand Ministry for the

Environment 2006). Table 10 shows methane and nitrous oxide emission growing by 4 per cent and 25 per cent respectively between 1990 and 2010.

Table 10. **Methane emissions have grown 4 per cent since 1990, nitrous oxide emissions have grown 25 per cent**

Greenhouse gas	Emissions 1990	Emissions 2010	Change	Percentage change
CO_2	25,014	33,199	+8,185	+33
CH_4	25,826	26,855	+1,029	+4
N_2O	8,311	10,455	+2,143	+26
HFCs	not known	1,087	+1,087	–
PFCs	630	41	–589	–94
SFs	15	20	+5	+32
Total	**59,797**	**71,657**	**+11,860**	**+20**

Note: Units are thousands of carbon dioxide tonne equivalent emissions.

Source: New Zealand Ministry for the Environment (2006)

The agriculture sector accounted for the largest share of greenhouse gas emissions in 2010 making New Zealand unique amongst developed countries. Within the agricultural sector, the largest source of emissions is from dairy cattle, sheep and nitrous oxide from soils. The Ministry attributes the increase in emissions to growth in dairy cattle numbers associated with increased nitrogen fertilizer use, driven by favourable milk prices.

Table 11. **The agriculture sector produced the largest share of greenhouse gas emissions in 2010**

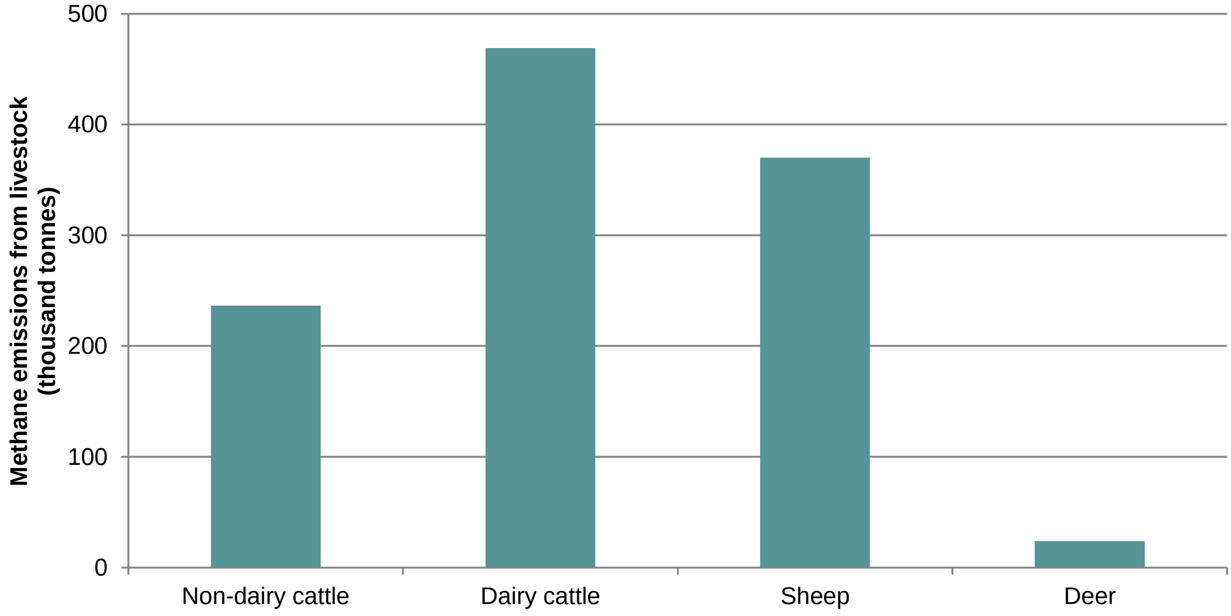
Sector	Emissions 1990	Emissions 2010	Change	Percentage change
Energy	23,458	31,108	+7,649	+32.6
Industrial processes	3,388	4,778	+1,389	+41.0
Solvent and other product use	41	31	–11	–25.4
Agriculture	30,855	33,748	+2,893	+9.4
Waste	2,053	1,992	–61	–3.0
Total (excl. LULUCF)	59,797	71,657	+11,860	+19.8
LULUCF	–27,388	–19,9801	+7,408	+27.0
Net Total (incl. LULUCF)	32,409	51,677	+19,268	+59.5

Note: Units are thousands of carbon dioxide tonne equivalent emissions.

Source: New Zealand Ministry for the Environment (2006)

Improvements in emissions per yield from livestock and dairy cattle will therefore have a significant effect on greenhouse gas emissions. NZ already has a strong programme of research and development in this area. For instance, NZ led an initiative known as the Primary Growth Partnership. The purpose of this initiative was to tackle greenhouse gas emissions from agriculture, funding research that could reduce emissions while maintaining production and allowing the sector to expand to meet global protein needs. Research spanned dairy, beef and cattle, and includes 'low methane yield per unit of output' trait selection trials, pharmaceuticals, feeding methods, and the use of nitrogen inhibitors. Nutrient budgeting and the application of smarter technology to economise on nitrogen and water use offer the most promise. Continued support for similar programmes, and the commercialisation of associated technologies and practices, will be important in maintaining or improving NZ's relative performance in agricultural emissions (**green growth opportunity 15**). In particular, policy-makers could consider prioritising low-carbon agriculture if public R&D expenditure is increased (see **green growth opportunity 1**).

Figure 49. **Dairy cattle and sheep both produce a large amount of methane emissions**

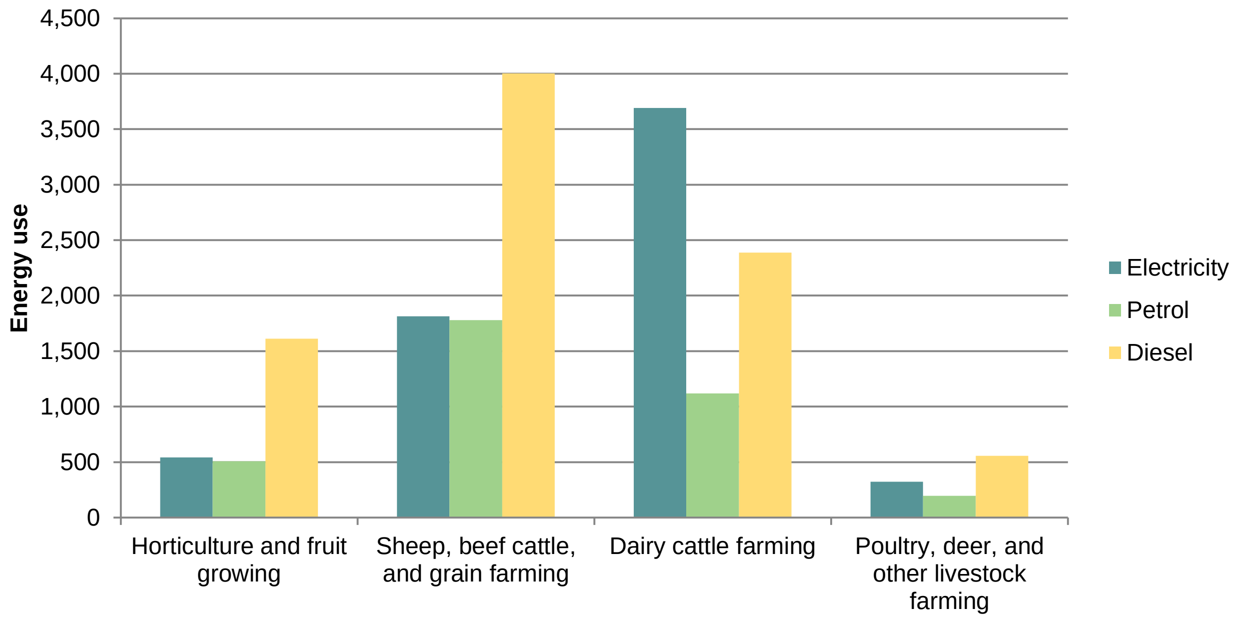


Source: New Zealand Ministry for the Environment (2006)

Energy use

The pattern of energy use in agriculture is illustrated in Figure 50. Perhaps the most striking feature is the use of fossil fuels in sheep and beef relative to dairy farming. A number of factors might contribute to this pattern of fuel use, including the fact that sheep and beef farming holdings are generally larger and often located in more remote areas. Dairy farming is shown to use more electricity relative to fossil fuels, which is not surprising given dairy farming's reliance on electricity for milking operations and irrigation.

Figure 50. **Dairy farming is electricity intensive, sheep and beef farming is fossil fuel intensive**



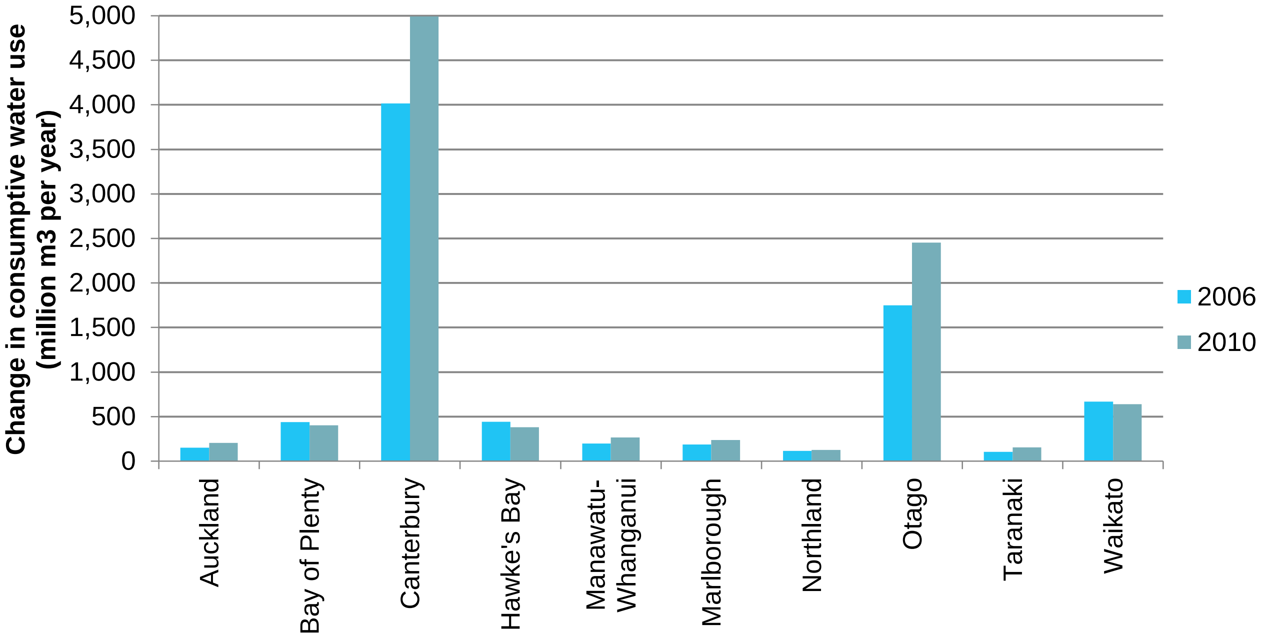
Source: Statistics New Zealand (2008a)

Water use

Water is allocated on a first-come-first-served basis, with limited ability to transfer permits, minimal monitoring, and limited cost-recovery. Allocating water on this basis does not encourage patterns of efficient investment and the timing of development may be biased towards acquiring abstraction rights. A dry land pastoral farmer, at the head of the queue, might invest in low cost high water use irrigation technology simply to secure a right. Locking in water allocation by not allowing transferability exacerbates the problem. As is common with non-priced resources, water might be used up to the point that its contribution to profit is zero. If water is scarce then the distortion of production is obvious. Too much water is being used and many existing uses are likely to be inefficient, both technically and economically.

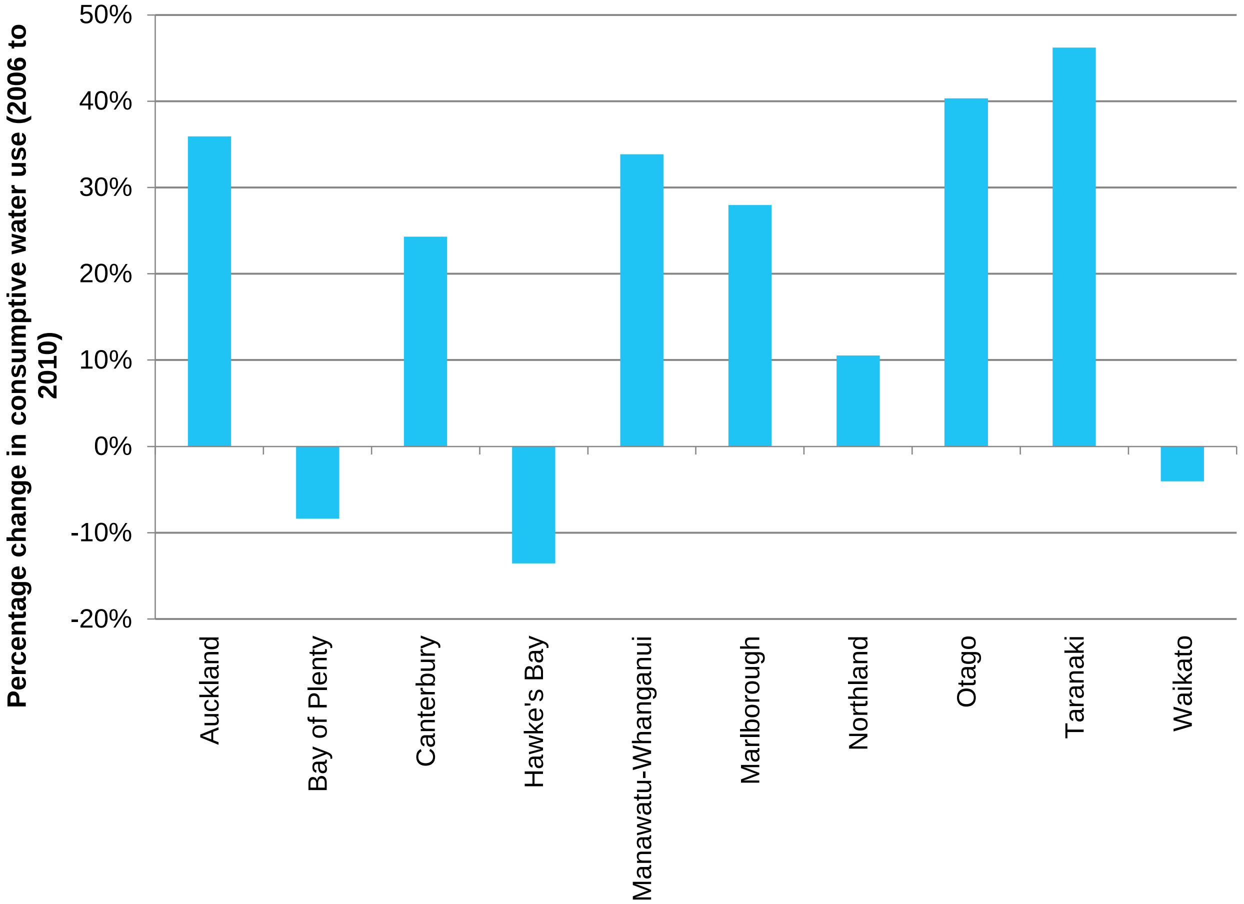
Figure 51 and Figure 52highlight the growth in water consumption in Canterbury and Otago. Data are not available to breakdown of water consumption according to use, but it would appear that the increase in Canterbury and Otago is driven largely by the expansion of dairy farming. Consumptive use of water over the period 2006 to 2010 increased in each major agricultural region; by 20 per cent and 40 per cent in Canterbury and Otago. A moderate reduction in consumptive use is reported for Waikato and Hawke’s Bay.

Figure 51. **Water use is extremely high in Canterbury and Otago**



Source: Aqualinc Research Limited (2006); Aqualinc Research Limited (2010)

Figure 52. **Canterbury and Otago are also among the regions with highest growth in water use**



Source: Aqualinc Research Limited (2006); Aqualinc Research Limited (2010)

Water quality

Table 12 shows the results of a survey of regional officials on the sources of adverse impacts on water quality. On a scale of zero (no damage) to ten (severe damage) the officials have expressed views on the contribution of activities to environmental impact. They believe that primary agriculture causes greater damage to water quality than other activities.

Table 12. **Agriculture is considered by regional officials to be the most damaging to water quality**

	Average	Weighted average (population)	Weighted average (area)
Primary agriculture	4.9	5.4	4.8
Human sewage	4.8	4.3	4.3
Urban storm run-off	3.9	4.1	4.2
Industry (excluding agriculture)	3.8	4.4	3.5
Agric. processing	3.7	3.7	4.2
Mining	2.6	2.1	3.0
Forestry	2.6	2.7	2.7
Other	0.7	1.6	0.3
Native vegetation	0.5	0.2	0.7

Note: Numbers show regional officials assessment of damage to water quality caused by a particular activity. Scale is zero to ten.

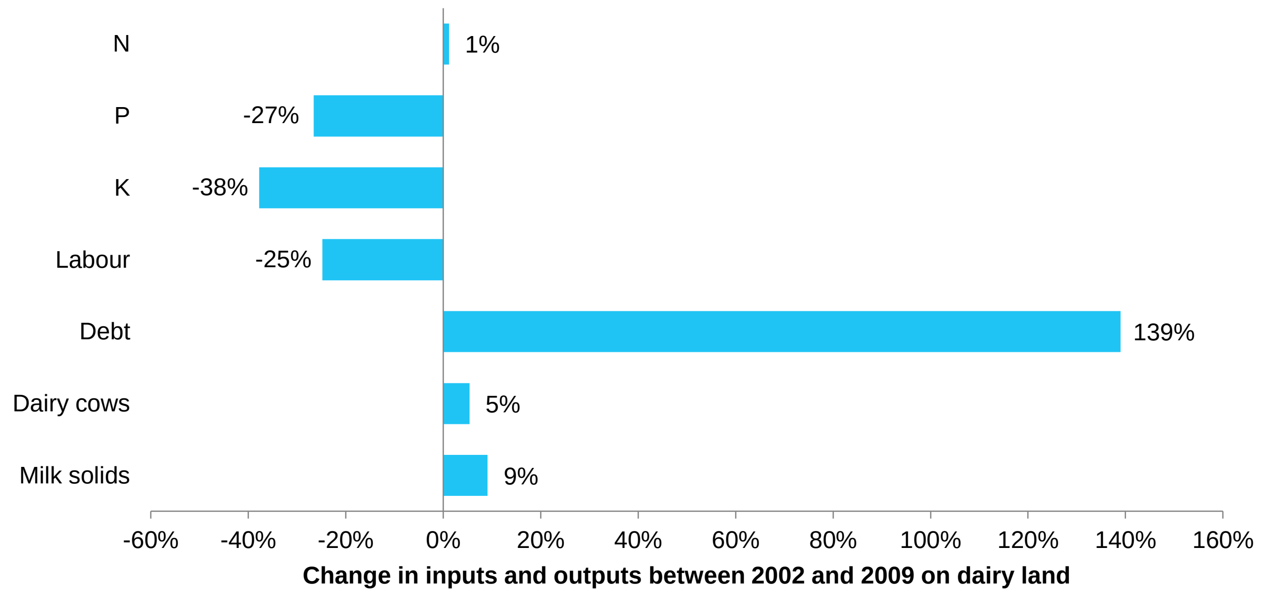
Source: New Zealand Ministry of Agriculture and Forests, (n.d.)

Concluding comments

Agriculture makes a significant contribution to the NZ economy, in terms of exports and GDP. Figure 53 illustrates trends in inputs and outputs on dairy land. This data suggests that output per hectare has increased and inputs, with the exception of nitrogen use which increased at 1.2 per cent, have decreased. In contrast, productivity on sheep-beef farm land decreased across all measures (New Zealand Ministry for Primary Industries 2012).

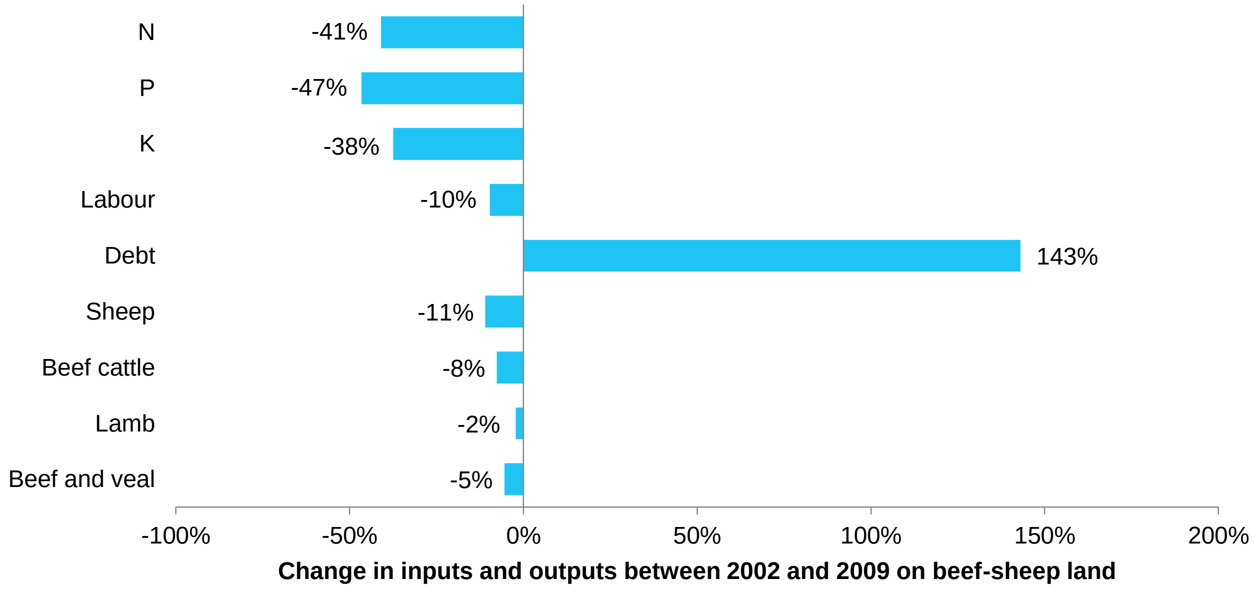
Increasingly there will be calls from the community to limit adverse impacts associated with intensification and increased demand for access to water for irrigation. Elevated levels of nitrate nitrogen and growth in greenhouse gas emissions will continue to present challenges.

Figure 53. **The outputs of dairy farming have increased, most of the inputs have decreased**



Source: New Zealand Ministry for Primary Industries (2012)

Figure 54. **All outputs and inputs other than debt have decreased for beef-sheep farming**



Source: New Zealand Ministry for Primary Industries (2012)

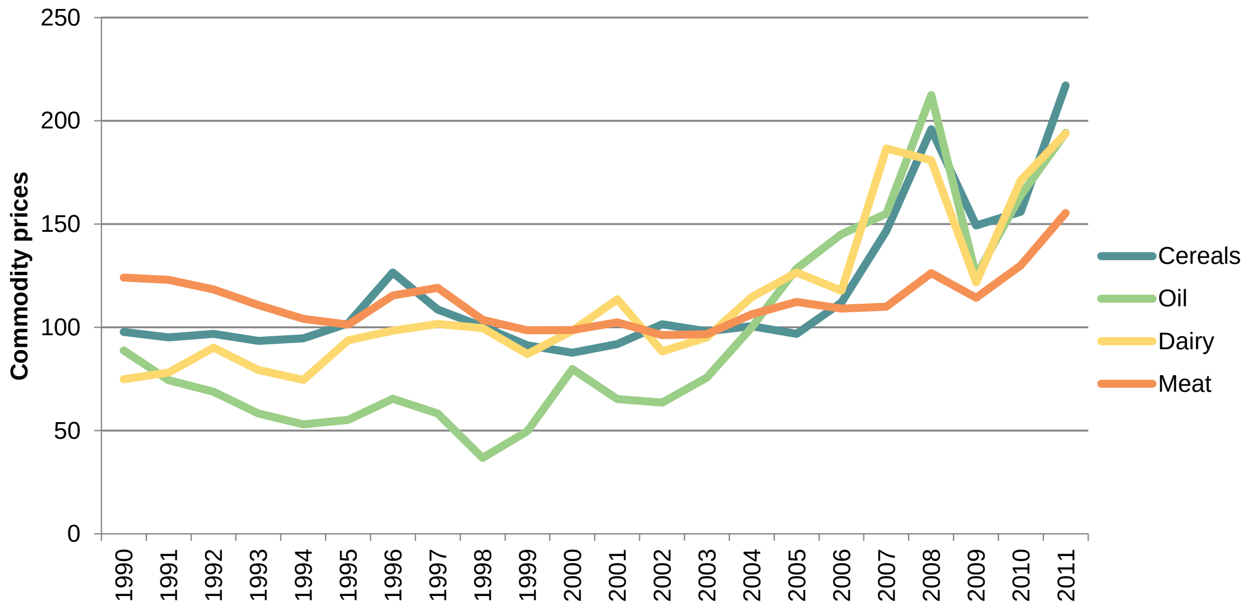
4.5.3 Review of world agriculture

Globally, the agricultural sector has provided the food necessary for a larger and wealthier global population. The World Bank reported a global population of 6.9 billion in 2011, 52 per cent living in urban areas (World Bank 2011a). Gross national income per capita increased from slightly over US$5,000 in 2002 to US$9,000 in 2010. Population growth coupled with rising incomes in developing countries is expected to account for most of the anticipated increase in global food demand in the near future. These projections raise questions about the determinants of demand and whether the supply of agricultural products can match demand.

Demand analysis reveals important relationships between food demand, price and income levels. Regmi et al. (2001) provide useful insights into these determinants. Growth in per capita income is a key driver of the composition of demand across commodity groups. In general, low income countries spend a greater share of their budget on necessities such as subsistence foods such as dairy products; richer countries spend a greater proportion on luxuries, which also includes foods and beverages. This is reflected in estimates of income elasticities, measured as the percentage increase in consumption associated with a given percentage increase in income, for food in poorer countries of 0.73. This compares to an income elasticity of 0.29 for richer countries. While these results indicate that a smaller proportion of household budget will go towards buying food as per capita incomes rise, the total amount spent will be higher. Importantly, from NZ's perspective, within the category of food, the composition of demand is expected to shift from low value commodities, such as cereals, to higher value commodities, such as meat and dairy products. However, working against this is the fact that one-fourth of the world's population remains in absolute poverty and lacks the income necessary to translate its needs into effective demand (FAO 2002). Regmi et al. (2001) also show that own-price elasticities for higher value food categories, such as meat and dairy products, increase as countries get poorer.

Figure 55shows commodity prices rising through 2008 and falling sharply in 2009. Increasing prices in 2010 are attributed to an upturn in economic growth, production shortfalls and low inventory levels.

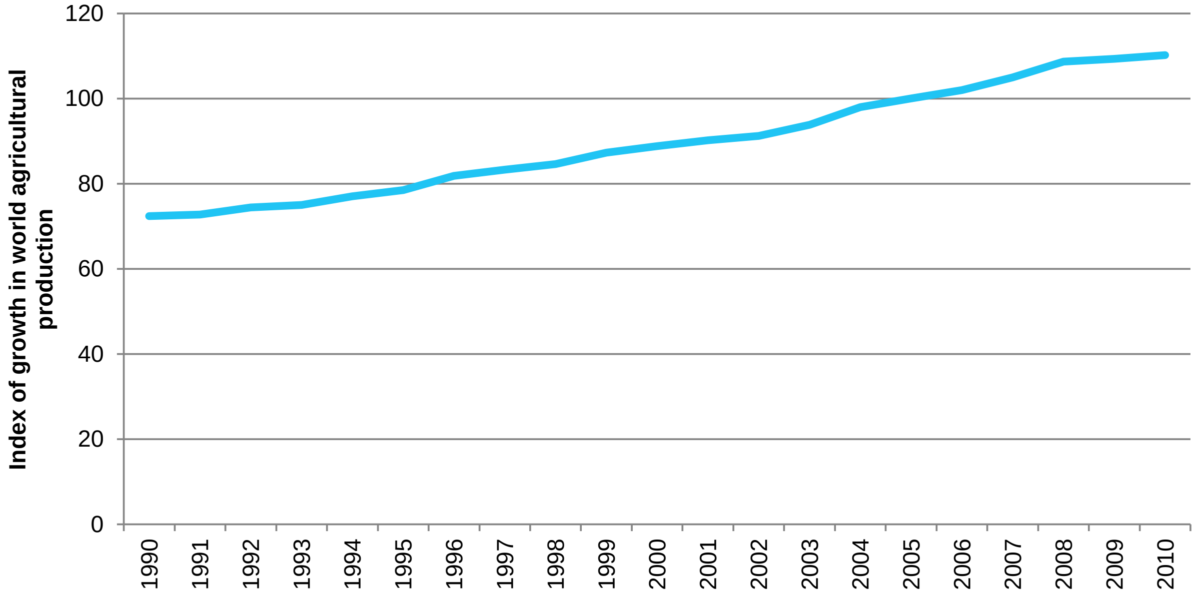
Figure 55. **Commodity prices are increasing**



Source: Food and Agriculture Organization (2012)

Turning to supply, Figure 56 shows growth in the world's agricultural production index increasing through 2008 and the rate of increase dropping off from 2009. Production has been driven by an increase in the area of land used for cropping, more frequent rotations and increased yields. However, there are signs that production costs are rising and productivity growth is slowing (FAO 2011). The cost of energy, fertilizers, and access to water are key drivers. Price volatility in energy markets has a direct impact on the cost of fertilizer, on-farm production and transportation; and, indirectly through the use of feedstock for biofuels. Growth in biofuel production is subsidised by policy mandates and subsidies. Adverse weather events, such as droughts, cyclonic events, are expected to increase the volatility of commodity prices in the future.

Figure 56. **Agricultural production has been steadily increasing for 20 years**

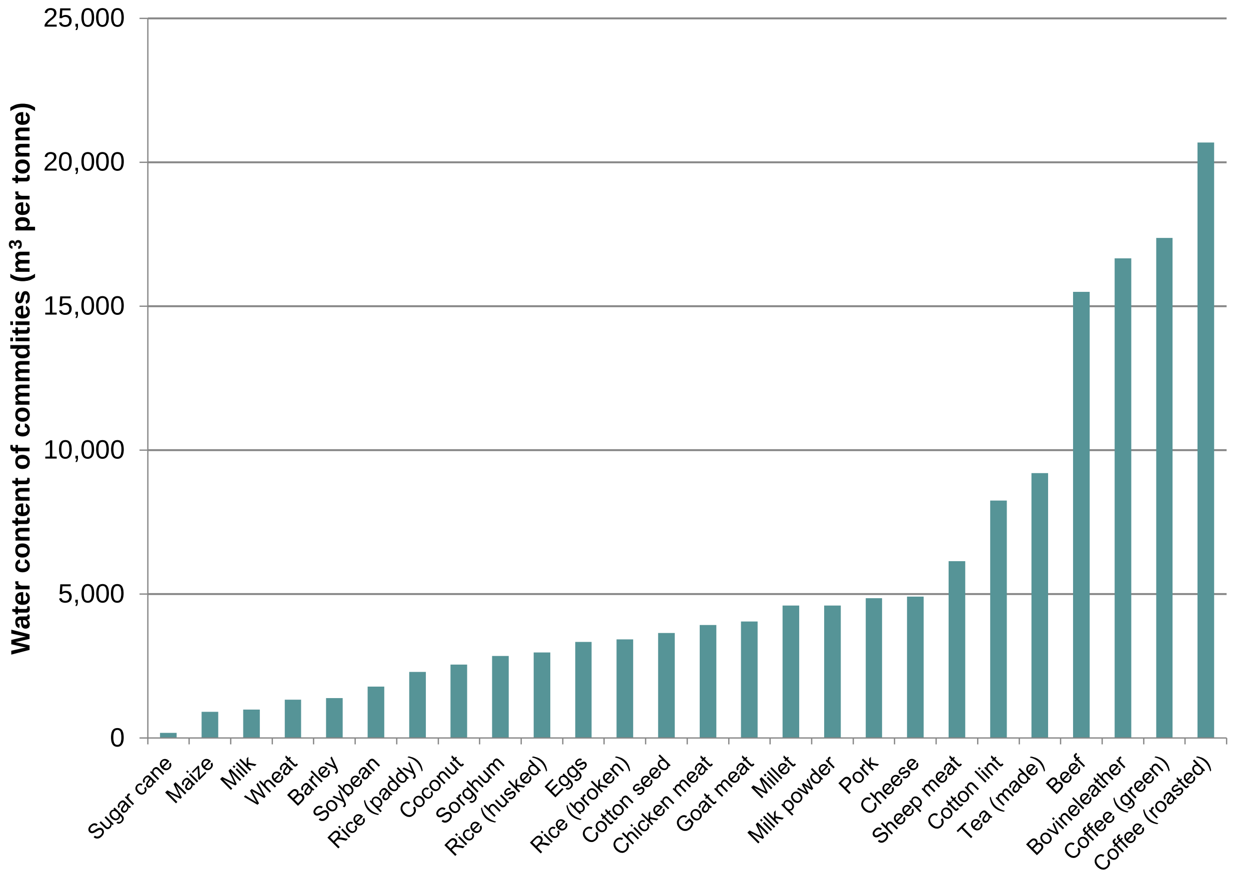


Source: Food and Agriculture Organization (2012)

The Food and Agricultural Organization reports that the food sector, including manufacturing, production, processing, transport, marketing and consumption, accounts for around 30 per cent of the world's total energy consumption and 20 per cent of the world's greenhouse gas emissions (FAO 2011b). High GDP countries use a greater proportion of energy for processing and transport. Not surprisingly, commodity prices are correlated with global energy prices. Simple correlation analysis between the oil price index and commodity price indices over 1990 to 2011 gives the following correlation coefficients: oil and cereals, 0.84; oil and dairy, 0.89; and oil and meat, 0.64.

Globally, on farm direct energy use amounts to between one and two per cent of energy consumption (FAO 2011b) with considerable variation across farming types and regions. On farm production systems are dependent on fossil fuels for mechanisation, transport, petroleum based pesticides and herbicides, and fertilizer production and application (such as urea-nitrogen). The dependence on synthetic nitrogen and the long distances involved in transporting inputs and outputs may explain the correlation between food prices and fossil fuel prices. For example, natural gas accounts for 90 per cent of the cost of nitrogenous fertilizer in the United States (Wenzel 2004). Electricity also plays an integral part in on farm production where it is used to power irrigation systems and milking machinery and a wide range of substitutes are available to ensure a reliable supply of electricity.

Figure 57. **There is much variation in the water content of agricultural goods**

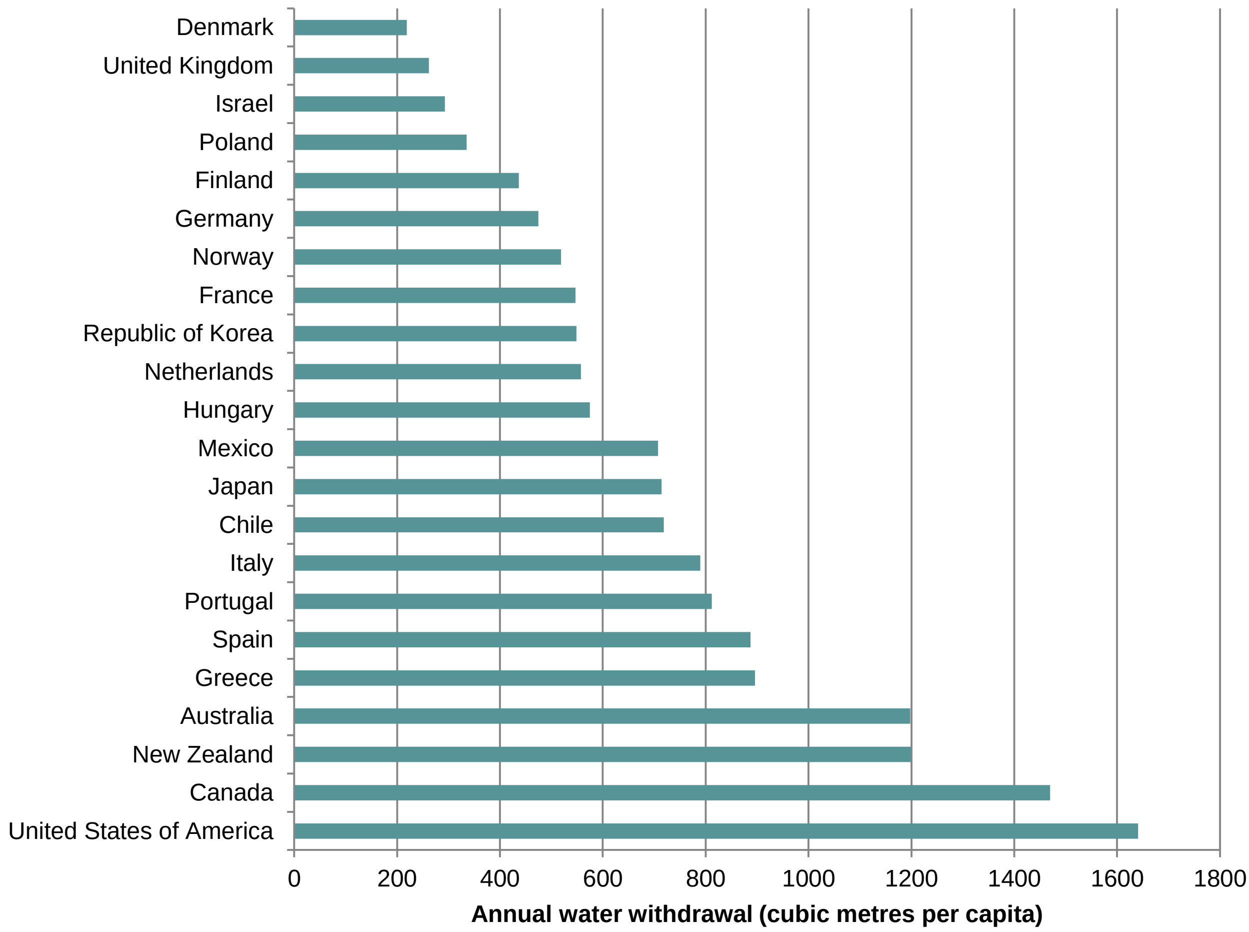


Source: Chapagain and Hoekstra (2004)

Irrigation accounts for about 70 per cent of the world's use and water withdrawals are expected to increase by 50 per cent in developing countries and 18 per cent in developed countries. In 60 per cent of European cities with a population over 100,000, groundwater is being used at a rate faster than it is being replenished. According to the World Bank, by 2025, 1.8 billion people will be living in countries or regions with absolute water scarcity. Figure 57 provides an indication of the water input to a range of agricultural products (Chapagain and Hoekstra 2004).

Figure 58 summarises FAO data for a selection of countries and shows NZ's annual water withdrawal per capita to be about the same as Australia.

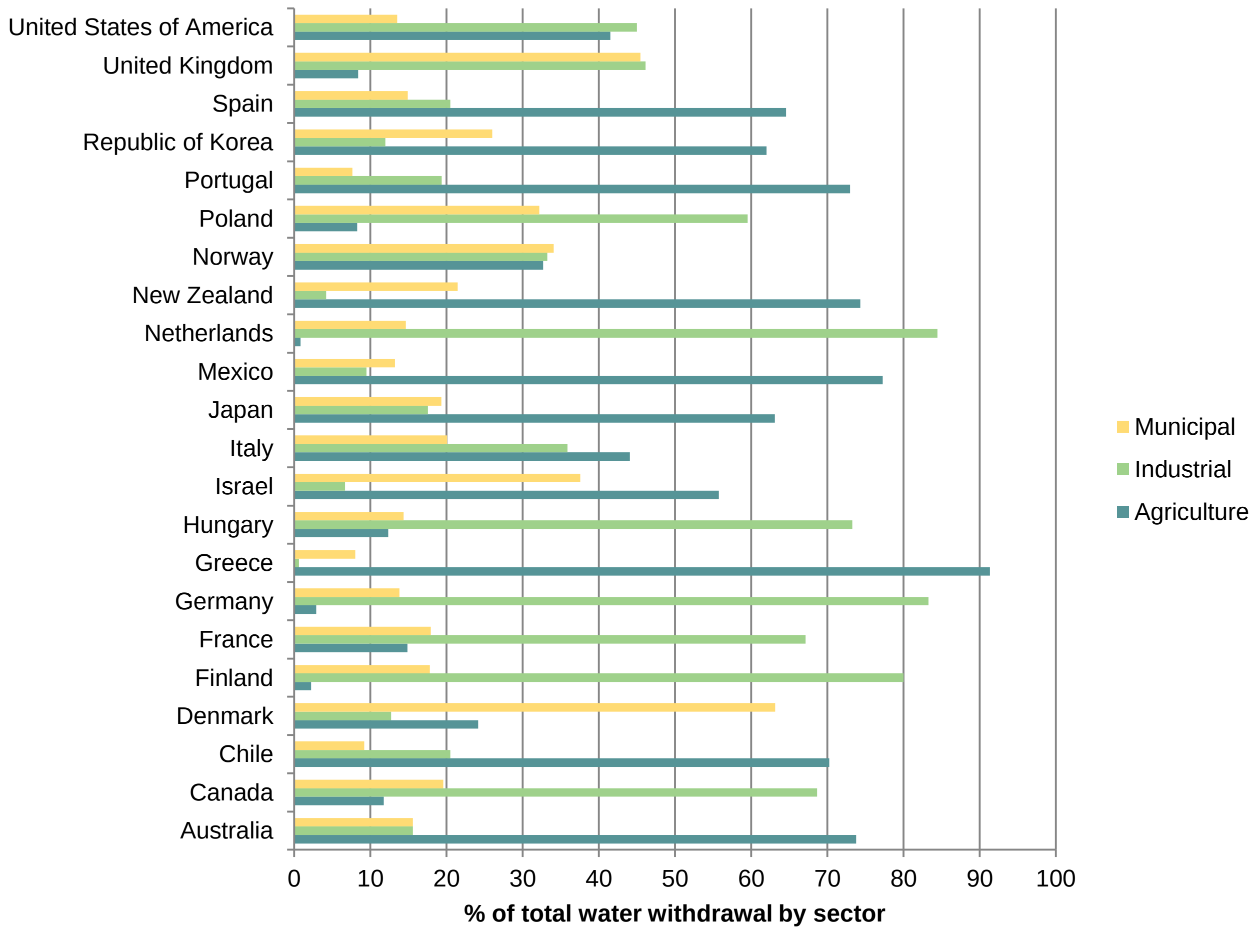
Figure 58. **New Zealand's annual water withdrawal per capita is higher than most OECD countries**



Source: Food and Agriculture Organization Statistics, Aquastat

NZ's water use in agriculture, as a percentage of total withdrawal, is similar to Australia, Chile, and Portugal. Total withdrawal needs to be balanced against recharge rates which, in NZ's case, are relatively high. For example, in Canterbury, White et al. (2003) estimate rainfall recharge rates in the order of 26 to 37 per cent. Industrial use of water in NZ, again as a percentage of the total, is the lowest among the countries listed in Figure 59.

Figure 59. **The vast majority of New Zealand water withdrawal is for the agricultural sector**



Source: OECD Statistics

World fertilizer consumption has grown at an annual rate of around 2.3 per cent and this is expected to continue over the near term (Heffer and Prud'homme 2010). The global capacity of nitrogen fertilizer production is expected to exceed demand in the near term, although energy prices and regulations governing greenhouse gas emissions will impact the price of manufactured nitrogen products. The depletion of the world's phosphate resources has raised concerns that there might not be sufficient phosphorus supplies from mining to meet agricultural demand in the future, within 30 to 40 years (Clabby 2010; Elser and White .2010).

Four themes arise from the review of world agriculture and signal opportunities for NZ agriculture.

– The demand for higher value commodities, such as meat and dairy products, is expected to increase.
– Energy use in the food sector, meaning beyond farm gate, dominates energy use at the farm level. Energy efficiency gains in food processing, including less reliance on fossil fuels and greater use of

renewable sources, offer prospects for NZ business to reduce the extent to which agricultural products are coupled with energy especially oil prices;

- It would appear that world supply of key fertilizers, nitrogen, phosphate and potash will meet demand in the near term. Nitrogenous fertilizers will be tied to the price of natural gas which exposes NZ agriculture to cost changes;
- Access to water is a critical factor in meeting the world's increased demand for food. New Zealand has a competitive advantage in respect of water supply, provided governance can deliver secure access to producers and adverse impacts associated with intensive agriculture can be managed appropriately.

4.5.4 Green growth in dairy farming

Over the past 20 years there has been a continuous expansion of the NZ dairy industry. Total milk solids processed increased from 600 million kilograms in 1991 to 1,500 million kilograms in 2011. This growth has been driven by increasing global demand.

At the same time, the dairy industry experienced a dramatic increase in productivity, measured in terms of the quantity of milk output per unit of livestock and labour. Average production per cow increased from around 270 kilograms milk solids during to over 310 kilograms, and the average number of peak cows milked per labour unit increased from 83 to 140 from 1991 to 2010 (Jiang 2011).

Beukes et al. (2010) and Jiang (2011) estimate potential productivity gains from technological advancement to be around $560 million. A further $430 million is possible from improvements in the utilisation of technology and potential improvements in management. In sum, potential total productivity gains could easily exceed $1 billion. However, this estimate is based on the assumption that optimised farming systems are adopted by all. Whether or not the potential can be realised depends on creative innovation and the rate of technological change.

The potential for green growth is explored under three headings: institutional innovation, using resources more efficiently, and innovative management.

Institutional innovation

Institutional innovation can come about from voluntary organisational initiatives by farmers; policies implemented by regional councils; and, cooperative initiatives involving farmers and regulators. The Dairying and Clean Streams Accord of 2003 was a voluntary agreement between the Ministry for Environment, Ministry for Agriculture and Forests, Regional Councils and the Fonterra Cooperative group aimed at addressing the impacts of dairy on water environments (Fonterra Co-operative Group et al. 2003). Amongst other things, the accord aimed at excluding dairy cattle from streams, rivers and lakes and their banks. Performance targets included: excluding dairy cattle from 90 per cent of streams, rivers and lakes by 2012; full compliance of dairy farm effluent discharges; all farms to have nutrient management plans in place by 2007; and, fencing off 90 per cent of regionally significant wetlands by 2007.

The Land and Water Forum (2010) reports that although NZ's freshwater quality compares well internationally, its quality and availability has been deteriorating. Both Environment Canterbury and the

Otago Regional Council have addressed deteriorating water quality associated with nutrient leaching, effluent and sediment runoff. Policies aimed at establishing environmental limits are being developed by both councils that will lead to on farm management initiatives such as nutrient budgets, managed fertilizer applications, use of nitrogen-inhibiting technologies, stock management practices, and effluent management.

The Otago Regional Council is proposing to establish limits, including: nitrogen, phosphorous, bacteria and sediment levels in receiving catchments. Water bodies will be monitored and when these limits are exceeded the Council will in the catchment to identify likely sources and approach land owners to adopt less polluting activities. The Council emphasises that the approach is focussed on individual land owners and relies on voluntary compliance and self-enforcement.

In the long run, the expectation is that monitoring systems will be implemented at the farm level. This approach to ‘non-point’ sources of pollution may create incentives for farmers to implement technologies and instruments aimed at measuring, monitoring and reporting on the use of fertilizers (including the application of pond effluent), water and nutrient levels, and dairy shed waste (slurry).

The management of nutrients and microbial contaminants is a priority in Canterbury. The Canterbury water management strategy (CWMS) lists a series of measurable outcome targets expected to be achieved by specified dates, such as the provision of nutrient management plans for 80 per cent of all agricultural land by 2015. In contrast to the approach proposed by Otago Regional Council, Environment Canterbury is moving away from effects based management to integrated management that includes management of cumulative effects of water abstraction and land use intensification through the use of zone and regional programmes. A recent study by Bidwell et al. (2009) suggests that it is technically and economically feasible to achieve a 20 per cent reduction in nitrate discharge rates as long as nitrogen inhibiting technologies are applied across the region.

Using resources more efficiently

Faced with greater water scarcity, it is necessary for NZ to improve both water quality and water allocation, including through enabling transferability and pricing of water (**green growth opportunity 13**). There are two broad options for supporting irrigated dairy farming without increasing pressure on limited water resources. First, investment in water storage or augmentation could provide opportunities for expansion. Government’s infrastructure fund supports this direction. The 2011 budget allocated $35 million over five years for the Irrigation Acceleration Fund to support the development of irrigation infrastructure proposals to the investment ready prospectus stage (Carter 2011). The CWMS has set a target of 850,000 hectares of irrigated land in Canterbury by 2040.

The second option involves improving water use efficiency. The costs of improving efficiency are generally claimed to be much lower than the costs of building storage and so there may be a case for providing incentives to water users to find more efficient and productive ways of using allocated water (Land and Water Forum 2010). Although a key part of the CWMS is to set efficiency targets, decentralising decision-making remains a challenge. This is where market mechanisms might deliver more efficient and productive allocations of water.

Wainono Farm illustrates the economic benefits associated with economising on electricity and water inputs to dairy production. Research into variable rate irrigation on this farm is part of a Ministry for Agriculture and Forests Sustainable Farming Fund project, co-funded by DairyNZ and the Foundation for Arable Research[13]. A major limiting factor is water availability and the farm is targeting an increase in output per millimetre of water applied. Variable rate irrigation technology has been installed with the aim of saving at least 20 per cent water and energy costs. Water savings between 25 per cent and 30 per cent have been achieved without any loss in pasture production.

Table 13. **Wainono farm increased milk solids by 20,000 kilograms without a commensurate increase in inputs**

	2009-10	2010-11
Milking area (hectares)	480	485
Milk solids (kilograms)	722,000	743,000
Peak cows milked	1830	1870
Stocking rate (cows per hectare)	3.81	3.86
Nitrogen applied for year (kilograms per hectare)	175	175
Working expenses (dollars per kilogram milk solids)	$3.47	$3.98

Source: University of Auckland (2012)

Precision application of water is part of best practice management, is economically viable and is based on the following technologies:

- investment in precision irrigation systems;
- GPS and electromagnetic soil mapping enabling quantified soil variability; and
- variable rate modification of sprinkler irrigators.

Irrigation schedules and application rates can be varied precisely according to soil type, electricity costs can be more accurately aligned with needs, soil moisture levels can be optimised to maintain potential plant growth and reduce the risk of nitrate leaching.

[13] The project is also supported by John & Sarah Wright, Precision Irrigation, Streats Instruments, Boraman Consultants Ltd, HydroServices, NZ Centre for Precision Agriculture-Massey University and Landcare Research.

A saving of 50 litres per second, or 28 per cent of total irrigation water, increases the supply of water for use on other areas of the farm. The additional 50 litres per second could grow an additional 4,300 kilograms of dry matter per day or 52,000 kilograms of milk solids per annum. Assuming earnings before interest taxes depreciation and amortization of $3.00 per kilogram of milk solids; this saving results in an additional $160,000 of earnings before interest and taxes. Electricity savings from not pumping 50 litres per second is approximately $16,000. However, in Wainono's case this saving was not realised as the water was applied elsewhere on the farm. In summary, the irrigation enhancement investment was $340,000 and the expected earnings before interest and taxes were $160,000. These returns are quite specific to the farm and soil patterns.

Litchfield's owns a 180 hectare farm in Dunsandel (Canterbury). With an average annual rainfall of 650 millimetres, irrigation is essential. Soil moisture and temperature monitoring provides continuous readings to the farm's computer. This knowledge provides a basis for optimising pasture production per unit of water. Potential savings have been estimated at 150,000 m^3 of water per year. Actual savings in electricity costs were $19,000.

Innovative technology and management

Further development of information technology and communication systems designed for agricultural use will allow farmers to economise on inputs and increase profitability (**green growth opportunity 14**). Innovative use of technology and management can also contribute to the reduction of externalities associated with intensive land based agriculture.

Precision dairy farming refers to the use of information technology and communication systems to improve the effectiveness and efficiency of farm management, and includes monitoring animal production and welfare, land use and effluent management. Information technology also opens up the potential for meeting increased concern that consumers have for identifying source of origin, covering every link in the supply chain, from animal location, in-field sensors, right through to the packaging and delivery.

Many precision dairy farming technologies are already in use and many uses are possible including:

- daily milk yield recording;
- milk component monitoring (e.g. fat, protein, and somatic cell count);
- pedometers;
- automatic temperature recording devices;
- milk conductivity indicators;
- automatic oestrus detection monitors;
- real time health data; and
- daily body weight measurements.

Recent advances in mobile communications technology provide an opportunity for farm managers and advisors to rapidly detect milk quality problems. A wide range of applications, monitoring and control systems are now available.

With precision agriculture, automated information systems and machine-to-machine communications, there is an opportunity to develop products for the domestic market and export. Actions which would help to realise this would involve building on existing initiatives by bringing together farmers, industry groups and research providers, namely crown research institutes, universities and technology firms.

4.5.5 Conclusions

New Zealand has an economic advantage as a relatively low cost producer of higher value commodities, such as meat and dairy products. Demand for these commodities is expected to increase. Emissions from agriculture dominate greenhouse gas emissions making NZ quite unique and the prospect of reducing emissions through stock breeding, vaccines and other pharmaceutical interventions seems limited. Nitrogen inhibitors are available, but uptake is not encouraged by higher cost. Similar reductions might be possible using contemporary fertilizer with smarter application technology, such as using targeted variable applications.

The world supply of key fertilizers, nitrogen, phosphate and potassium, is expected to meet demand in the near term. Nitrogenous fertilizers will be tied to the price of natural gas which does expose NZ agriculture to cost increases. Access to water is a critical factor in meeting the world's increased demand for food. New Zealand has a competitive advantage in respect of water supply, provided governance can deliver secure access to producers and adverse impacts associated with intensive agriculture can be managed appropriately.

Agriculture makes a significant contribution to the NZ economy and NZ's pastoral based systems of agriculture are world-leading.

Elevated levels of nitrate nitrogen and growth in greenhouse gases continue to present a challenge. The benefits of using smart technology on environmental impact and costs can be significant. By extending the scope of information technology to cover a broader range of farm management decisions, substantial efficiency improvements may be achieved.

The expansion of pasture based systems of dairy farming overseas, such as in South America, Ireland and to a lesser extent China, often led by NZ investors, creates additional commercial opportunities for these technologies. Technology that is able to provide consumers with point of origin information, traceability and environmental performance provides another opportunity to lead the market.

4.6 Forestry and fishing competitiveness matrices

There is declining natural capital in forestry and fishing

4.6.1 Forestry competitiveness matrix

There are few cross-country indicators available for forestry. Change in forest cover is one of the best and carbon dioxide sequestered is another. New Zealand's forest cover declined over the period 2005-2010. It was not alone in this. Its main rivals exporting to Japan, namely Indonesia, Malaysia and Papua New Guinea, all have high rates of deforestation. The forestry case study in section 4.7 provides detailed analysis of the NZ industry, current challenges and future opportunities for green growth.

Table 14. **The forestry sector is a sink for carbon dioxide emissions but is shrinking in land area**

Performance relative to rivals	Performance deteriorating	Performance steady or improving
Relatively green	*Green with risks*	*Green* • *emissions*
Not relatively green	*Not green, could worsen* • change in extent of forest cover	*Not green, may improve*

Source: Vivid Economics

4.6.2 Fishing competitiveness matrix

Information about fisheries sustainability is usually presented at a species, stock or ocean level of aggregation rather than at country level. This makes cross-country comparisons difficult. One country-level indicator shows the intensity of trawling activity within the exclusive economic zone. For this metric, New Zealand's relative position is better in its main export market, Australia, than in the global market. Several of its export rivals trawl more than half of their Exclusive Economic Zone and New Zealand does not.

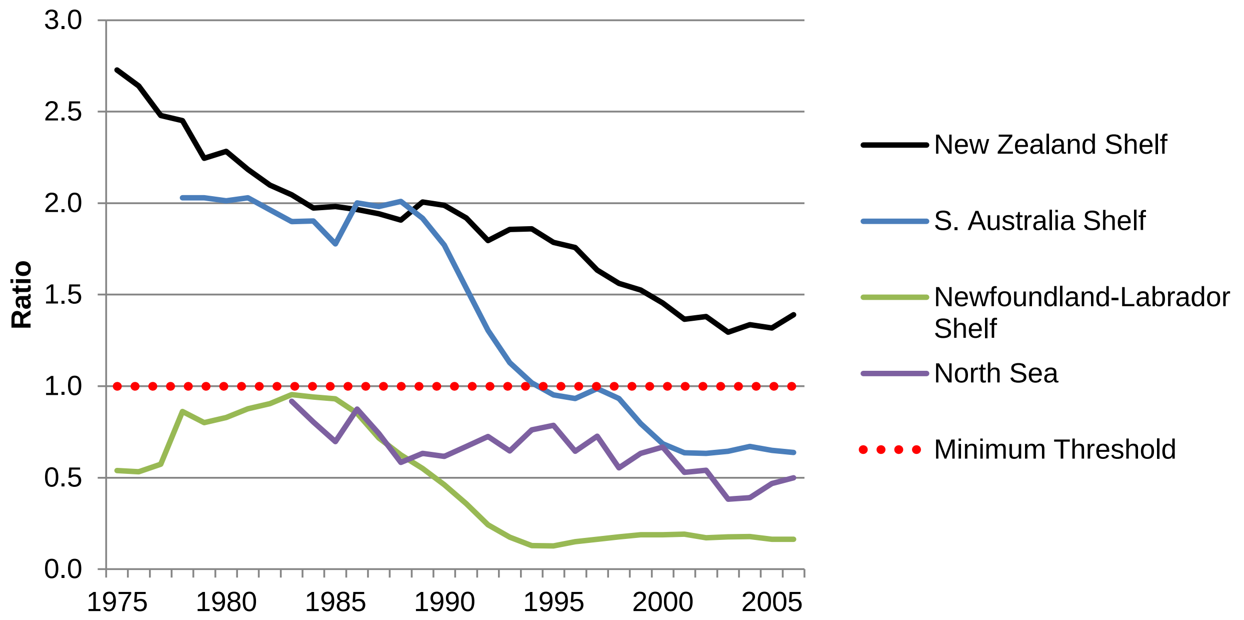
Table 15. **Marine fishing effort is less intensive than in other regions**

Performance relative to rivals	Performance deteriorating	Performance steady or improving
Relatively green	*green with risks*	*green* • proportion of exclusive economic zone that is trawled (relative to export rivals)
Not relatively green	*not green, could worsen*	*not green, may improve* • proportion of exclusive economic zone that is trawled (relative to global market)

Source: Vivid Economics

According to OECD data, around 10 per cent of New Zealand's marine fish species are threatened while the average in the OECD is 28 per cent. As a result of better management, New Zealand has not mined down its stock as far or as quickly as some other regions. Thus it reports a higher ratio of current biomass to minimum sustainable biomass, as shown in Figure 60. This ratio shows that New Zealand's stock is not severely over-exploited, but these figures do not reveal whether it is to the optimum level, which would be close to the biomass associated with maximum economic yield or maximum sustainable yield. The fisheries case study in the next section provides detailed analysis of the industry and opportunities for green growth in the sector.

Figure 60. **New Zealand has mined down its fish stocks but maintained the ratio of current biomass to sustainable biomass above the minimum sustainable level**



Note: sustainable biomass is when fish stocks are harvested at maximum sustainable yield; a marine ecosystem below the minimum threshold is being overfished

Source Worm et al. (2009)

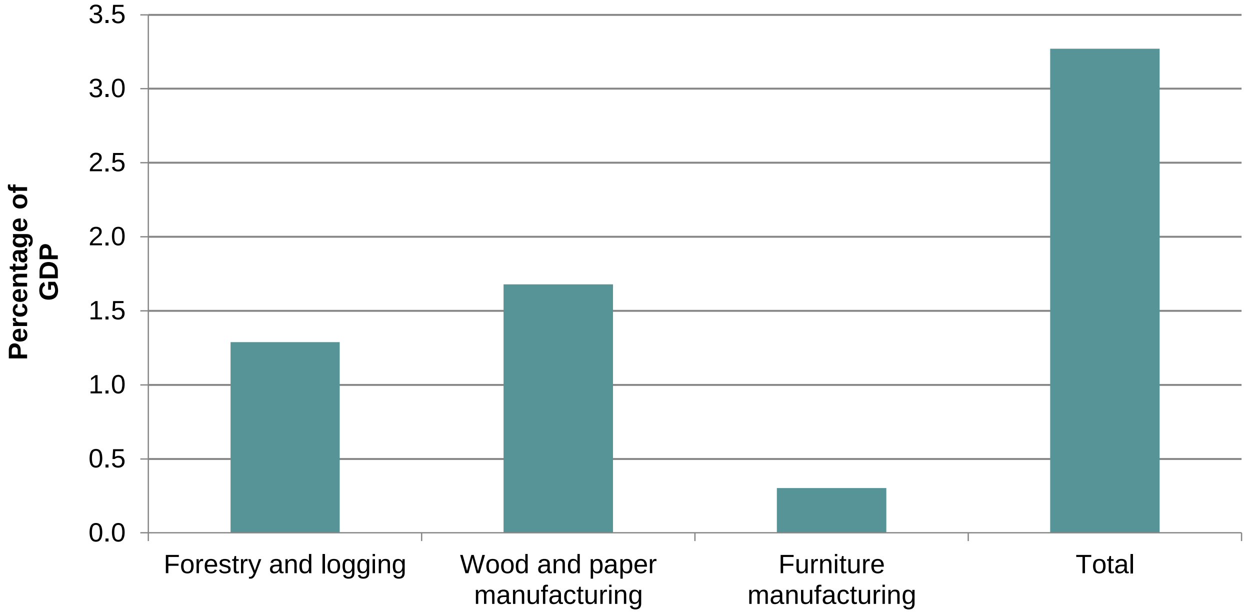
4.7 Forestry case study

An important sector with many green growth opportunities

4.7.1 Introduction

The forestry industry is an important part of the New Zealand economy, contributing 3.3 per cent to NZ’s GDP in 2010, which is comparable in size to the dairy sector. Employment in the sector for 2010 was 26,000, with 63 per cent of this employment in manufacturing, , and the rest employed directly in forest production (Forest Owners Association 2010) (Figure 61). Forestry is an important employer for some regions. For example, it is responsible for four out of every ten jobs in Kawerau (NZIER 2011). The forestry sector is notable amongst NZ’s industries in that it generates 50 to 55per cent of its primary energy from renewable sources such as residues from saw milling and pulp and paper to generate heat and electricity.

Figure 61. **Share of GDP for industry groups in the forestry sectors**



Source: Forest Owners Association (2010)

Investment

Capital investment in wood processing and manufacturing is estimated to be worth $5 billion, with a replacement value of approximately $11 billion (Woodco 2012). There is an additional $1 billion worth of capital investment in logging and forestry transport infrastructure. However, (Woodco 2011) reports that the recent investment record has not been sufficient:

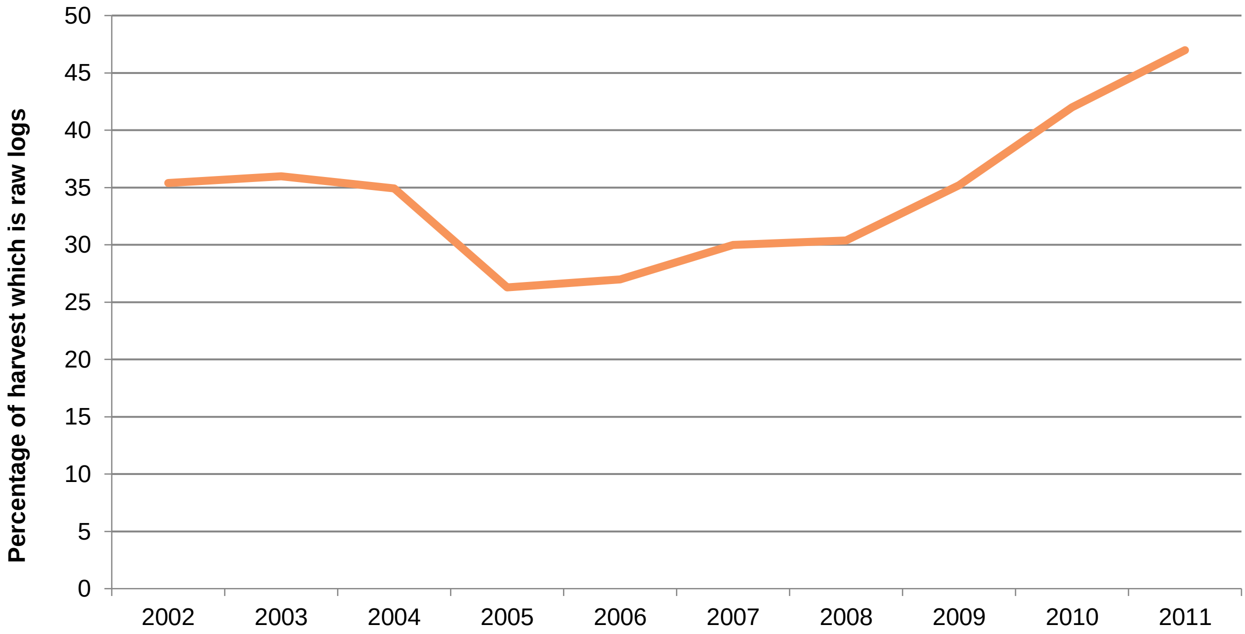
> *'Significant investment and expansion of wood processing and manufacturing capability in New Zealand remains a major challenge. Investment in processing has not kept pace with wood harvest increases. There has been little significant capital investment in new wood processing capacity over the best part of the last decade. [The Ministry of Agriculture and Forestry's] projections assume that this state of affairs will continue to hold – at least for the next two or three years.'*

As outlined below, the lack of investment in recent years means that an increasing proportion of the harvest is being shipped directly as unprocessed, low-value logs. One of the key drivers is increased demand from China which means that local processors find it difficult to compete with export log prices. One of the key challenges the NZ forestry industry faces is to increase investment in processing to yield higher value products

Export

Forestry exports are even more significant for the economy than its direct contribution to GDP. In 2011, exports stood at $4.6 billion, which amounted to 10 per cent of all merchandise exports (NZIER 2011) placing it as the third largest export earner after the dairy and meat industries. Recent years have seen strong growth in wood exports, with increases averaging 19 per cent per annum over the last five years. About 70 per cent of the total harvest is exported - much of it as raw logs. In the year to March 2010, the percentage of the harvest exported as logs reached a record high of 42 per cent driven by strong demand from China. By 2011 this had increased further to 47 per cent (Forest Owners Association 2011).

Figure 62. **Per cent of wood harvest exported as logs**

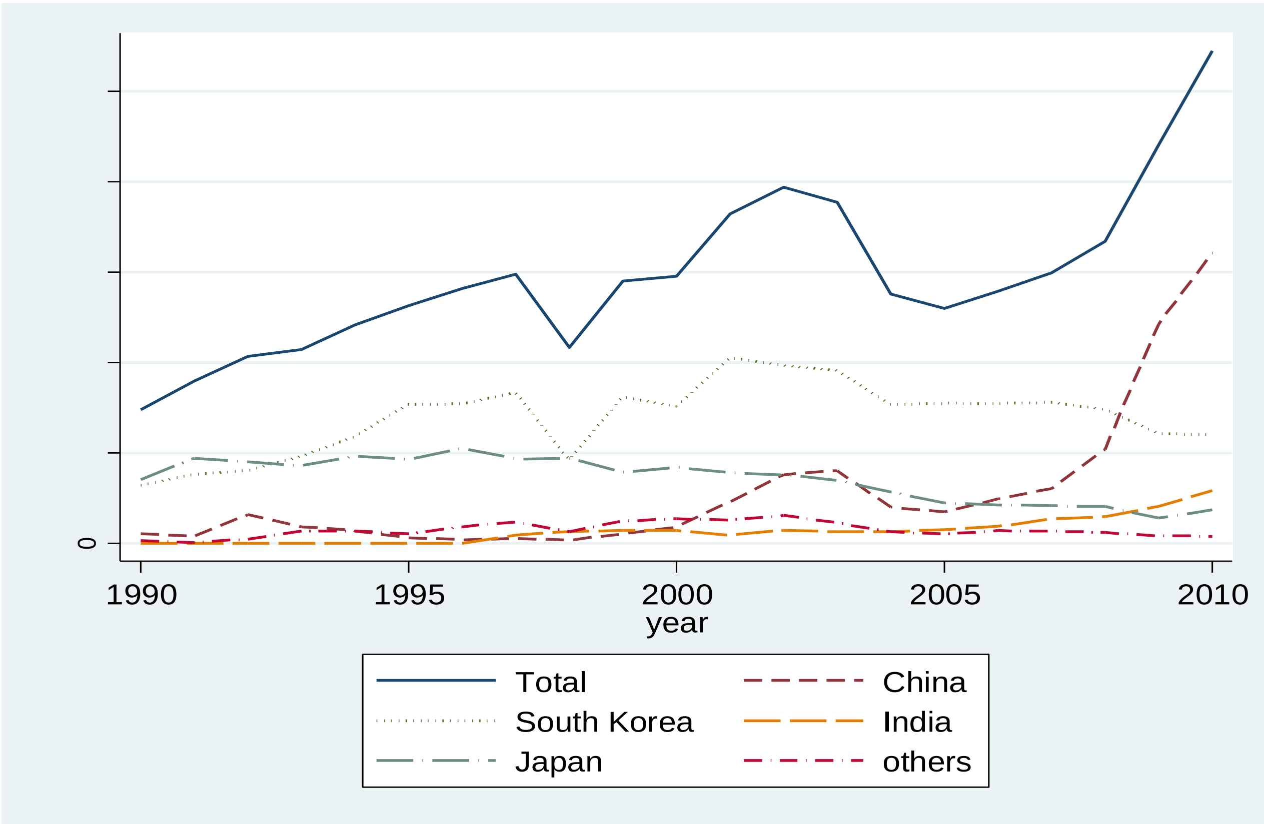


Source: Forest Owners Association (2010)

New Zealand is a small player in the international wood export context - with a market share of just over 1 per cent of the industrial wood and forestry markets. Asia is becoming an increasingly important destination for NZ exports and now contributes 20 per cent of the forest products trade in this area by value. The USA and Australia are also important export markets.

Figure 63 shows annual export volumes of logs from 1990 to 2010 for the five major overseas markets, which illustrates the dramatic increase in total exports of logs after 2005. The main reasons are i) an increasing supply of harvestable wood and ii) an increase in demand from China and India due to the strong economic growth in these two countries. Another important reason is that Russia raised its log tariff in 2007, which forced traditional Russian log buyers, such as China, to sign contracts with NZ and other log suppliers.

Figure 63. **Annual export volume of logs by country from 1990 to 2010**



Source: Forest Owners Association (2010)

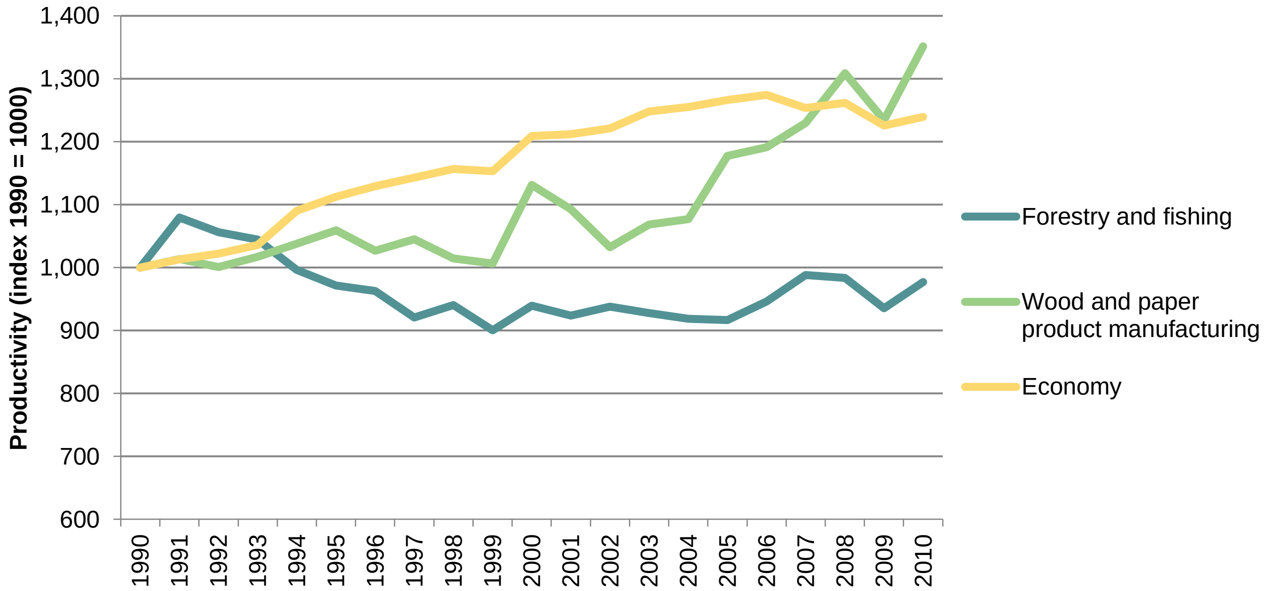
Productivity

Figure 64 illustrates the change in total factor productivity (TFP) over the last two decades in NZ. Whilst the wood and paper manufacturing sector has seen TFP growth broadly in line with the economy as a whole, productivity in the forestry sector has stagnated.[14] The NZ Ministry of Agriculture and Forests (NZ MAF

[14] The data includes a contribution from fisheries as well which makes a small contribution to the total.

2009) has analysed productivity in the sector over the period 1988-2006 and compared it to a number of other countries. During this period TFP growth in wood and paper processing was –0.1 per cent, whereas TFP growth in Canada was 1.5 per cent and Finland averaged 5.1 per cent. US performance was lower than NZ at -0.4 per cent per annum. The MAF also notes that ‘if the gains from privatisation in the early 1990s are removed and figures for the last 10 years are used, TFP growth in forestry and logging is 0.5 per cent and is –0.8 per cent for wood and paper products, compared with a 1.4 per cent national average’.

Figure 64. **Productivity growth in the forestry sector**



Source: Statistics New Zealand (2012b)

The reasons for the poor productivity performance over this time period are discussed at some length [15] and NZ MAF (2009) attributes the low productivity growth during this period to a number of factors:

> *‘In all but a few cases, New Zealand’s wood processing facilities are small by international standards and use older and more labour-intensive systems. A significant proportion of the small to medium sized mills established over the past 10 years have used second-hand mill equipment from Australia, the US and the like. This immediately puts these operations at a disadvantage. While set-up costs might be lower, the technology is already 10 or even 20 years out of date. New Zealand’s mills are also viewed as being undercapitalised. Companies have been prepared to use additional labour, rather than invest further capital to maximise site (and individual) productivity.’*

[15] TFP in the paper and wood manufacturing sector increased at a higher rate over the four years subsequent to 2006. Whether this trend will continue remains to be seen. On the other hand, in the forestry logging sector, TFP growth has continued to remain low.

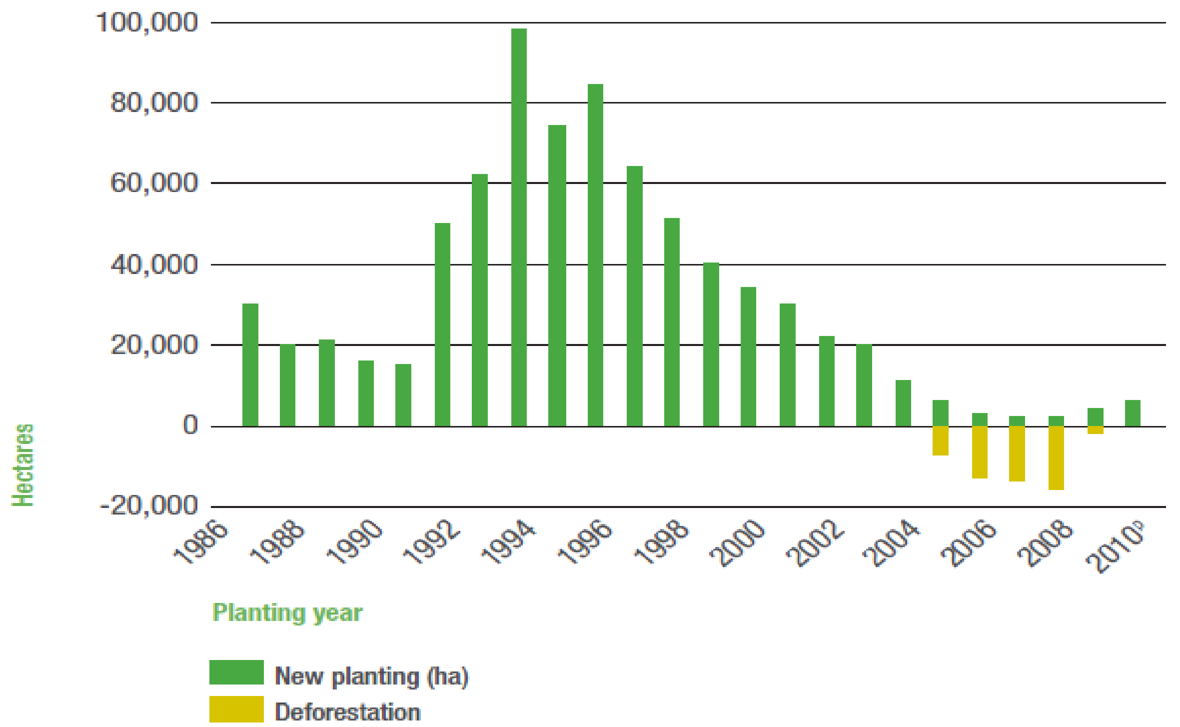
They present figures for the productivity for different sized mills. The very largest mills have 36 per cent lower cost index compared to small mills. They also suggest that the impressive Finnish performance is likely due to strong investment in high-tech equipment. As noted above there has been almost no new investment in wood processing facilities over the last decade. An example of the importance of new capital investments to increase productivity is cited by NZ MAF (2009). ‘In the forests of Finland and Sweden, it is now rare to see an individual chain sawing a block of trees.’ The new generation of steep terrain tree felling machines can operate in very steep terrain and cut 650 tonnes an hour. Operating in double shifts just one such machine can cut 250,000 tonnes annually.

The ‘Wall of Wood’

About 7 per cent of NZ’s landmass is in plantation forests (1.75M Ha). Plantings are dominated by one crop – Pinus radiata - which comprises 90 per cent of the total plantation estate. Figure 65 shows the new planted areas in production forests from 1986 to 2010. Much of these new plantings are approaching maturity (Figure 66). A large number of trees are 10 to 20 years old and radiata is typically harvested at 28 to 40 years old. Hence many of the forests planted in the 1990s will be ready for harvest in a decade or so, leading to a large increase in the supply of wood over the same time frame (Figure 67) – the so called ‘wall of wood’. The increased planting in the 1990s were due to a spike in log prices and declining returns from other land uses. More recently, uncertainty surrounding the government’s treatment of deforestation carbon liabilities has been a significant disincentive to investment in forestry plantations (Harrington 2005). Increased returns from other land use (particularly dairy)[16] and land ownership changes due to the return to Maori of forestry land under treaty settlements are also important factors.

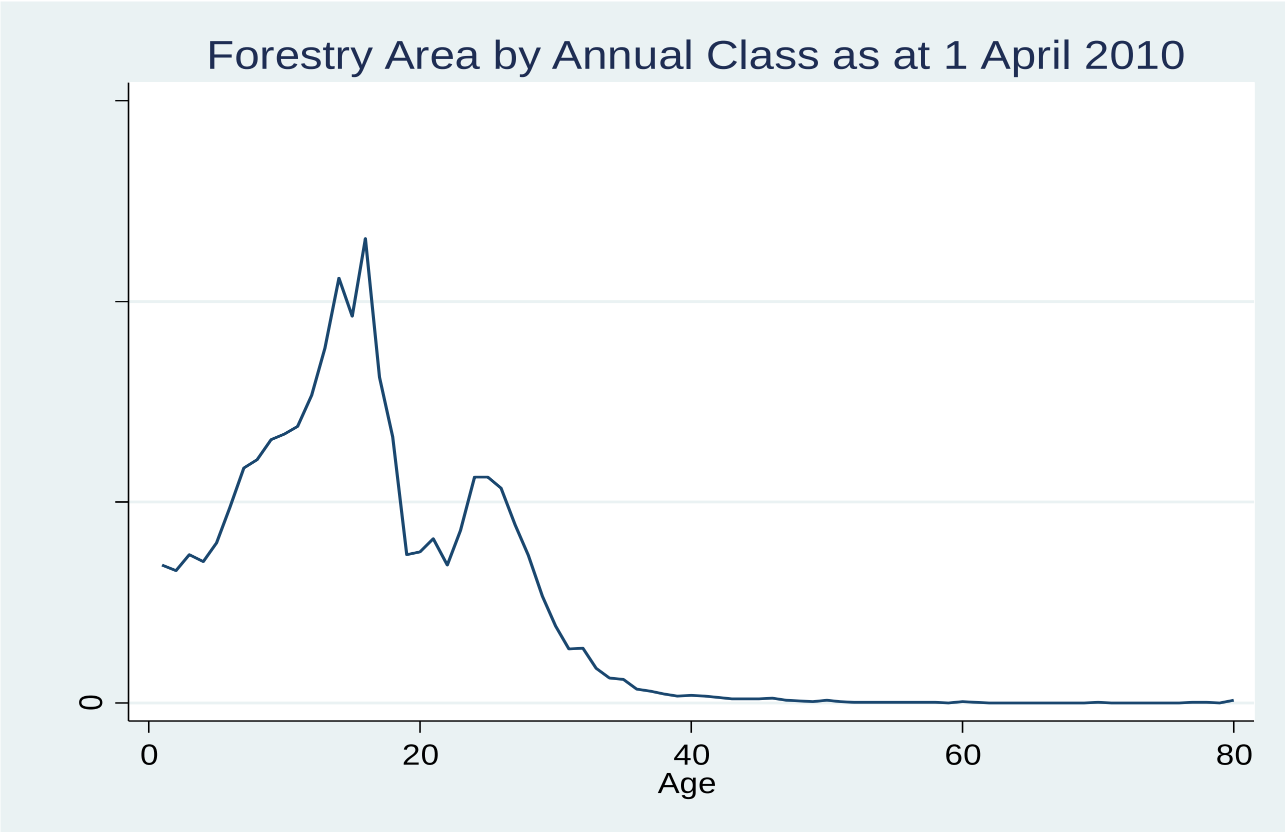
[16] For example, in 2007, 32 per cent of the area harvested was converted to other land uses compared to the historical norm of three per cent of harvested land not replanted (MAF, 2009).

Figure 65. **New forest plantings and deforestation**



Source: Forest Owners Association (2010)

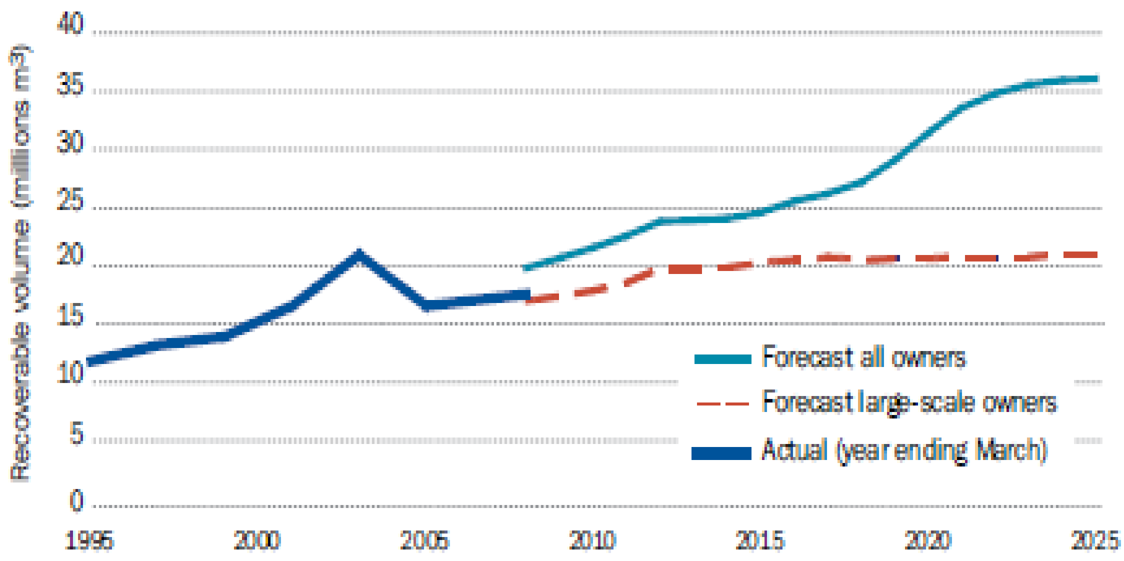
Figure 66. **Forest area by age**



Source: Forest Owners Association (2010)

Figure 66 also illustrates that there will be a significant reduction in harvestable forest following the wall of wood, meaning that supply will start to decrease dramatically in the latter part of the next decade. In addition, much of the wood for harvest will be from small scale owners in remote areas, which will increase the cost of harvesting. The total volume of the harvest for the year ending June 2010 was 23.5 million tonnes, an increase of 20 per cent over the previous year. By 2022 the harvest is expected to be 35 million tonnes which is 40 per cent higher than the current level (Figure 67).

Figure 67. **Historic harvesting and forecast future wood availability (radiata pine only)**



Source: *Woodco* (2011)

Under business as usual the 40 per cent increase in harvest expected in 2022 is likely to all be exported as logs generating (in today's dollars) additional exports of $1.29b with total exports for the industry increasing to $6.17 b (Katz 2012). One of the challenges for the sector is to develop strategies to break away from this scenario and create value in NZ.

Ownership

A study of the industry by the NZ Ministry of Agriculture and Forests (2009) writes of significant changes in the forestry ownership structure with publicly listed companies such as Fletcher Challenge and Cart Holt Harvey divesting their forestry assets to Timber Investment Management Organisations (TIMOs). Since 2006 there have been publicly listed NZ companies that own forest resources. The TIMOs are investing in forestry for a number of reasons, including as a hedge against more risky investments- since risk adjusted returns have historically been good and are correlated with inflation. MAF (2009) have viewed this as a negative development, with the TIMOs investing less in projects that have 'long-term benefits (for example, silviculture research) and less expansion of plantation forest area (they prefer to buy existing forests)'. A major new development is the return of significant forestry land to Maori[17] iwi which may have more incentives to add value to production within NZ. Overall ownership of NZ forests is heavily concentrated offshore with over 70 per cent of the total forest area owned overseas (Woodco 2011). The sawmilling industry consists of a large number of small NZ owned mills and a few large mills owned by overseas investors. Almost all the wood product manufacturing plants, pulp mills and paper mills have overseas owners, with the exception of Carter Holt Harvey. The demise of the vertically integrated companies has implications for the industry as a whole since there are two distinct value chains – forest production and

[17] Maori own 14 per cent of the land underlying forest estates including 36 per cent of pre 1990 forests. These figures are expected to increase. (BERL, 2010).

wood processing. The forest owners are interested in securing the highest value for the raw logs they harvest. For example log prices are currently highly driven by strong demand from China. There is little incentive to add value in NZ. The wood processing industry does have an incentive to invest however with log prices high and volatile it may be seen as too risky. Large owners control over 60 per cent of the total resource. Much of the rest is owned by a large number of small players with over 14,000 owners holding less than 100 ha. The fragmented structure is also seen in the sawmill processing sector with 15 medium to large producers and many small scale operations making up the total of around 350 sawmilling operations.

Greenhouse gas emissions

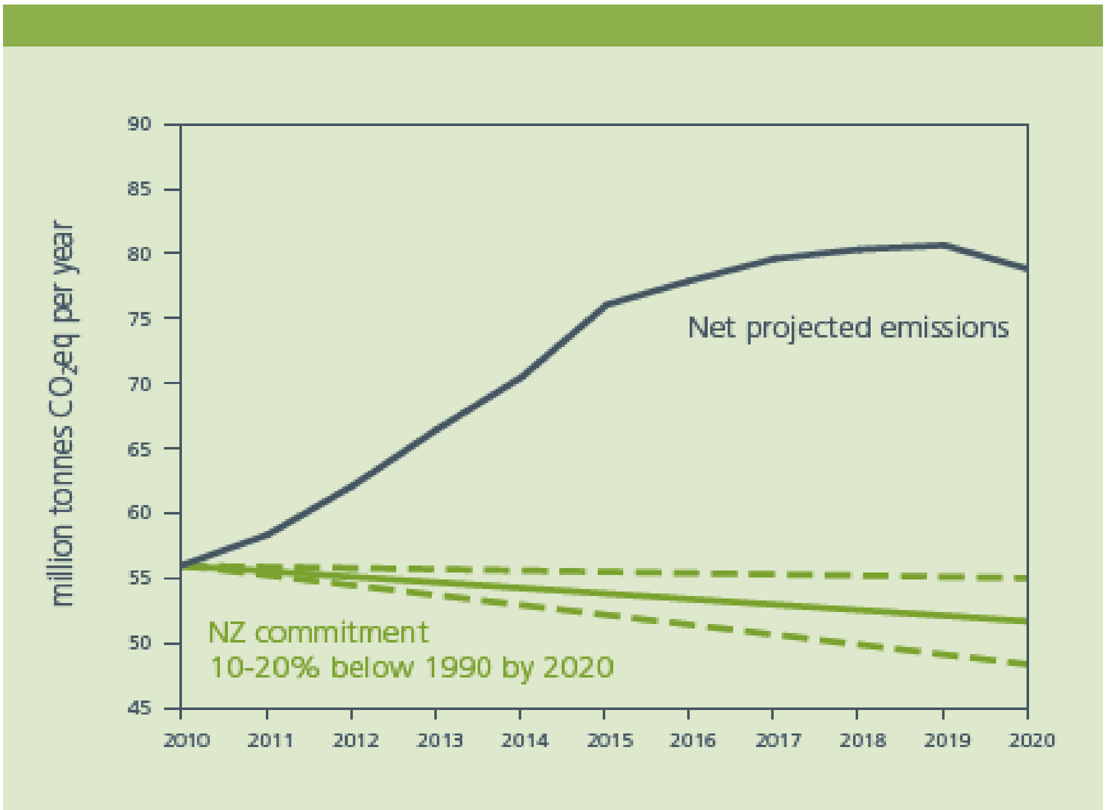
The carbon dioxide absorbed by growing forests plays a key role in enabling NZ to meet its current Kyoto targets despite gross emissions increasing significantly.[18] However, as the wall of wood is harvested NZ may need to buy carbon credits to offset the carbon emissions as forestry moves from being a sink to a source of CO_2 emissions (Figure 68).[19] The way carbon sequestration is treated for forestry is a key policy question which needs to be addressed both nationally and internationally. The current arrangement is that the CO_2 locked up in the forest is deemed to be released into the atmosphere as soon as the forest is harvested despite the fact that much of it ends up in longer term wood products. If this is recognised[20] it would increase incentives for forestry. The other issue is the uncertainty of the carbon price. Analysis undertaken by MAF (2009) shows that participation in the NZ ETS will have a positive return for forest owners even at a modest price, and that returns will be significantly positive for a high carbon price. However uncertainty in the carbon price path and the final price on harvesting (in 20-25 years) and government policy uncertainty may well discourage investment in forestry plantations (Harrington 2005).

[18] In 2010 NZ gross emissions were71.7 million tonnes—an increase of 19.8 per cent over the 1990 level.

[19] For example to meet NZ’s 2020 target under the Copenhagen Accord.

[20] The New Zealand government is advocating internationally for such a change.

Figure 68. **NZ net projected emissions**



Source: Parliamentary Commissioner for the Environment (2010a)

Overall performance

the statistics presented above make the case that NZ is adding relatively little value to its forestry resources – indeed much of the harvest is shipped out as raw logs. Woodco (2011) sums up concerns over the performance of the NZ forestry industry in recent years:

> *'Over the last twenty years, the forest industry has been characterised by cyclical conditions that have encouraged companies to take a short-term view and to concentrate on minimising costs. While this has provided a level of financial relief, it has worked against the long-term competitiveness of the industry. Remaining competitive internationally requires progressive investment in plant, equipment and skills, in order to steadily improve productivity. The industry has also faced frequent changes in ownership, with the result that it now has very few vertically integrated companies. It's not a sensible strategy to do nothing and wait for opportunities to arise. Forward-looking decisions on industry direction are more likely to give better long-term results.'*

This story is to some extent the story of the NZ economy as a whole and one of the reasons why our incomes are falling behind other OECD countries (B. Easton 2002). The challenge for NZ and the forestry sector is to transform the industry from commodity production with current low returns to a high value green growth industry.

4.7.2 International context

The traditional forestry sector is facing a difficult time worldwide as demand for major products, such as newsprint, continues to decline due to falling demand. The forestry sector in Australia in many ways is following a similar path to that seen for NZ. Kettle et al. (2012) writes:

> *'The withdrawal of private and government funding for Australian pulp and paper R&D is well known and has been an unfortunate work in progress since the 1990s. The demise of the industry in Australia, highlighted by mill closures and increased off-shore ownership, in the last 10 years is staggering and shows little signs of abating as judged by recent events.'*

They argue strongly that the way forward for the industry is to develop innovative new products. They list a number of areas which are promising including:

- the development of reinforcing of composites with wood fibres;
- biopolymers for plastics;
- creation of ultra-strong composites for construction;
- prefabricated houses;
- chemical derivatives from cellulose; and
- Biofuels.

They suggest that value-adding R&D is an essential part of a strategy to transform the traditional industry and that 'improved eco-efficiency is a boundary condition for the development'.

The Finland example

One country which is clearly committed to the high-value R&D approach is Finland which has the most successful forest industry cluster in the world (Forest Cluster 2012a). Total harvest in 2009 was 57 million m3, which is more than double the NZ harvest. Total exports were €12.9billion ($20.4billion) and the total value of production in 2007 was €23.7 billion ($37.5billion) (Pahkasalo 2009). The most recent figures for NZ were exports of $4.7billion in 2011 and a contribution to GDP of around $3.0 billion in 2009 (Forest Owners Association 2012; Statistics New Zealand 2011). [21]

The Finnish forestry sector, like NZ and Australia, is operating in a challenging environment. However, their response is somewhat different. They have established an industry cluster and created an innovation and R&D research centre (www.forestclusterportal.fi) with the objective of developing new products to transform the industry and double output by 2030. Funding for the cluster is €50 to €80 million ($80 to

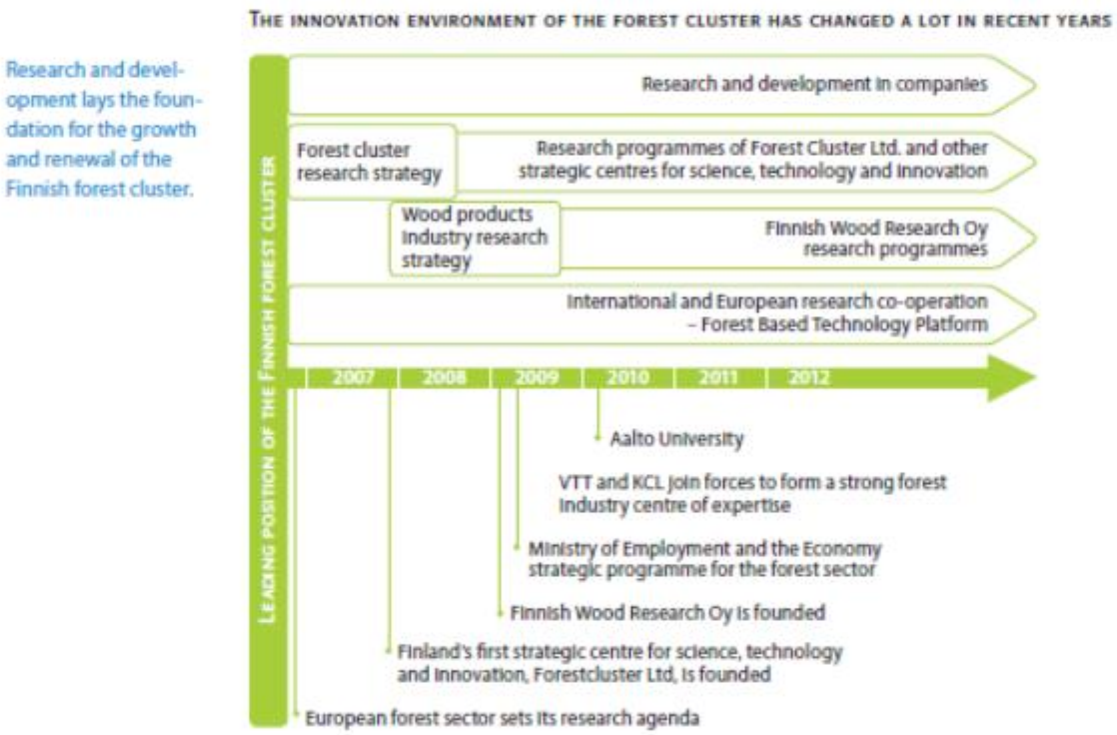
[21] Combined contribution of forestry and logging and wood and paper products manufacturing.

$126million) per year with the money coming from industry and the government. The key research strands are (Forest Cluster 2012a):

- Intelligent wood and fibre products;
- New products manufactured from wood-based materials;
- Bio refineries that utilise wood diversely;
- Sustainable forest management;
- Added value for wood biomass;
- Intelligent, resource-efficient production technologies; and
- Customer solutions for the future.

There is growing awareness of the importance of the new ‘bio-economy’. For example the strategic centre for the forestry sector recently announced it is ‘is expanding its activities from research focused on the forest industry also towards other areas of the bio-based economy. As a result of the metamorphosis it is now Finnish Bio economy Cluster FIBIC’ ('Finnish Bioeconomy Cluster', 2012). Results from the first two years of the five year €50million research program are reported by Forest Cluster (2012). They believe that the forest-based industry ‘will play decisive role in the development towards a bio-economy. With this goal in sight, diversifying the product output of the primary wood refining process – pulping – is a rational strategic starting point. The pulp mills of today are being redefined as the bio refineries of tomorrow.’ The forestry cluster has evolved as part of an integrated landscape created to encourage innovation in the sector Figure 69.

Figure 69. **The Finnish forestry cluster**



Source: Forest Cluster (2012a)

The Finnish forestry industry has a clear strategic plan but more importantly the plan is backed up with a solid institutional structure, which is well funded. As will be seen below there is no shortage of strategic plans in NZ, however, there is very little direct funding, along the lines seen in the Finnish forestry cluster, to realise them.

Transforming the Canadian industry

The traditional forestry sector in Canada also faces static and/or declining traditional markets with low growth prospects under business as usual.[22] The Canadian industry's strategic plan in response to this has been somewhat similar to that in Finland. The Canadian institute, FPInnovations, the largest not-for-profit forestry and wood processing research institute in the world, has produced a series of reports exploring the potential opportunities for bio-products as part of their Biopathways project (FPInnovations 2011a; FPInnovations 2010a; FPInnovations 2010b; FPInnovations 2010c; FPInnovations 2011b; FPInnovations 2010d):

[22] Reasons for this include the loss of USA housing market, a historical dependency on the declining newsprint market and impacts of the mountain pine beetle outbreak which have reduced wood quality in significant parts of Western Canada.

'The Biopathways project is a blueprint for an exciting future for Canada's forest products industry - a blueprint that would see the industry lead the world in innovation and give Canada an advantage in world markets. It's a future defined by new prospects for growth as the Canadian forest sector moves from an established, process-driven commodity industry to a nimble and 'green' industry serving wider markets and driven by opportunities emerging in the 21st century bio-age.'

Table 16. **Gross market opportunities for bioproducts**

Products	Annual growth rate (%) 2009 – 2015	Global market potential 2015 (US$ billion)
Green chemicals	5.3	62.3
Alcohols	5.3	62.0
Bio-plastic and plastic resins	23.7	3.6
Platform chemicals	12.6	4.0
Wood fibre composites	10.0	35.0
Glass fibre market	6.3	8.4
Carbon fibre	9.5	18.6
Canadian forest products industry	neg. to 0 - 2	50.0

Source: FPInnovations (2010c)

A key element of the project is to rank emergent products and markets against traditional outputs (Table 5). Looking further ahead, (FPInnovations 2010c) have projected global market revenue for the period 2015 to 2030 and compared it to the global market for conventional forest industrial products (Table 17). The comparison indicates that the conventional forest product market is expected to be stagnant, whilst the bioproduct market is projected to grow strongly over the next 20 years. By 2030, FPInnovations believes it will be 2.4 times bigger than conventional forestry.

Table 17. **Global market potentials for products from forest biomass (billion US$)**

	2015	2020	2030
Bio-energy, bio-chemicals, fibre composites	505	776	1,309
Conventional forest industrial products	495	512	545

Source: FPInnovations (2010c)

Many of the new products and markets identified by the Canadian studies are high value. The reports argue strongly for an integrated bio-refinery approach with different product streams to maximise the value added from forestry. Key findings are that 'numerous viable options exist to convert forest biomass to bioenergy, bio-chemicals and biomaterials' and that 'these options are best achieved by integrating their production with the traditional forest industry.' Integrated production of traditional wood products with bio-products improves the economic case, increases employment by up to five times and is environmentally beneficial (Natural Resources Canada 2011).

It is worth noting that the NZ industry, via Woodco, has recently initiated a project called Woodscape, which will essentially replicate the Biopathways work in NZ. This work is being completed as a joint collaboration between Scion and FPInnovations providing direct access to the Canadian techno-economic models and their translation into the NZ environment.

4.7.3 Green growth opportunities

There are substantial opportunities for green growth in the forestry sector. As discussed above the sector has seen very little investment and low productivity growth in recent times. New Zealand has an existing comparative advantage in raw material availability, the quality of its institutions and environmental performance. However there are a number of other countries in the forestry sector which base their competitive position around low wages including Chile, Malaysia and China. Competing on the basis of low wages is not a sensible strategy for NZ (New Zealand Ministry of Agriculture and Forests 2009). It will be seen below that there are opportunities to increase productivity and output of the forestry sector by adding value. Technological developments have the potential to enhance the industry from one of traditional wood products to one with a range of supplementary liquid and solid biofuels, bio-plastics and bio-chemicals. It will be argued below that and NZ has the potential to take advantage of the opportunities for increasing demand for these products. As the recent strategic action plan developed by Woodco (2012) observes:

> *'The forest and wood products industry has an outstanding story to tell.....It is an industry that is based on wholly renewable resources, producing 100 per cent of its products from plantation forests and recycled waste fibre; is New Zealand's largest biomaterial recycler and has a very low carbon footprint. In the future it will be substantially independent of non-renewable energy inputs apart from transport fuel (and even this could be sourced from New Zealand wood in the long*

run). The industry already provides greenhouse gas offsets, reducing New Zealand's overall carbon footprint.'

There are, however, a number of obstacles to achieving high value green growth in the forestry sector. The investment required to lift the performance of the sector has been non-existent over the last decade. Frequent ownership changes over the last twenty five years are another reason for the poor performance of the sector, as is the dispersed and fragmented structure of the industry. [23] There has been continual reshuffling of senior management and operational structures with firms often in survival mode instead of focusing on long-term strategies to deliver high value products (Woodco 2011).

Industrial Strategies Plan

In 2011, Woodco - a pan-industry body encompassing the Forest Owners Association, Wood Processors Association, Pine Manufacturers Association, Farm Forestry Association and the Forest Industry Contractors Association [24]- published a strategic study of the NZ forestry industry, which argued the need for an industry strategic action plan (Woodco 2011). The strategic report (Woodco 2011) and the follow-up Strategic Action Plan (Woodco 2012) are the latest in a series of reports dating from the 1990s onwards prompted by concern at the direction taken by the industry as a whole.

As noted in (Woodco 2011) earlier strategic plans have had limited success:

'A central theme that comes through all these earlier studies is that New Zealand's forest growers and processors need to make a step-change in their thinking and practices, as the Pacific Rim is an increasingly competitive market for timber products. While the major industry players have generally been supportive of these reports and their findings, there has been surprisingly limited uptake of the recommendations. '

The report suggests that the reasons for insufficient action were structural, including frequent changes in ownership and senior management and short term thinking prompted by periods of poor profitability (with cost cutting the main imperative). They also suggest that the fragmented nature of the industry and lack of large vertically integrated companies may also be factors. Another issue which is often raised is the fact that most of the industry is foreign owned and in some cases sees NZ as a source of raw material for wood processing and manufacturing off-shore. This means that there is no strong incentive to add value within NZ. Thus the interest of foreign owned firms are not necessarily aligned with 'New Zealand Inc.' which has a strong interest in creating value within NZ.[25]

[23] A notable exception is the Norwegian owned Norske Skog mill at Kawerau which is one of the most productive in the world (TradeNZ, 2010).

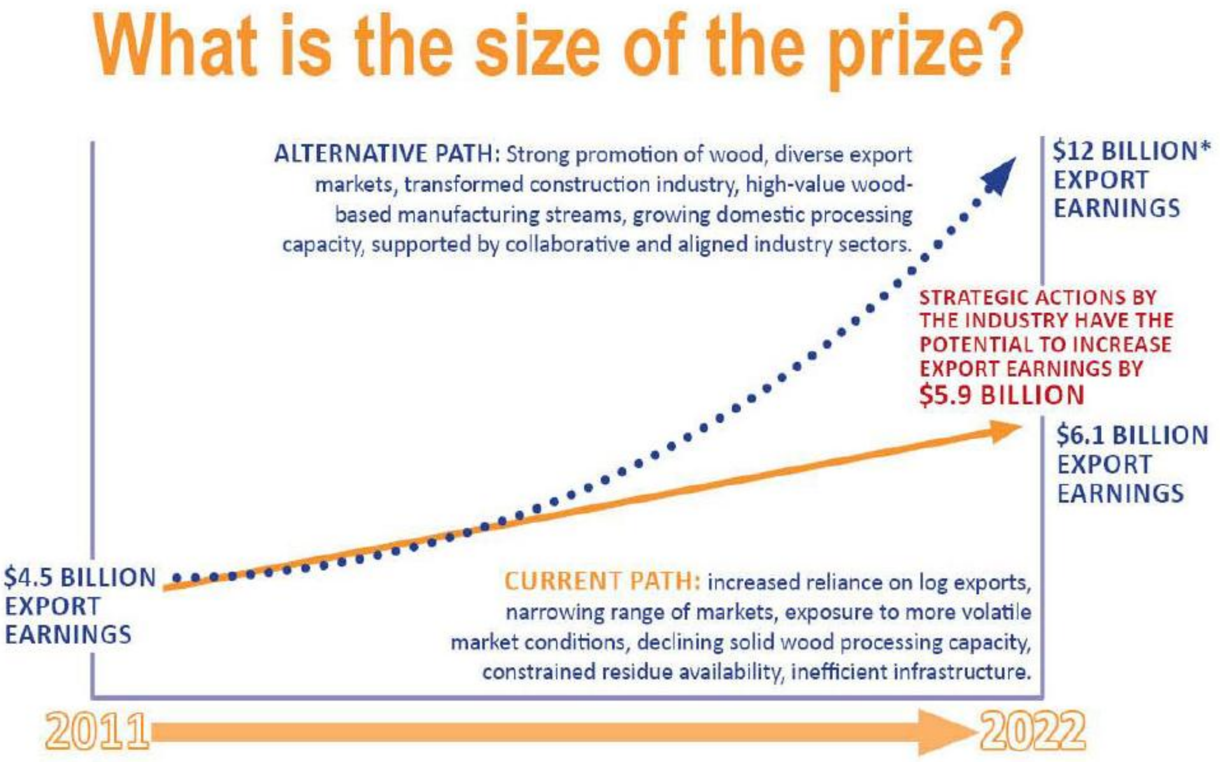
[24] Some key members of the sector are not part of Woodco, in particular Norske Skog

[25] Woodco is a pan industry group whose members are in the main foreign owned companies, which suggests that Woodco might be hesitant to raise this as an issue.

The strategic study attempted 'to identify the key opportunities and challenges facing the NZ forest industry and to gauge the level of support for dealing with these matters in a collective and concerted manner'. The report conducted an in-depth series of interviews with key stakeholders in the industry and concluded that there is a need, and strong support, for a pan-industry action plan.

The Strategic Action Plan presents a scenario which sees an increase in forestry exports from the current level of $4.5 billion a year to over $12 billion a year by 2022 (Figure 70). The economic analysis was undertaken by Katz (2012) and challenges a business-as-usual scenario focused on shipping all the extra forestry harvest as logs, which would only increase exports by $1.3 billion to $5.8 billion a year in 2022. Under this scenario, wood processing capacity would continue to decline, which would adversely impact on a number of high value manufacturing opportunities through their dependency on lower cost, woody residues as feedstock.

Figure 70. **Forestry export earnings for different scenarios**



Source: Woodco (2012)

The Strategic Action Plan envisages increasing processing and manufacturing capacity in NZ and developing new high value manufactured exports. Such a strategy could increase exports by a further $6.2 billion resulting in total exports of over $12 billion.

Table 3 details the added value options. The suggestion is that 16 million tonnes of the total harvest of 25 million is not shipped as logs. Instead 11 million tonnes are exported in the same product mix as the existing product mix of processed exports. In addition, 5 million tonnes is exported as high-value engineered wood products, including laminated veneer lumber, cross laminated timber, and advanced packaging products. The scenario also envisages a small income stream from turning waste products into biochemicals.

Table 18. **Gains from implementing the Woodco Strategic Action Plan**

Scenario	Description	Additional NZD millions 2020
BAU	Exports (year ended September 2011) Export all the additional volume harvested by 2022 as logs	4,882 1,292
1	Net gain from processing 16 million m^3 of the exported logs to the current export mix	4,012
2	Net gain from increasing sawn timber recovery rates by 5 percentage points	217
3	Net gain by processing a portion of the exported processed products as higher-valued engineered wood products	1,528
4	Net gain by processing forest residues, wood waste and effluents from chemical pulping into bio-chemicals	400
	Total gain	**12,331**

Source: Katz (2012)

The strategy details a range of initiatives based on five themes including:

- the Markets and Products theme in which the main proposal is a 6 per cent per annum increase in exports which will be achieved by identifying key markets and business models for successful collaborative marketing as well as ‘in market’ innovation centres and campaigns; and
- the High Value Manufacturing theme, some parts of the strategy for which include R&D, training of architects and engineers, implementation and uptake of technology and mechanisms to facilitate information sharing.

Other levers include i) monitoring international developments around drop-in biodiesel plants and developing plant designs and economic models suitable for NZ conditions and feed stocks; and ii) identifying new product lines and processes. The recommendations continue along similar lines for the other three themes of Research and Innovation; Operating Environment; and Putting It All Together.

The total budget is $4.4 million a year and the strategy aims to realise potential export gains of over $6 billion a year. To put this in some perspective the annual R&D budget of the Finnish forestry cluster is approximately €450 million ($700 million) of which industry contributes €150 million ($230 million) (Finnish Forest Industries 2010a).

While the strategic plan has a detailed analysis of the potential increase in exports, there is little analysis of associated costs. The strategy would require substantial investments, quite possibly in the billions of dollars.[26] The key to the success of the strategy will be whether the necessary investment is forthcoming. Hence, monitoring investment intentions will be crucial to establishing as early as possible if the plan is working.

Another important issue which the Action Plan does not address is what happens after the supply of wood reaches its peak in the 2020s and starts to decline. Investment in high-tech wood manufacturing facilities would likely need some kind of security of wood supply, which again points to structural challenges in the industry. The horizon for returns on forests is necessarily long term; however, without high value manufacturing the expected returns may not be high enough to justify planting. This in turn feeds through to erratic supply which makes it hard to justify the substantial investments required for high value wood processing and manufacturing – a complex feedback cycle across the value chain.

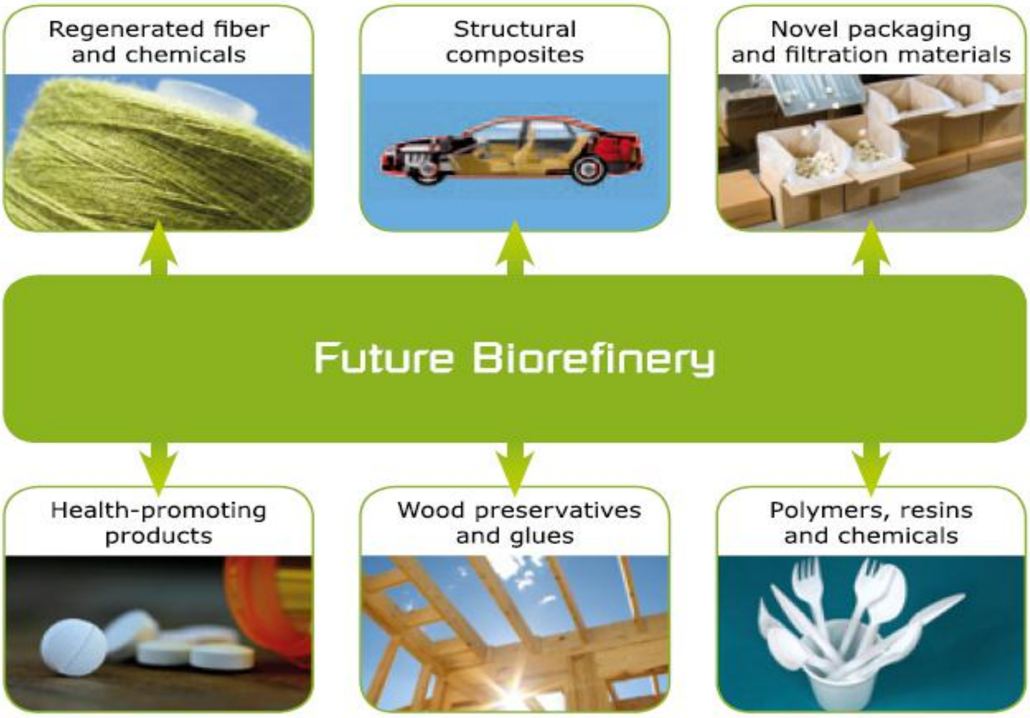
Overall, if it is to be realised, the action plan may require a considerably more active and interventionist approach from central government.

Towards a bio-economy

An alternative, or more likely a complement, to the traditional approach to adding value to wood products, seen in the strategy outlined above, is to place much more emphasis on the new emerging bio-product technologies. The hope is that an increasing share of consumer products can be derived from renewable sources such as wood. Figure 71 is from a Finnish publication which illustrates the range of possible new bio-products. New large scale pilot plants in the area of wood based biofuels and wood-plastic composites have already been established by both Finnish and Canadian companies (Finnish Forest Industries 2010b). As noted above these markets are expected to grow strongly over the next two decades to C$1.3 trillion ($1.6 trillion) - almost three times the expected traditional forest industry market.

[26] By way of comparison the current capital stock is worth $11 billion. The Finnish Forestry industry invests 5 per cent of revenue every year which is almost $2 billion a year.

Figure 71. **New products that will be part of the bio-economy**



Source: Forest Cluster (2012a)

In the transportation fuels section of the Strategy a scenario was presented from Scion that to plant 1.75 million hectare of marginal land into forest and use this, as well as the existing forest estates, for the production of transport biofuels. This would double the existing forest plantation area. This theme is developed further here, as the case for embarking on such an afforestation strategy is considerably enhanced once other potential high value bio-products are included in the value chain. As will be shown, recent significant technological breakthroughs open up huge possibilities for the manufacturing of a range of bio-products. These products derived from sustainable forestry would compete directly with fossil oil-derived products.

The 'New Zealand Bioenergy Strategy' (2010b) is considered in detail in the transport case study in this report (section 5.3). The authors see benefits from leveraging a biofuels production strategy to enhance development of the wider bio-economy sector:

> *'Bioenergy is currently the leader into the bio-economy through the proven technologies and established infrastructure of the forestry and wood processing sectors. Bioenergy can provide the 'pull' to the production of bio-chemical and bio-based products that will form a significant part of the wider bio-economy. Whilst it is very hard to quantify the opportunities in this area they are potentially the most important aspect of NZ adopting a strategy to develop a comprehensive bio-energy sector.'*

It seems likely that there will be numerous 'niche' markets in the bioenergy area and the larger bio-economy. Possible areas that have already been identified include bio-plastics, chemicals from bark and tree stumps, fine chemical feedstocks for paints and adhesives, reinforced plastics using wood fibres, food sweeteners, biodegradable plastics and bio-products from industrial waste gases.

Developing a world class bio-based products industry in NZ could potentially be the catalyst that sparks the development of a large number of firms in this sector, leading to a virtuous circle involving industry clusters that drive further innovation and growth. Growth and innovation could be further enhanced by significant government R&D investment and policies to facilitate firms with good ideas obtaining start-up financing and ongoing support.

New Zealand has a number of strengths in this area as the following exemplars illustrate:

- Currently 8 per cent of NZ energy comes from bioenergy.[27] Fonterra already produces ethanol from milk whey;
- The NZ workforce is comparatively well-educated and experienced in biomass processing (for example the pulp and paper industry);
- There is a strong forestry industry with large tracts of marginal land which could be developed for raw materials and a climate which is ideally suited for growing fast rotation forests;
- There is an established expertise in renewable energy and bio-based processing. Engineers trained in NZ universities are world-class; and
- A number of countries have set targets for biofuels uptake, which may lead to export opportunities.

The geothermal industry offers an insight into the potential offered by sustainable technologies and products. NZ has exploited a first mover advantage in geothermal systems and as a result has world class expertise. It is poised to develop geothermal technologies export industry based around the strong worldwide demand for clean energy, which could well result in exports worth billions of dollars each year.

It will be seen below that there is a clear opportunity to develop the bio-economy alongside adding value to the traditional wood-processing sector as outlined in the Woodco report. Developments and opportunities in the bio-product market are examined below.

Examples of bio-products

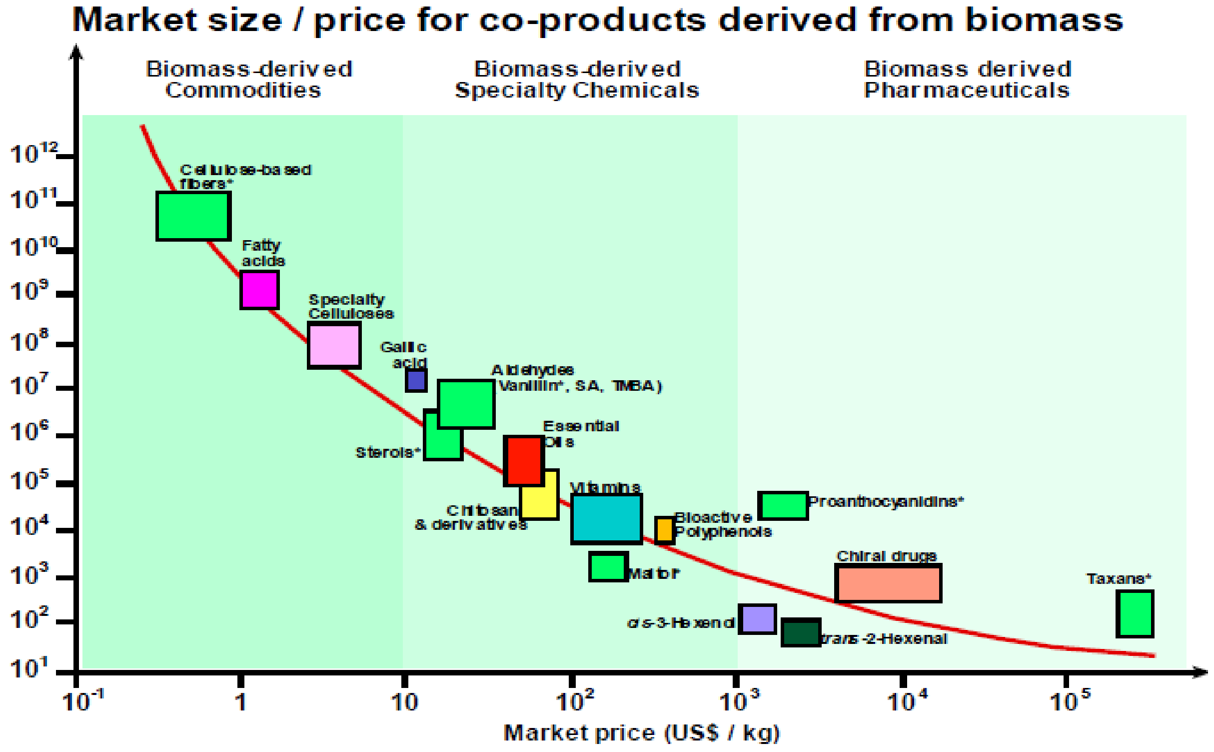
As explained above many existing consumer products currently derived from non-renewable resources such as oil may in the future be derived from renewable resources such as trees. Technology is advancing rapidly in this area (Forest Cluster 2012b). Liquid fuels, plastics, composite materials which can replace metals, pharmaceuticals, solid fuels, innovative packaging, polymers resins and chemicals, and many other products can now, or soon will be able to, be produced from woody matter. Figure 72 gives a sense of the range of new bio-products, ranging from relatively low value commodities such as $1 per kg for biofuel production, through bio-chemicals fetching a market price of $10-$1000 per kg and ending with specialty bio-pharmaceuticals worth up to $100,000 per kg. It also illustrates that market volumes are small for the high

[27] Mainly using wood for direct heating in the forestry sector.

value products. The challenge is to develop an integrated approach to extract as much value as possible from the forestry feedstock. The graph suggests that there is a matrix of opportunities. A strong focus on (say) pharmaceuticals would not help much for example with the ‘wall of wood’ problem, as production would necessarily be much less than the harvest supply. On the other hand, as argued above, focusing on high volume/low value commodities such as logs is not a viable strategy either.

The following sections examine some of the new bio-products and where they fit in the value chain. It will be seen that one promising option is to build integrated bio-refineries, each of which can produce a range of different bio-products. One of the most important bio-products that can be derived from woody matter is drop in liquid fuel which can replace diesel or gasoline. The technology and production costs are reviewed in further detail in the transport case study (section 5.3). The conclusion from this review is that the there is a growing consensus that biofuels are or soon will be competitive with oil if the price of oil stays at or is higher than current levels.

Figure 72. **The value chain for bio-products from forest biomass**



Source: FPInnovations (2010c)

Solid fuel

Wood pellets can be used in some cases as a direct substitute for coal. They can be used for direct heating or to produce electricity with up to 20 per cent by mass replacing coal in electricity generation plants. The demand is essentially limitless although the price is relatively low and derived from the price for coal. Technological developments mean that, with a carbon price of 30-50 Euro, biomass-based pellets will be competitive with coal by 2020 (European Climate Foundation 2010). In addition, European Union countries have a mandated target of 20 per cent renewable energy production by 2020. The EU assumes expected growth from heat and power production from biomass to equal the increase in renewable electricity and heat production from all other sources taken together (European Climate Foundation 2010).

It is already economic to ship wood pellets from Canada to Europe (FPInnovations 2010c)[28] Since, in many cases, low quality waste streams can be used to generate wood pellets, this may well be an important part of the forestry value chain. Currently there are two wood pellet factories in the world producing 500,000 tonnes per year. The number of pellet factories is expected to increase to tens or hundreds in the future (European Climate Foundation 2010).

The Canadian study (FPInnovations 2010c) is more pessimistic, doubting the viability of using wood pellets as a direct substitute for coal. However they find positive returns of 17 per cent for a combined heat and power generation plant located next to a facility requiring large amounts of continuous heat, such as a pulp and paper mill (or in the future a bio-refinery).

Only a relatively small proportion of the fuel input can be pellets before they impact on the performance of a coal power boiler, which has spurred the search for an alternative. The Crown Research Institute Scion (Hall, Estcourt, and Kimberly 2011) is among a number of international research groups investigating the potential for turning forest residue into a 'bio-coal' material, which is more similar to coal by using torrefaction (heat treating in a low oxygen environment). The resulting product has a high energy density, is materially stable and has improved fuel and processing properties. Forest residue could potentially be torrefied at the harvest site to reduce transportation costs considerably.

Hall et al. (2011) estimate 'in-forest' residues could be between 4-6 million tonnes per annum by 2030, which is comparable to current coal demand in NZ. Torrefied woody biomass could be co-fired with coal at Huntley reducing the 1.8 million tonnes of coal burned there each year. The price of thermal coal in NZ is approximately US$150 per tonne, which makes the potential market for domestic coal (and hence torrefied woody bio-mass) worth around US$600 million per year.[29]

Bioplastics and biopolymers

Bioplastic and biopolymer production from forest estates is another exciting possibility. Bio-plastic technology is evolving rapidly. New technologies mean that bio-plastics can be made durable, partially durable or bio-degradable.[30] Today around 85 per cent of plastics could technically be substituted for bio-plastics. They are already found in the following sectors (European Bioplastics 2011):

– automobile (for example car seat foams);

[28] Note however that Canadian wood pellets are being made from pine bark beetle impacted wood and therefore feedstock costs are relatively low. With this source of input likely to rapidly decline in 2017, challenges will arise for Canada in this market.

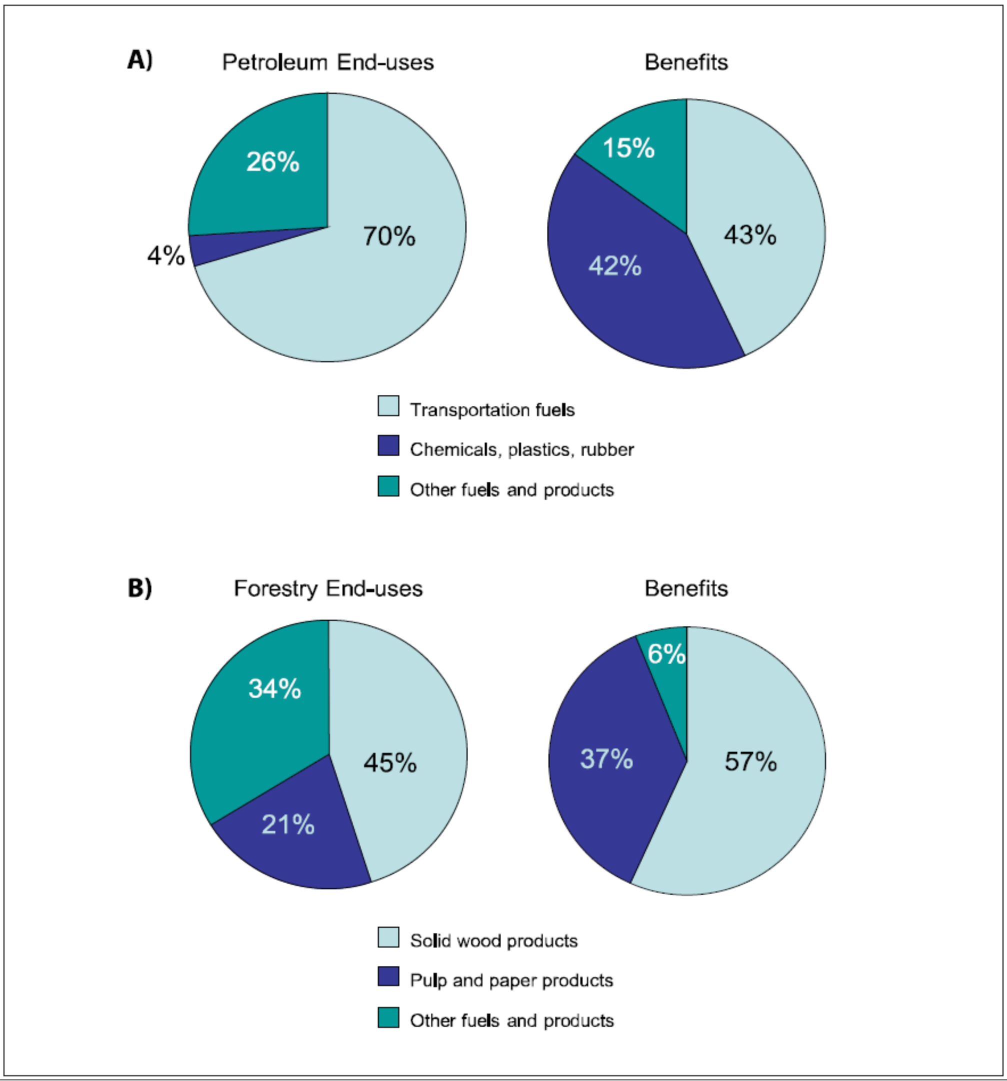
[29] More recently the price of coal worldwide has fallen.

[30] Conventional plastics can also be made bio-degradable

- textiles and fibres;
- consumer electronics (for example smart phone covers);
- food industry (for example drink bottles);
- horticulture and agriculture; and
- toys and sports gear.

These products are potentially very high value, certainly more so than liquid biofuel production and consistent with current drivers in the petrochemical industry (Figure 73). For example, it can be seen that a small amount of petroleum feedstock (4 per cent) is needed for the chemical, rubber and plastics industry to deliver 42 per cent of the total value for the petroleum industry. Whilst it does not make sense for NZ to have a strong presence in that industrial sector based on petroleum, the ready availability of raw material combined with NZ's comparative advantage in forestry makes developing a bio-plastics industry in NZ a real option. Figure 73 also illustrates that there is no corresponding high value sector for the forestry sector.

Figure 73. **Benefits of various end-uses of petroleum and forestry products**



Source: FPInnovations (2010c)

The bio-plastics market is growing at around 20 per cent a year (European Bioplastics 2011), driven by high consumer acceptance, policy for product performance (for example carbon footprinting), increased petroleum prices, the need to reduce imported fuel dependence as well as the advanced technical properties and functionality of the new materials. Current production is mostly based around starch, corn syrup or ethanol with plastics from woody matter a newer technology (European Bioplastics 2011).

Worldwide production of bio-plastics in 2010 was 0.7million tonnes, which is expected to increase to 1.7 million tonnes in 2015. There is plenty of room for expansion as current global production in 2015 will still be less than 1 per cent of the total global plastics market (250Mt per cent per year; European Bioplastics 2011).

The NZ plastics industry is already a significant part of the economy employing 8,000 people with a turnover of $2.6 billion. However, it does not manufacture the base raw plastics materials, which are imported mostly from North America.

New Zealand already has considerable expertise in bio-plastics. The Crown Research Institute Scion has an extensive bio-based plastic research programme and is also part of the Biopolymer Network (BPN; other members are Plant and Food Research and AgResearch). A recent example is a joint venture with Zespri to develop a bio-plastic spife (spoon-knife for consumers of kiwifruit) made from kiwi fruit waste. Scion (2011a) also reports on a number of other research strands:

> *'one initiative uses microbial technologies which can transform biomass, including organic solid wastes and wastewaters into high performance bioplastics…which offers a potentially viable route to lower cost PHA production or new polymers from New Zealand resources….developing novel bio-plastics and additives from bio-resources in New Zealand through thermochemical methods and green chemical polymerisations.'*

The Biopolymer Network is also active in this area and has developed a range of bio-plastic products, including an environmentally friendly bio-foam alternative to expanded polystyrene, which won the 'Best Innovation in Bio-plastics' category at the International Bio-plastics Awards in 2008 (Biotechnology Learning Hub 2011). Other products include a flax-derived fibre, which can be used to replace fibreglass in composites and starches extracted from amaranth seeds. The Biopolymer Network notes that the starch 'has a soft and silky feel making it an ideal base for a large range of cosmetic powders including face powders, body powders, and eye shadow'.
The Network has also extracted and functionalised pine bark tannins for use in 'new biopolymers derived from pine bark for industrial applications…. and formulated into industrial polymer products (for example. plastics and coatings)' ('Biopolymer Network,' 2012).

Lignin
Use of cellulose to generate biofuels (via fermentation of sugars) and bio-plastics (via use as a composite reinforcement) is likely to generate a lignin by-stream. In softwoods, lignin makes up nearly 30 per cent of

the wood material and, therefore, use of this material is critical to the economics of wood-based bio-refineries. New technologies mean that lignin can generate significant revenue streams in its own right.

It can be used to produce ‘carbon-black’, which is an additive used in car and truck tyres. Current list prices are around US$2,200-US$3200 per tonne. FPInnovations (2011a) report that ‘initial results with rubber compounders are promising, and the potential for a profitable business in the $750 to $1000 per tonne range is encouraging.’

Lignin can also be used to make wood glues for plywood and laminates. The Canadian research (FPInnovations 2010c) also suggests further opportunities:

> *‘to replace resins in other applications, such as foundry resins, adhesives in fibreglass insulation material, binders for the stabilization of soil during oil drilling and as a binder in brake pads and other automotive products. Improved thermal stability, anti-oxidant properties, insulation properties and/or shelf life are among the advantages that might be available.’*

Lignin can also be used to make carbon fibre, which is used for the production of light weight automobile and aeroplane components. Current carbon fibre use is limited by high prices with the raw material, polyacrylonitrile, which costs $11,000 a tonne. Lignin can be produced at prices well below this (FPInnovations 2010c). Carbon fibre has the potential to replace aluminium at prices below around $2,200 per tonne, which would result in a large increase in worldwide demand.

FPInnovations (2010c) considered the economics of an add-on 50 tonne/day lignin plant to an existing Kraft pulp and paper mill. Their analysis yields a return on capital employed of 44 per cent.

There are a number of other promising high value markets for lignin-derived products, such as monomeric phenolics. As an example of the potential supply from NZ, consider the available NZ forest harvest expected in 2022, which is 35 million tonnes. If all of this was processed as biofuel this would lead to lignin production of 10 million tonnes. At a price of $1000 per tonne this would be worth $10 billion. Of course revenue is only one side of the equation and the Canadian report notes that as supply increases lignin prices may well decrease and existing market volumes are small compared to potential supply.

Nanocrystalline cellulose (NCC)
NNC is a natural nanotechnology material, which has impressive optical, magnetic, electrical and high strength properties. Its tensile strength is eight times higher than stainless steel and more than 30 times that of aluminium.

FPInnovations and a Canadian paper manufacturer have launched a joint venture company, CelluForce, which has built a demonstration plant in Quebec. This is expected to produce one tonne per day of NCC from two tonnes of pulp when fully operational. The product is so new that markets have to be created. However, FPInnovations (2010a) see a significant number of potential applications and markets, including:

> *'Reinforced polymers; High-strength spun fibres and textiles; Advanced composite materials; Films for barrier and other properties; Additive for coatings, paints, lacquers and adhesives; Switchable optical devices; Pharmaceuticals and drug delivery; Bone replacement and tooth repair; Improved paper, packaging and building products; Additive for foods, cosmetics and; Aerospace and transportation.'…*

CelluForce (2012) report that:

> *'the ultimate objective is to build commercial-scale plants. We are looking at a price equivalent to specialty chemicals, not paper, 20 to 30 times the price of specialty paper. The cost of building a full-scale plant (approximately 25 tonnes per day) would be the equivalent of a new pulp mill.'*

An indicative calculation illustrates the potential impact for NZ. Total paper and paper board production is approximately 620,000 tonnes per year. The export price is approximately $1,800 per tonne. If just 10 per cent of total paper and paper board production was instead replaced by NCC exports[31] then, based on the figures quoted above, exports could increase by $2.2-$3.3 billion. Such a scenario would mean substantial capital investment requirements. Of course, this example assumes a price premium over paper along the lines of the CelluForce statement above, which may not be sustainable as supply increases.

Fibre-based products

New technology means that wood fibres can be extracted for use in composite materials, such as replacements for fibre-glass or plastics reinforced with glass fibres. Such products have the virtues of being renewable, stronger and lighter than glass fibre composites.

Scion (2011a, 2011b) has developed suitable processes and feedstocks to achieve this using softwood feedstocks:

> *'a new wood plastic pellet technology which has the potential to revolutionise the composition of plastics worldwide' … 'applications for the technology are wide-ranging and could include decking, fencing, pallets, furniture, automotive parts, appliance housings, computer peripherals and many common applications for plastics and fibreglass products.'*

[31] Recall that total harvest was 23.5million tonnes so the total production for the NCC example above would be a small fraction of the total raw harvest tonnage –just 0.3 per cent or perhaps 1 per cent of the raw harvest taking into account wastage.

Although the new process was developed in NZ, could use existing production facilities, and deliver twice the value of other product lines, none of the forestry companies operating in New Zealand decided to proceed to the production stage. Instead Scion had to seek a partner in Europe[32] to commercialise the product, however the intellectual property is retained by Scion (Warnes 2012). The lack of interest displayed by the NZ forestry industry may illustrate the lack of strategic direction highlighted by the Woodco (2011) report.

The Canadian studies suggest a high return on capital employed of 42 per cent however the world market is currently relatively small.[33] They note that a 10 per cent penetration rate of the entire US textile glass fibre market 'represents a relatively small tonnage compared to typical Canadian pulp and paper mills'.

Pharmaceuticals and others

Substances obtained from wood fibres can be used in pharmaceuticals in many ways. The sweetener xylitol is already in wide use.

Plant stanolesters are being used to lower cholesterol and cancer-preventing drugs are being developed made from lignin (Forest Cluster 2012b).

There is also a great deal of innovation in packaging materials. Forest Cluster (2012) reports that 'the exploitation of nanocellulose technology will enable the development of entirely new paper grades. Printed electronics will likewise open new possibilities as soon as the electronic components, which will be connected to packaging, become inexpensive enough for the needs of the consumers.'

An integrated approach

The Canadian Bio-Pathways studies emphasise that the key to maximising the revenue from each tree is to integrate conventional wood production with a number of new technology product lines (FPInnovations 2010a):

> *'The most promising future involves saw mills and engineered wood products together with bio refineries for production of pulp/bio-energy/bio-chemicals'*

Some of the technologies reviewed above promise much higher returns than conventional products and can be co-produced with biofuels. The International Energy Agency (2011) also favours such an approach:

> *'The economic production of biofuels is often a challenge. The co-production of chemicals, materials food and feed can generate the necessary added value.'*

The European Union not only sees the value of integrated bio-refineries but is investing heavily in developing them (Clever Consult BVBA 2010):

[32] Sonae Industria in Portugal.

[33] If panels in cars and trucks were replaced with carbon-fibre the world market would be substantial.

> *'In Europe, there is also a growing focus on bio-refineries. These use biological matter (as opposed to petroleum or other fossil sources) to produce transportation fuels, chemicals, and heat and power. Because they combine and integrate the technologies necessary to convert renewable raw materials into industrial intermediates and final products, they can straddle the whole value chain.'*

They report on over 300 projects in Europe aimed at moving from research and demonstration stage to

> *'[address] the entire value chain. Aspects included in these projects were the production of biomass, logistics, intermediary processing steps and conversion into end-products with the feasibility of techniques shown at pilot scale.'*

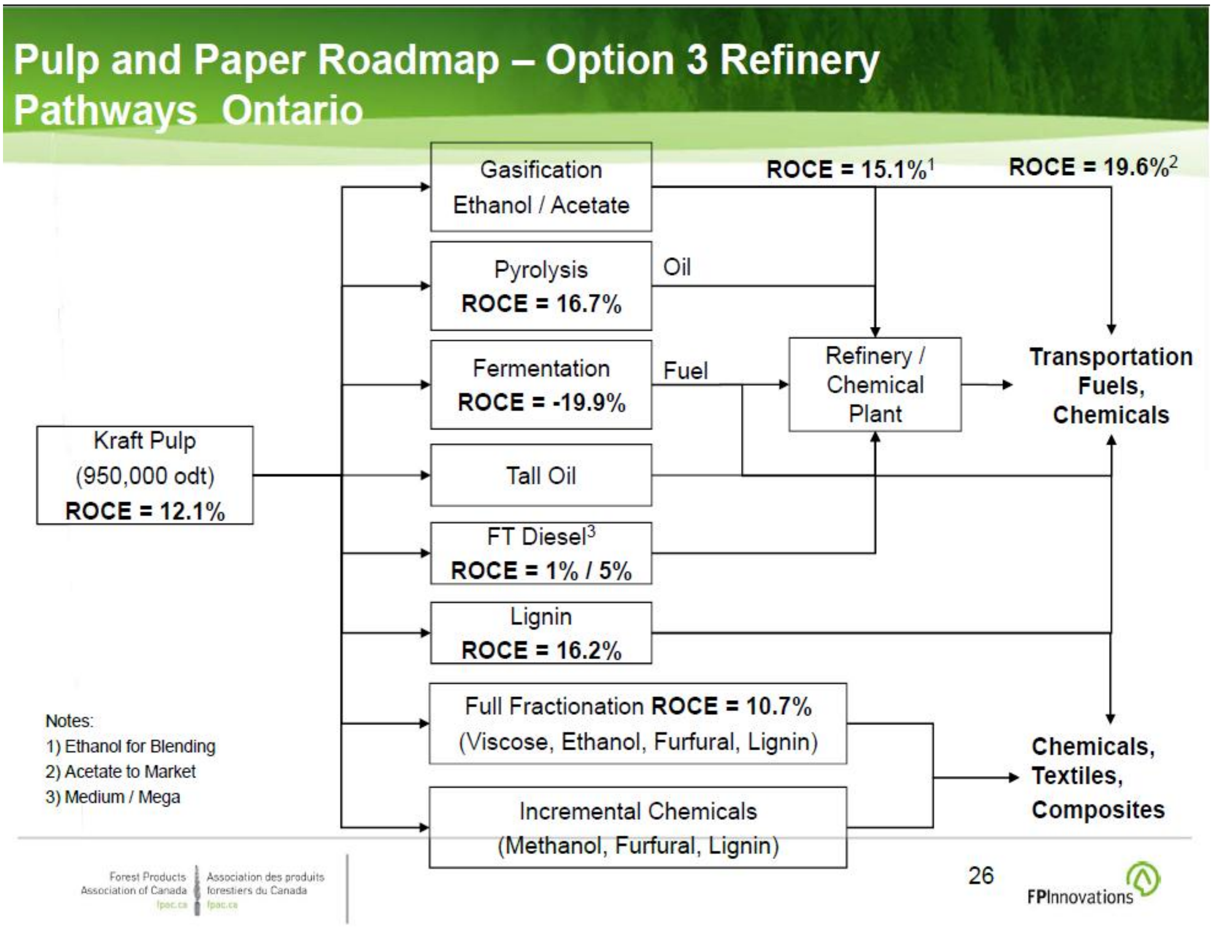
Funding for the projects is €1.2 billion, of which €800 million is from public funds.

Table 26 of the transport case study shows cost estimates for NZ production of bio-diesel from the Parliamentary Commissioner for the Environment (2010). The key message from the breakdown of the costs in that table is that a substantial part of the cost of bio-diesel production is in the feedstock. The idea behind integrated plants is to take advantage of synergies. For example, bio-products can use low grade logs, waste wood and waste material from pulp and paper mills. Or a bio-refinery can generate a number of co-products creating more value from each log. Clearly lignin is a valuable product which would otherwise be wasted if trees were used only for bio-diesel.[34] As seen above there is also a large number of other potential high value co-products that an integrated plant could produce.

It is clear that a key part of an integrated bio-refinery would be the production of biofuels. Technology is moving rapidly in this area with cost estimates coming down over time. The Crown Research Institute Scion (2011a) has developed world-leading expertise in this area, including a process to improve the conversion of softwoods into sugars which can be used as a fermentation feedstock for biofuels and biochemicals. The advantage of their approach is that it utilises existing pulping infrastructure and generates a high quality lignin by-product for further conversion to additional chemical outputs, such as those noted above.

[34] Although some biofuel production technologies such as pyrolosis use the entire feedstock (see the transport case study).

Figure 74. **Hypothetical bio-refinery with different product lines**

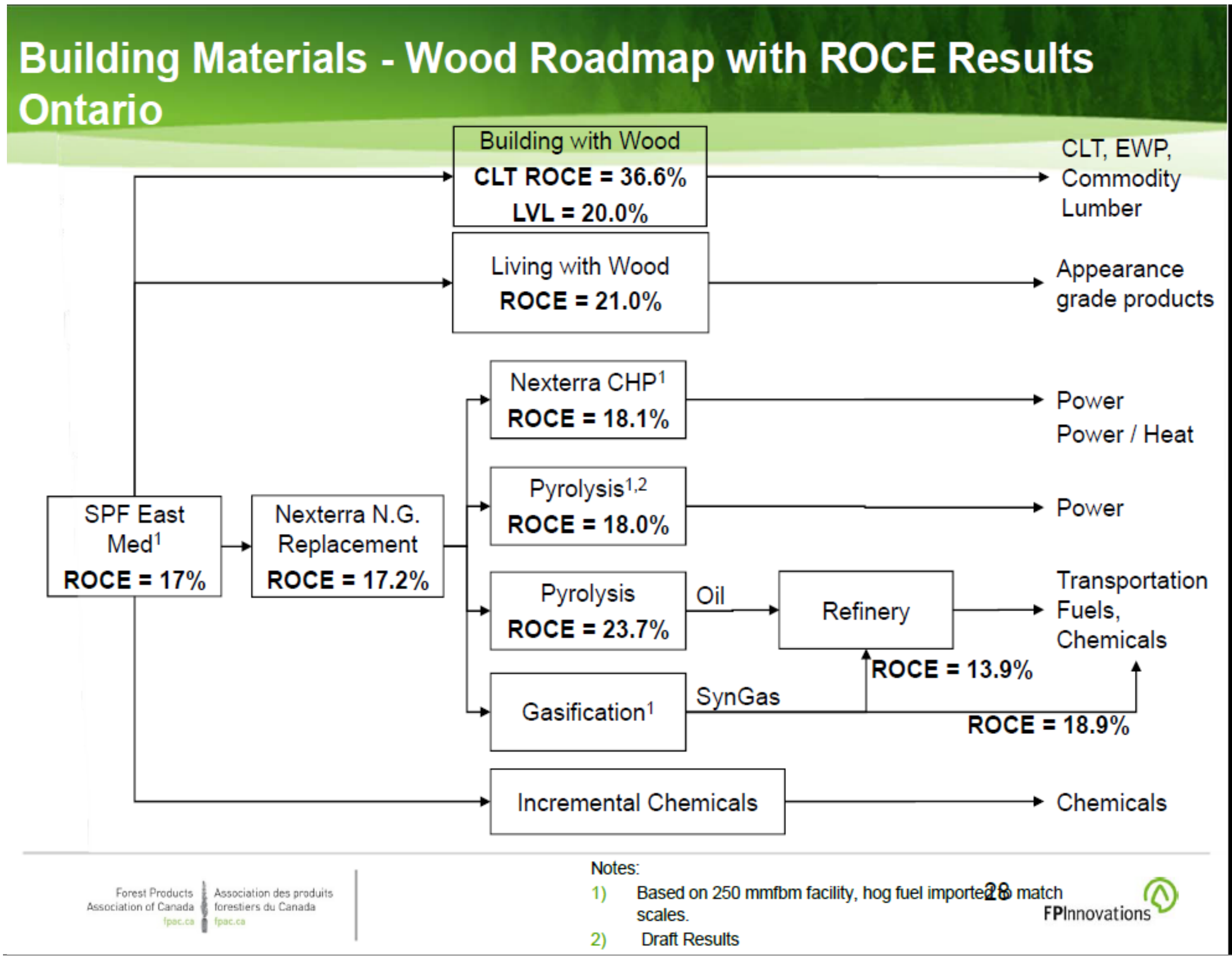


Source: FPInnovations (2010a)

Figure 74 is reproduced from an FPInnovations presentation (FPInnovations 2010a) and summarises their analysis of a hypothetical bio-refinery in Ontario producing a range of different products. The overall return on capital employed is around 12 per cent.

The study also analysed a number of other scenarios, such as high value wood products produced with co-production of biofuels and biochemicals (Figure 75). These had estimated returns of 17 per cent.

Figure 75. **Hypothetical high value wood scenario with different product lines**



Source: FPInnovations (2010a)

The Canadian examples provide evidence for the claims from the IEA, the EU, and the Finnish Forestry cluster that integrated bio-refinery production can lead to much higher returns than conventional technologies. A large amount of work remains to be done to find what mix of products and technologies is best suited to NZ conditions. As noted above, Scion and FPInnovations are collaborating on a project to model the costs of different bio-refinery options for the NZ environment.

The industrial wood fibre processing site at Kawerau is an excellent example of the kind of synergies that an integrated bio refinery might hope to achieve. The site is shared by four companies - Norske Skog Tasman, SCA Hygiene Australasia, CHH Tasman, CHH Wood Products and Sequel Lumber (New Zealand Trade and Enterprise 2012). Also on the site are Kawerau's geothermal power stations supplying low carbon electricity(New Zealand Trade and Enterprise 2011a). As well as power generation, the geothermal operations supply process steam for the companies for use in the production of pulp and drying lumber and paper products.

The site is the largest industrial user of steam from geothermal in the world. The combination of low carbon electricity and steam for heat energy makes the Norske Skog mill one of the lowest cost and profitable mills in the world (New Zealand Trade and Enterprise 2011a). Despite this, the company announced plans to halve production at is Kawerau Mill in New Zealand due to the excess of newsprint production capacity in Australasia and the need to reduce the level of exposure to exports into Asia. The company is also pursuing a range of renewable energy opportunities as part of a broader regional diversification strategy. In 2011 Norske Skog launched a joint venture with key technology holder Licella and in May this year bio-crude was produced from forestry residues at a demonstration plant at Somersby in New South Wales, Australia.

4.7.4 The green growth opportunities for forestry

The opportunity identified above identifies an ‘eco-system’ approach. There are economic green growth opportunities across a range of different sectors including the traditional wood processing sector; advanced engineered wood products; biofuels; bio- plastics; structural composites; and so on. The advantage of taking an integrated approach is that the different products can often be co-produced. For example, waste woody residue from a saw mill can be used for biofuel production.

A transport biofuels case study by Scion (Hall and Jack 2009) contains a scenario identifying 1.75 million ha of marginal land suitable for planting with trees and conversion to liquid transportation fuels, which would double the size of forest plantations in NZ. This would double NZ’s plantation forestry area and meet up to 65 per cent of NZ’s current liquid transport fuel demand. A more modest proposal was to use only the low grade L-logs for liquid fuel production with higher quality S-grade logs used for traditional forestry products. This suggests a 50-50 split between the traditional forestry industry and the new biofuels and biochemicals sectors.

An approximation can be made of the combined export potential of the new forestry industry in 2040 based on the Scion afforestation proposal. The current sustainable harvest of 30 to 33 million m^3 (Goulding 2005) would be almost twice the projected 2022 levels by 2040, rising to between 60 and 65 million m^3. The Woodco strategic plan details how the traditional forestry sector could generate $12.3 billion in exports by 2022. Emerging evidence suggests that the revenue and return from the new bio-pathway sector may be at least as good as from the traditional forestry sector. This suggests that net exports from the extra production should be at least as high as the traditional sector (which is the opportunity cost). This means that net forestry exports could be at least $22 billion[35] in 2040 if this opportunity was realised. The alternative business as usual strategy would see: no increased forest planting; no value added above the existing level; log exports continuing to dominate; and exports increasing to around $6 billion a year in the late 20s and then declining. The potential $22 billion or so in forestry exports does not translate directly into the increase in GDP for two reasons. The first is that the contribution to GDP is value added so costs would need to be deducted; however increased production for domestic consumption will offset this to some extent. Historically in NZ export value almost exactly matches the sectoral contribution to GDP. The second factor is that extra forestry production displaces production elsewhere in the economy unless it is assumed that total employment increases.

[35] That is taking the midpoint estimate of the sustainable harvest as 31.5 million for current production and doubling to 63million m3 per year. Using the Woodco projected exports of $12.3 billion for the 2022 harvest of 35 million m3 yields a figure of (63/35)*12.3 =$22 billion.

Another way of trying to estimate the green growth potential of forestry is to suppose that sustainable production increases to 63 million m^2 and NZ manages to achieve the high returns obtained in Finland. In this case total output in the sector would be $41 billion[36]. The forestry industry in Finland is of course trying to increase the value of production by a factor of two by 2030 as discussed above, if this were realised the figure of $41 billion would be a conservative estimate of the potential of the sector. By way of comparison, in 2008-2009, dairy exports were $10billion. The challenge for New Zealand is to realise the exciting green growth opportunity outlined here.

4.7.5 How to Get There

The analysis here suggests that there is a real opportunity to develop a smart, productive, sustainable forestry sector **(green growth opportunity 21)**. To achieve this will require smart thinking. It is unlikely to be achieved if left to the market for reasons outlined above. New Zealand needs a clear industry strategy with strong government leadership. Industry and government could develop a roadmap for the development of a forestry-sector-led bio-economy. The roadmap could include proposals to develop a forestry cluster which encourages industry cooperation and promotes innovation along the lines of that in Finland. The Finnish forestry cluster demonstrates the potential benefits of a more co-operative approach than that seen in the NZ forestry sector to date. The strategic plan presented by (Woodco 2012) is a committed decision to build an opportunity and has industry and government buy in but arguably requires further resourcing.

A strong building and wood-processing industry is a prerequisite for woody-mass biofuels and bio-products as the primary feedstock initially will be the residues created by these industries. Expanding traditional wood processing and manufacturing as outlined in the Woodco report is an essential first step. Furthermore, new high quality engineered building materials could be developed. Education and demonstration of the potential of these materials for the construction industry could play a key role as could direct government procurement of buildings, where appropriate, that use these materials. These could help provide a demand pull to the new technology.

A successful strategy should also aim to dramatically increase R&D and innovations. The Finnish cluster has often been referred to here since it is extremely successful. The size of the population and wood harvest are similar to NZ’s however their productivity is considerably higher than in NZ and is growing much faster. Government R&D funding for the forestry sector in NZ is $24-$29 million a year (New Zealand Ministry of Agriculture and Forests 2009). Finnish R&D spend in this area is $700 million a year of which $230 million is contributed by industry. Finnish productivity growth is 5.1 per cent a year whilst that in NZ is -0.4 per cent a year. This suggests that if NZ has aspirations to develop a productive world class forest industry it may need to increase R&D spending in this area by at least an order of magnitude. NZ MAF (2009) makes the point that the current R&D structure in this area is complex with a large number of research providers and suggests that there is a lack of strategic direction.

[36] Total harvest volume in Finland is 57 million cubic metres and value added to the economy is $37.5 billion. Applying the same ratio of harvest volume to value added in NZ, total output would be (63/57)*37.5 = $41 billion.

As noted above the Crown Research Institutes are already doing some excellent work and the world class expertise in this area provides a suggestion that increasing the R&D budget will yield further benefits over the longer run. In addition, it may be worth considering creating an institute or company similar to the Finnish forestry cluster institute, which has a mandate to develop innovative new products and processes right across the value chain. Alternatively, funding for Scion could be expanded considerably. The OECD (2007) identifies 'the strict application of the customer-contractor principle to public funding of R&D' as a weakness in NZ innovation policy which 'can result in drawbacks, with regard to building long-term capabilities, financing research infrastructure, transferring research results to business and offering internationally competitive wages to research leaders and staff'. The OECD concludes that core funding be increased to cover one third to one half of funding for government research organisations.

R&D is only the first part of the story – commercialisation is also crucial. Information flows can be very important so that businesses are fully aware of new opportunities and R&D providers are aware of where effort should best be directed in both the short and long term. MAF (2009) suggests that commercialisation of scientific breakthroughs is often a challenge and points to the limited amount pool of venture capital. They write:

> *'New Zealand is not taking full advantage of its most promising developments because the local industry lacks the capital, and market, to commercialise them. However, overseas forestry companies and investors are benefiting from New Zealand's scientific breakthroughs. Reversing this trend is one of the challenges for the sector. If the New Zealand forestry sector is to remain competitive on the world scene, it needs to improve its uptake of new technology.'*

A recent report (Finnish Forest Industries 2010a) examining innovation in the Finnish context and highlights a number of key components of a successful innovation strategy including:

> *'Public investment in the construction of pilot facilities and demonstration environments must be increased to such an extent that new business opportunities can be capitalised upon quickly, thus increasing competitive edge. The risk financing of companies in the sector must be increased substantially. In Finland the commercialisation of research and creation of new entrepreneurship and business must be accelerated by means of research funding, investment subsidies and taxes.'*

A similar approach here may be called for if NZ is to compete successfully. Venture capital or risk financing of companies needs to be a key part of a successful innovation strategy. Government funding may be needed to move from the laboratory to small scale plants and then to small scale commercial plants and finally to full scale commercial operations. [37] There is currently some money set aside ($30 million - $50 million) for

[37] There is some money set aside ($30 million - $50 million per annum) currently for industry funding of Primary Growth Partnerships (PGPs) across the agricultural, horticultural, seafood, food production and forestry sectors, however to date the forestry industry has struggled to get funding through this path.

industry funding of Primary Growth Partnerships (PGPs) across the agricultural, horticultural, seafood, food production and forestry sectors however to date the forestry industry has struggled to get funding through this path (Stuthridge 2012).

International experience suggests that it is an advantage to develop a bio-refinery as an integrated part of an existing pulp and paper mill, implying the need to work closely with existing pulp and paper producers. Joint ventures have been set up between industry and government successfully in North America, which suggest that this may be an approach worth pursuing here. It is encouraging first start to see that detailed cost modelling for NZ bio-refineries similar to the work done by FPInnovations in Canada is already underway and that the funding is split on a 50:50 investment basis by industry and government, demonstrating a willingness to work together on these opportunities. Clear opportunities exist for industry to launch joint ventures with overseas companies which have developed new technologies in this area. As noted above Norske Skog is already moving in this direction, however the current state of the forestry industry suggests that many firms are a long way from embracing such a vision, or have enough investment capacity, and that the government may well have to provide strong leadership if opportunities are to be realised.

One possibility would be to create a new vertically integrated state owned enterprise at least the size of Solid Energy. The mandate of the new state owned enterprise would be to aggressively pursue high value investment opportunities for the benefit of NZ and it could help create an environment where the private sector has the confidence to take advantage of the new opportunities in the sector.

There are a number of other key points that a strategic plan would need to address. The first is capital requirements which would be, at the very least, billions of dollars and possibly tens of billions of dollars over the next couple of decades. One possibility would be to direct some of the Cullen funds to this area. There would be a return on the investment for these funds which this initial review suggests should be reasonable.

The recent decision by Norske Skog to halve its pulp and paper production at Kawerau, and the fact that an increasing amount of the harvest is being exported as logs, points to the need to focus on getting better value from the existing forest plantation. In the long term, the Scion afforestation proposal should be considered seriously, in which case a plan needs to be developed to double the size of existing forests. One approach could be for a new vertically integrated state owned company to play a role in establishing the new forests. However there may well be other policy approaches which could give private landowners incentives to plant forests on marginal land. A clear example here is the vexed issue of carbon credits for growing forests. If the price of carbon was high and stable this would create considerable incentives for private landowners to plant plantation forests, particularly if some allowance is made for the proportion of the harvest which ends up in long term wood products. In conclusion, there is a clear opportunity to transform the forestry industry and this represents a substantial green growth opportunity in this sector for New Zealand.

4.8 Fisheries case study

A large exclusive economic zone under active management whose full potential is yet to be realised

4.8.1 Introduction

The seafood sector depends on well-functioning ecosystems; utilizes fossil energy; and relies on sound governance to prevent over-fishing and enhance economic returns. Fisheries are capable of supplying a sustained source of protein provided they are managed well. Although a well-designed governance arrangement can provide the basis for sustainable harvest it does not insulate the ecosystem from external impacts, such as climate change. The impacts of climate change on the seafood sector are uncertain and may require adaptation by seafood enterprises and government. For capture fisheries, climate change can affect productivity, growth rates and mortality rates (OECD 2011c). For cultivated fisheries, climate change may change the choice of species. Extreme weather events also adversely affect aquaculture sites.

Capture fisheries depend almost completely on fossil fuels. The cost share of energy within a particular fishery is determined principally by the technology in use, stock abundance, and price of other factors of production. Although somewhat dated, Wilson (1999) estimates energy costs in the region of a little under 10 per cent of gross earnings for a trawl fishery down to as little as 5 per cent of gross earnings for passive methods such as gillnetting. Another estimate, based on a survey of Alaska fishers, puts energy costs at 10 to 20 per cent of gross income (Rice, Baker, and Haight 2008). Tyedmers et al. (2005) estimate global fisheries account for about 1.2 per cent of global oil consumption. Global greenhouse gas emissions from fishing are estimated at more than 130 million tonnes of CO_2 which is about 0.5 per cent of 2010 global CO_2 emissions.

Higher biomass levels may, other things being equal, lower the energy cost per unit of harvest. Re-balancing biomass levels and energy consumption would most likely involve cooperative actions by both commercial fishers and government on setting harvest levels. In the near term, both inshore and deep water fisheries are affected by changes in global fuel prices.

Wilson (1999) claims that fishing is one of the most energy-intensive forms of food production methods in the world today. However this assertion should be considered alongside the energy used to produce other sources of protein. Tyedmers et al. (2005) provide insights into the relationship between seafood, as a source of protein, and energy used. They show that while an 8 per cent edible protein energy return on fuel energy investment appears low, it is higher than many other animal protein production systems, including US pasture based beef production.

Numerous economic activities use the marine environment, including transport, communications, and increasingly, the development of oil and mineral resources. As an open economy, NZ is heavily dependent on exports, and the benefits associated with oil exports, transportation, and communication systems are enormous. With these benefits come the risks of economic cost associated with adverse events. Oil spills from development and utilization of the marine resource (BP, Deep Water Horizon) and transport (Exxon

Valdes, oil; Rena, oil and cargo) can have a devastating impact on the marine environment, taking many years to recover. Land based sources of pollution also contribute to a decline in the productivity of marine ecosystems; including, both point sources (sewage discharge) and non-point sources (urban development and intensive agriculture).

This case study shows the economic and environmental benefits associated with an industry based on the sustainable use of a renewable resource. The first section provides a brief overview of the quota management system (QMS) as implemented in 1986 and is now recognised as a world leader in fisheries management. Export volumes and values are described for the period 2000-2010, after which profile trends for the three top export earners: rock lobster, hoki, and mussels, from 2000 to 2010 are derived. The second section sets the global scene in respect of production, trade, and future supply and demand. NZ's exclusive economic zone (EEZ) is the fourth largest in the world, providing the basis for a seafood industry that generates the fourth largest exports in 2010. Three case studies are used to illustrate recent innovations in the seafood sector. The final section identifies risks and highlights opportunities for further economic growth.

4.8.2 New Zealand seafood sector

NZ's marine capture fisheries encompass the Territorial Sea from the shore out to 12 nautical miles and the EEZ from 12 to 200 nautical miles, an area of 4.4 million km^2. This area, along with approximately 15,000 km of coastline, provides the natural resource foundations for NZ's seafood industry. The marine ecosystem is diverse and primary productivity is considered to be moderate. Two-thirds of NZ waters are more than 1,000 metres deep where commercial opportunities are minimal. Most commercial fishing occurs in more shallow waters, less than 1,000 metres deep.

Governance

The management outcomes of NZ's fishery resources have evolved from a state of over-harvest and excess capacity to become a leading example of economic and sustainable management. Internationally, NZ is held as an exemplar through the removal of subsidies and a robust rights-based system of management (The Prince's Charities' International Sustainability Unit 2012; OECD 2011c). Governance is based on two structural pillars: harvest limits and tradable rights. NZ recently became one of only two countries to achieve a top ranking in a review of fisheries management systems around the world (Worm et al. 2009) and in a second study was ranked first among the 53 major fishing nations for managing marine resources (Alder et al. 2010).

The cornerstone of NZ's fisheries management regime is the quota management system , which was introduced in 1986. An annual catch limit is set for fish stocks in up to 10 geographic areas. By controlling the amount of fish taken from each stock, the QMS is the foundation of the sustainability of NZ's fisheries. Legislation requires catch limits for every fish stock to be set at levels that will take each stock towards its maximum sustainable yield. Catch limits are based on stock assessments undertaken by fisheries' scientists with active participation by fisheries' managers, and representatives of commercial and environmental interests. The commercial fishing industry pays for a significant share of the research costs by way of an annual levy.

Under the QMS commercial catching rights for each of NZ's 636 fish stocks have been split into quota shares which can be freely bought and sold. Harvest levels are monitored and financial penalties (deemed values) are levied if fishers cannot cover their harvest with harvesting rights. New Zealand is one of only a few countries in the world to use individual transferable quotas on such a broad scale and across so many fisheries. Secure transferable quota rights provide an incentive for fishers to align their investments with expected returns and ensure that catch levels are covered by quota because they have a stake in the future productivity of the fishery.

Conservation

Benthic Protected Areas

Approximately 1.1 million km^2 of New Zealand's EEZ is closed to bottom trawling and dredging; one of the largest areas of marine space closed to bottom trawling in the world.[38] Benthic protected areas mainly cover areas that have never been trawled. Additional closures protect sea mounts and hydrothermal vents.

Marine Protected Areas

New Zealand's first marine reserve (Goat Island) was established in 1975. Today, the area protected as a marine reserve covers 1.26 million ha; ranging in size from 93 ha (Te Awaatu Channel) to 745,000 ha (Kermadec Marine Reserve).

Environmental impacts

Regulations and industry agreements are in place to protect species such as sea lion, fur seals, sea birds, and dolphins.

Energy use

Since 1998 energy use in the primary production sector has been increasing. Energy use includes diesel and fuel oil for vessels and land transport and, to a significantly lesser extent, electricity for refrigeration, cool stores and water pumping. Light fuel oil is the main fuel used by the catching sector whereas most of the electricity is used by the processing sector to run refrigeration equipment. Once a vessel has been purchased, at considerable cost, opportunities for lowering energy consumption per unit of harvest include: active management of speed while at sea, use of innovative harvesting technologies, and regular maintenance.

In 2008 diesel accounted for 50 per cent of energy use by the primary sector and 20 per cent of total diesel use in NZ. In 2008 a survey of energy use within primary industries ranked fishing as the fifth largest user of energy[39]. Diesel (2,488 TJ) and fuel oil (1,942TJ) accounted for most of the energy used (4,504 TJ) by fishing. Total energy use by fishing was about 10 per cent of that used by primary industries. Carbon dioxide

[38] Protecting New Zealand's Seabed from the Impacts of Bottom Trawling, available at www.fish.govt.nz.

[39]http://www.stats.govt.nz/browse_for_stats/industry_sectors/Energy/EnergyUseSurvey_HOTP2008/Technical per cent20Notes.aspx

emissions from diesel use in fishing are approximately five per cent of NZ's CO_2 emissions[40] which are reported to be 33 million tonnes[41].

On July 2010, producers of transport fuels became participants in the Emissions Trading Scheme (ETS) requiring payment of NZ Units (NZUs) to government to cover emissions of GHGs. The price of transport fuels were expected to increase because the companies supplying fuels will pass on the cost of NZUs to consumers. Cost increases, other things remaining equal, are expected to lower quota prices. As compensation for any fall in the value of fishing quota resulting from the increase in the cost of fuel under the ETS, the government set aside 700,000 NZUs. Eligibility was based on quota ownership.

Employment

Data from the 2006 census show a count of 7,155 resident people working across the seafood sector. Approximately 40 per cent of these people are employed in harvesting and cultivation and slightly over 50 per cent are employed in processing. Given limits to wild capture harvest - through the QMS – opportunities for employment growth will most likely arise from activities that add value; transforming a primary commodity into higher consumer valued products. The expansion of aquaculture should also create opportunities for employment.

[40] http://www.energyfed.org.nz/Fishing.pdf

[41] The conversion assumes 38.31 MJ/l of diesel and an emission factor of 0.00271 tonnes of CO2 per litre (New Zealand Climate Change Office, Projects emission factors, 2004)

Table 19. **Employment in seafood sector 2006**

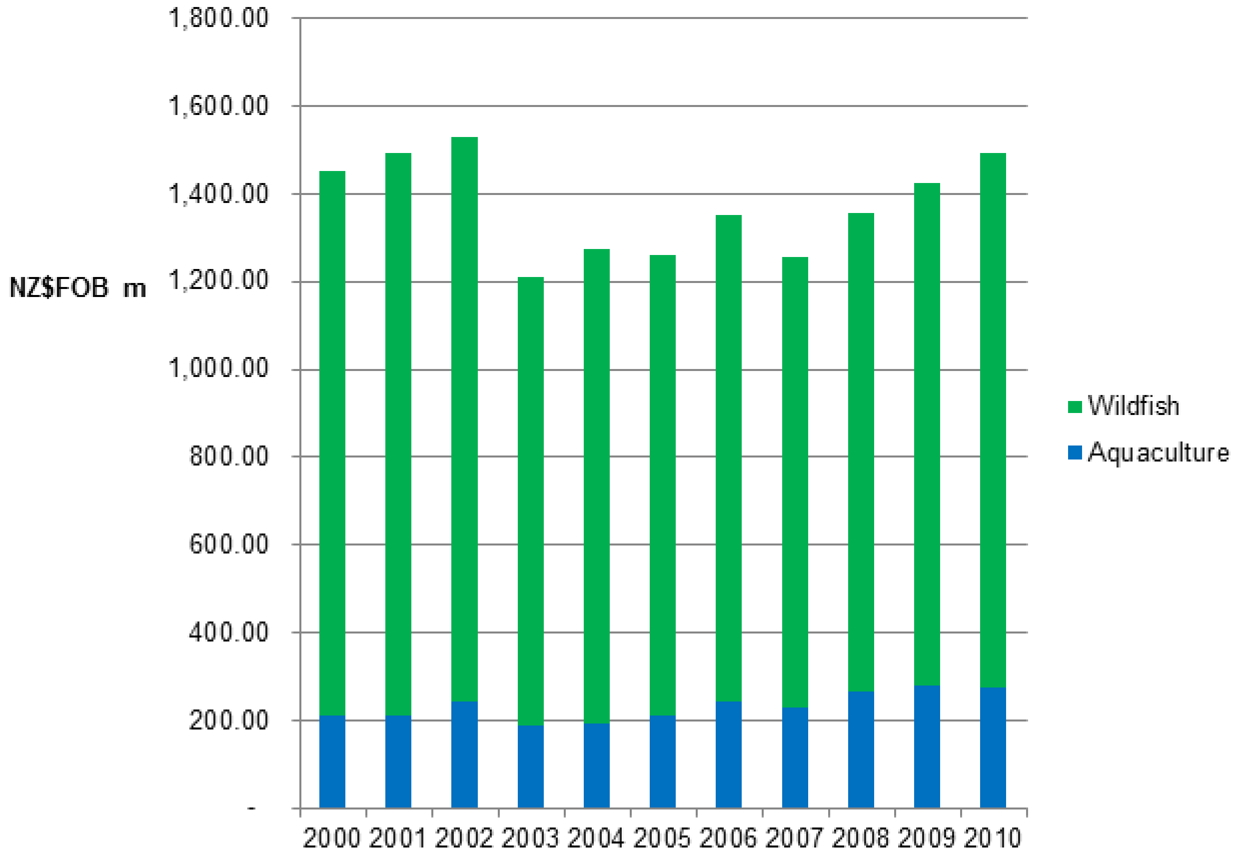
Sectors	Residence population count	Per cent
Rock lobster and prawn fishing	255	4
Fin fish, line fishing and other	1,518	21
Aquaculture	1,086	15
Seafood processing	3,678	51
Wholesaling	618	9
Total resident population count	7,155	100
Total direct and indirect employment (FTE)	26,620	

Source: Statistics New Zealand and Seafood Industry Council

Seafood exports

In 2010, seafood was NZ's fourth largest export earner. Almost 90 per cent of the harvest, by value, is exported. Export earnings from the seafood sector in 2010 were $NZ 1.49 billion; wild capture $NZ 1,219 million, aquaculture $NZ 274 million, valued free on board. The trend in export earnings is illustrated in Figure 76. A dramatic decline in export earnings occurred in 2003, falling from around NZ$1.5 billion to NZ$1.2 billion; the result of currency appreciation and lower volumes. The value of export earnings has steadily increased from 2003 to 2010 with nominal earnings slightly below the 2002 peak.

Figure 76. **Exports earnings from wild capture fisheries and aquaculture**

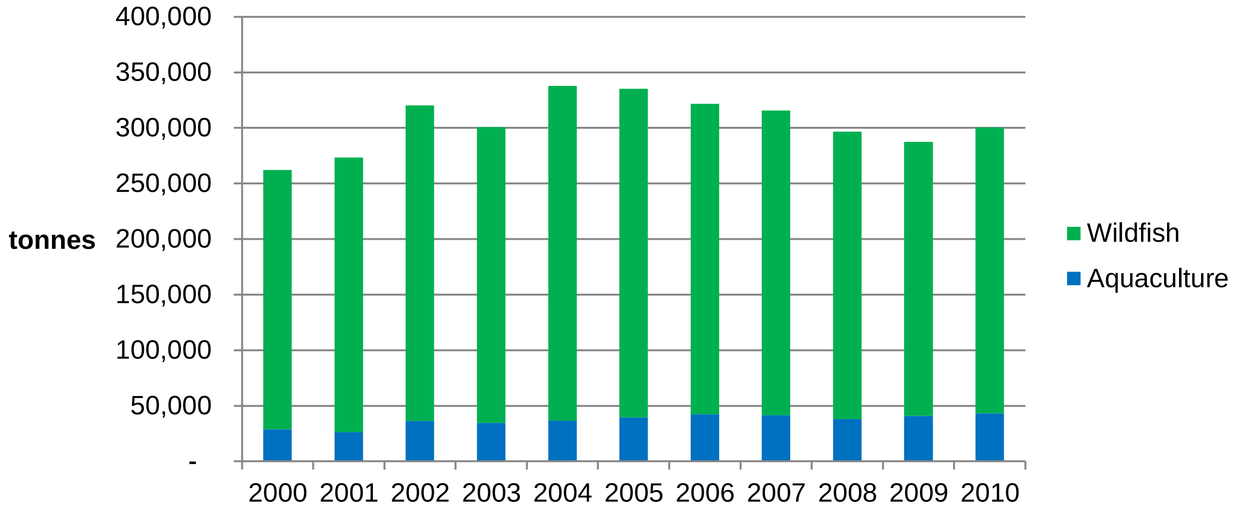


Note: FOB stands for 'free on board'

Source: Seafood Industry Council

Figure 77 shows the composition of exports by volume. The volume exported peaked in 2004, declining to 2009, increasing to around 300,000 tonnes in 2010. Export volumes from aquaculture have remained below 50,000 tonnes. Variations in total volume are attributed mainly to wild capture. Barring significant improvements in biomass, it would appear that the volume from wild capture fisheries is converging on the limits of exploitation, settling at around 300,000 tonnes. Economic growth in wild capture fisheries will depend on adding value to a harvest constrained by sustainability. Commercial opportunities might exist from increasing production from aquaculture.

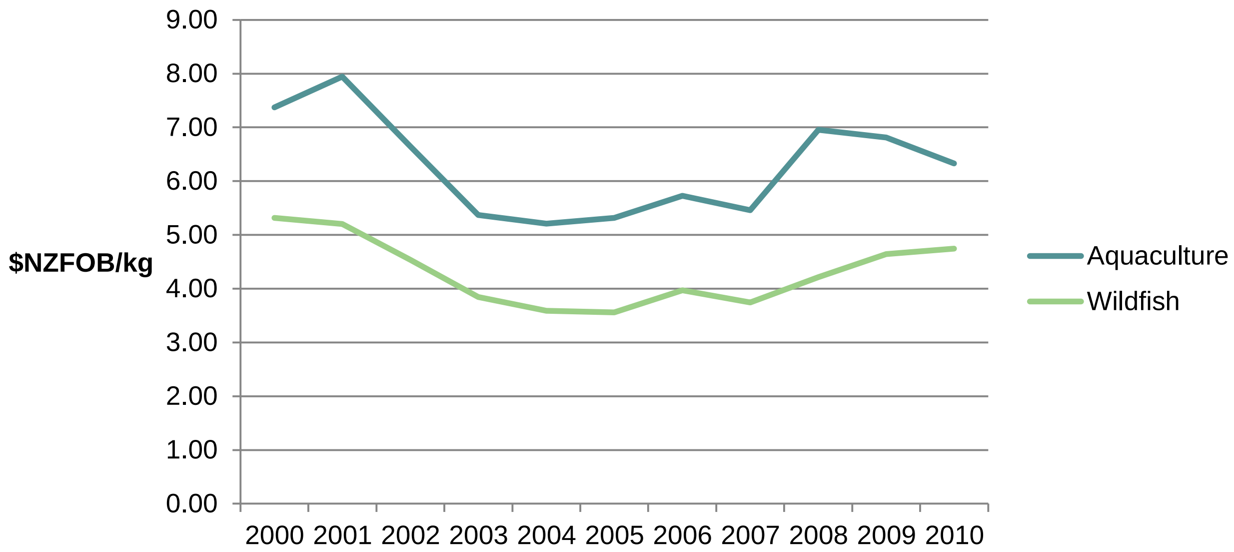
Figure 77. **Weight of fish products exported**



Source: Seafood Industry Council

The trend in nominal returns per kilogram exported is illustrated in Figure 78. Export earnings from wild capture exports follow a 'U' shaped pattern, bottoming out in 2004 and increasing through 2010. Returns from aquaculture show a similar pattern although they dipped in 2008, a result of the global recession. The income elasticity of demand for cultivated seafood products are typically higher, relative to wild capture products, and are therefore more likely to be adversely impacted by economic downturns.

Figure 78. **Nominal returns per kilogram of fish product exported**



Note: FOB stands for 'free on board'

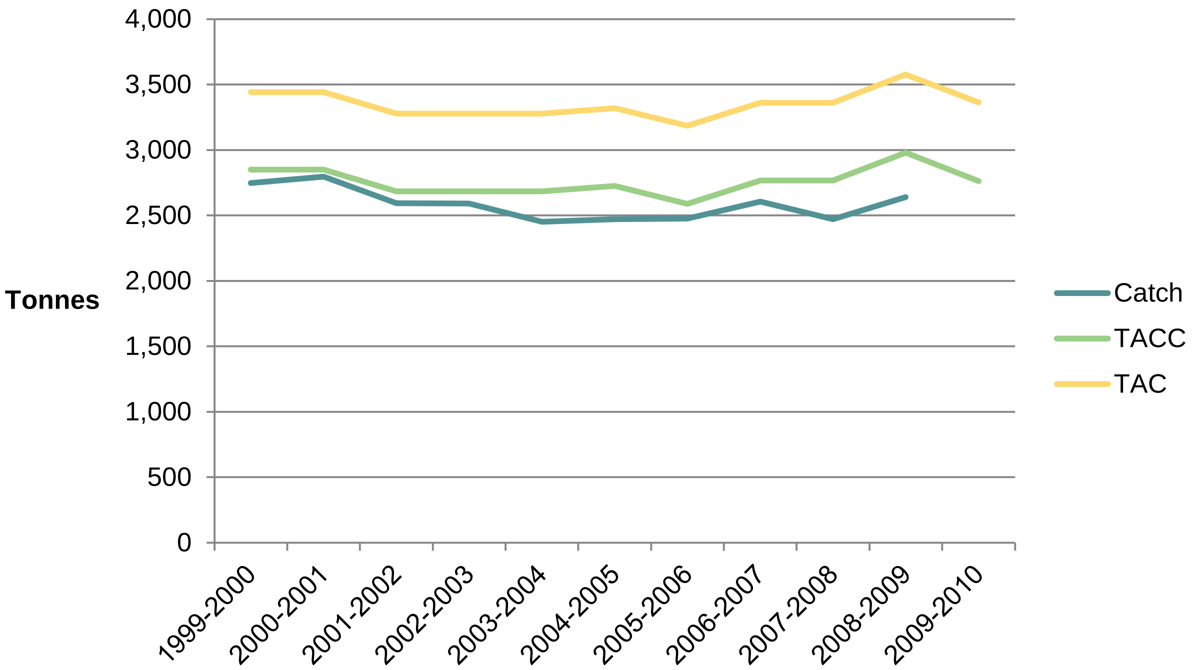
Source: Seafood Industry Council

The top three export species by value in 2010 were rock lobster (NZ$ 229 million), hoki (NZ$ 172 million) and mussels (NZ$ 171 million). The top five export markets in 2010 were Australia (NZ$ 286 million), Hong Kong (NZ$ 250 million), China (NZ$ 200 million), USA (NZ$ 178 million), and Japan (NZ$ 129 million). Among the five export markets, China's seafood demand has been increasing rapidly in both volume and value.

Rock lobster

Rock lobster is a target fishery with negligible by-catch. Allowances for recreational customary use, and other sources of fishing related mortality are made in each quota management area. The annual total allowable commercial catch (TACC) for rock lobster averaged around 2,758 tonnes over the period 2000 to 2010; 93 per cent of the allowable catch was harvested. While there appears to be some scope for increasing the harvest of rock lobster within existing TACC limits, it would appear that stock abundance and economic considerations have kept the harvest level at slightly over 90 per cent of the TACC.

Figure 79. **Rock Lobster harvest and allowable limits**

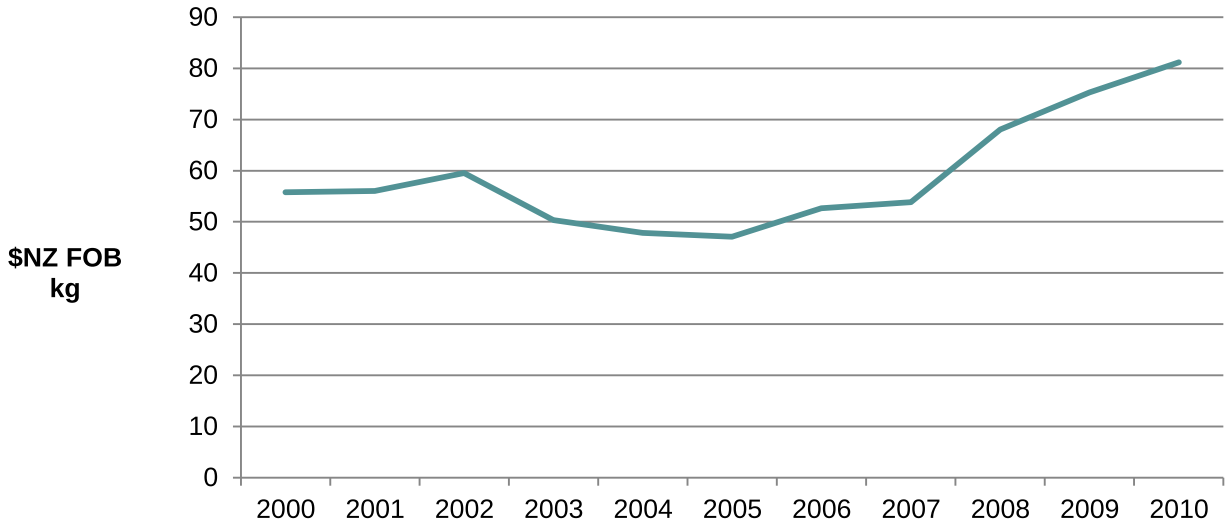


Source: New Zealand Ministry for Primary Industries

Note: TACC stands for 'total allowable commercial catch', and TAC for 'total allowable catch'

The average volume exported was 2,360 tonnes valued at NZ$ 58.87/kg free on board. Figure 80 shows export earnings per kilogram have steadily increased since 2006.

Figure 80. **Unit value of exported rock lobster**



Source: Seafood Industry Council

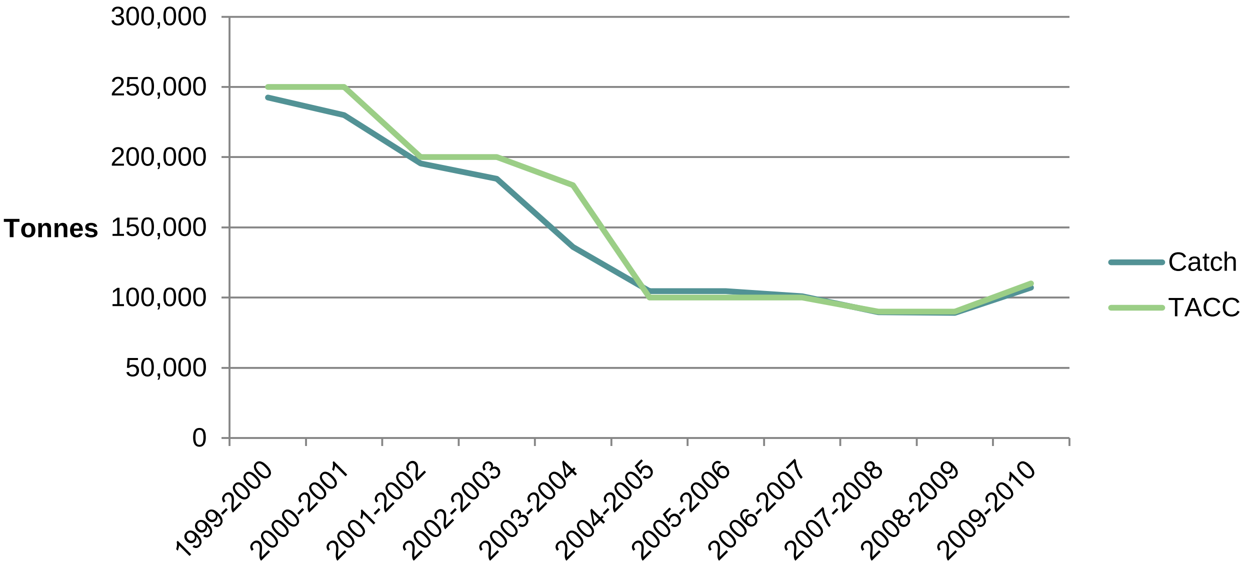
Note: FOB stands for 'free on board'

Exports of rock lobster in have improved over the last five years. The export level was not influenced noticeably by the financial crisis in 2008. Asian and Pacific countries are the main export markets for rock lobster. Australia, China, Hong Kong, Japan, Taiwan, Singapore and United States are major export markets in terms of weight and value. Exported chilled live lobster ranks the highest in terms of volume, 95 per cent, and value, 96 per cent.

Hoki fishery

Hoki is a deep water species. The fishery was developed in the early 1970s by Japanese and Soviet vessels. The main fishery has operated from mid-July to late August on the west coast of the South Island where hoki aggregate to spawn, although there is a year round fishery with effort also on the Chatham Rise and Sub-Antarctic fisheries. Spawning aggregations also occur in the Cook Strait. Hoki disperse outside the spawning season. Figure 81 shows the annual harvest at, or close to, the TACC for most years.

Figure 81. **Reported harvest of Hoki**

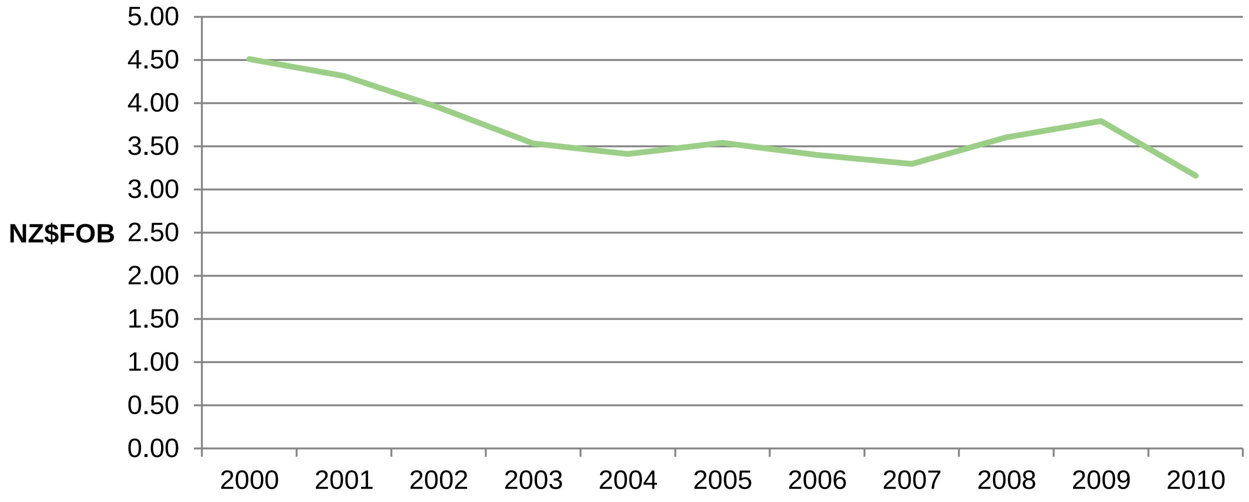


Source: New Zealand Ministry for Primary Industries

Note: TACC stands for 'total allowable commercial catch'

In general, as Figure 82 highlights, the value per kg exported has fallen. Hoki is exported in six product forms, frozen fillet being the most important, contributing almost 51 per cent of total export in weight and 72 per cent in value. Frozen 'head & gutted' is the second important product form in terms of volume and value, contributing 44 per cent of total export in weight and 24 per cent in value. Frozen fillet and frozen 'headed & gutted' products contributed to almost 95 per cent of total exports in terms of both weight and value. China is the main export market for 'frozen headed & gutted' product. Frozen fillet exports have fallen dramatically over the last 11 years. The decline can be attributed to a number of factors, including the global financial crisis, increases in the price of oil, and reductions in the TACC. Export levels peaked in 2001.

Figure 82. **Hoki exports by value**



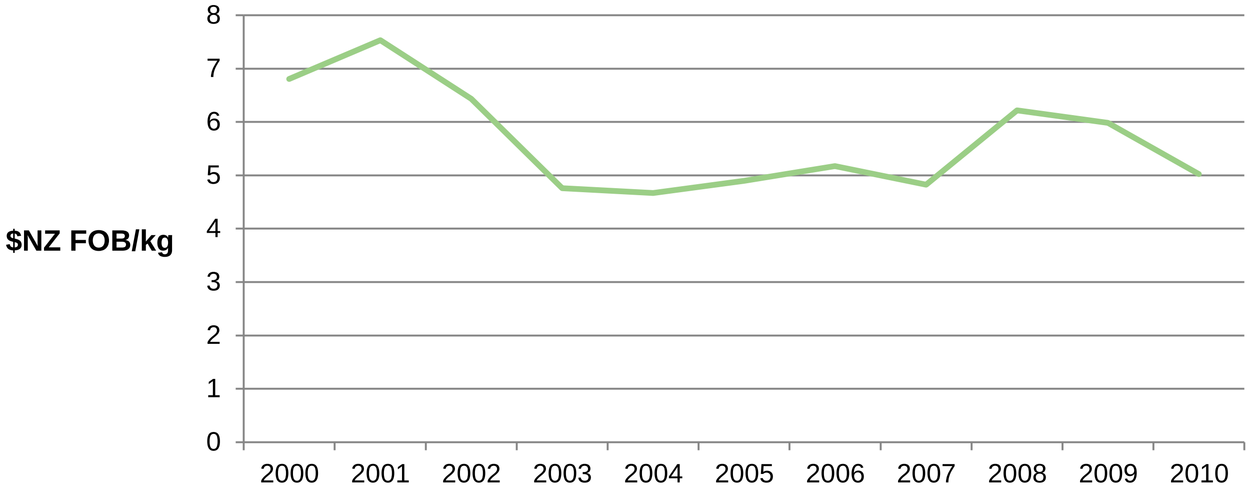
Source: Seafood Industry Council

Note: FOB stands for 'free on board'

Mussels

A time series of nominal price is shown in Figure 83. The series shows considerable variation: peaking in 2001 at over NZ$ 7/kg free on board; falling to below $NZ 5/kg free on board in 2003.

Figure 83. **Value of mussel exports**



Source: Seafood Industry Council

Note: FOB stands for 'free on board'

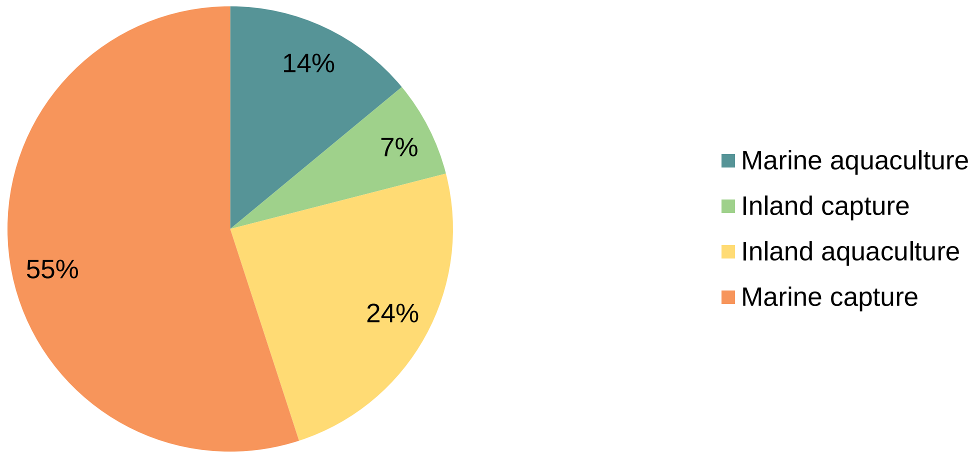
Mussels were exported in 15 product forms. Half-shell (HS) frozen mussels account for the highest volume and value exported, contributing to 82 per cent of total mussel exports in weight and 77 per cent in value.

Meat frozen product is the second important form in both weight and value; contributing 9 per cent of total export in weight and 11 per cent in value. The unit value of powder in capsule product is the highest with $85 kg and unit value of live product is the lowest with $3 kg. Over the last 11 years NZ exported HS frozen mussels to 98 countries. Top export markets include the United States, South Korea, and Australia. United States is the largest export market with 43 per cent share by volume and 41 per cent share by value.

4.8.3 World review of fisheries and agriculture

Global production from marine capture fisheries peaked in 1996 and declined, with annual fluctuations, to 2008. Capture fisheries and aquaculture supplied the world with about 145 million tonnes of fish in 2008 (FAO, 2010). Figure 84 shows that around 70 per cent, or approximately 100 million tonnes, occurs in the marine environment. Marine based production has remained fairly static since 2004, with most of the growth coming from land-based capture and aquaculture. World aquaculture production is dominated by the Asia-Pacific region, with China being, by far, the largest producer. The FAO points to a declining contribution from traditional aquaculture producers, such as Japan and France.

Figure 84. **Share of world fisheries production 2008**

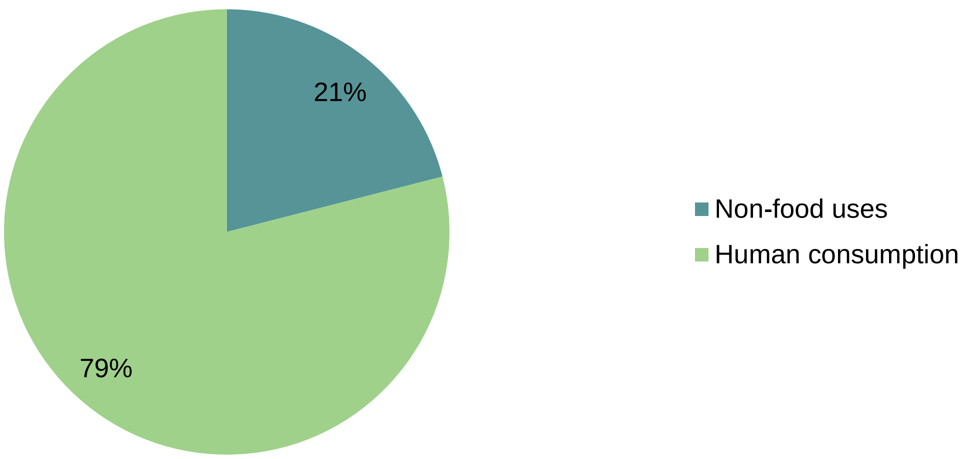


Source: FAO (2010)

Globally, fish provides about 1.5 billion people with 20 per cent of their average intake of animal protein. Figure 85 shows human consumption accounting for approximately 80 per cent of total production, an increase from 73 per cent of total production in 2004. Being highly perishable, almost 40 per cent of total production in 2008 was marketed as fresh. Freezing is the main method of processing. Fish prices have followed the general upward trend observed in food prices although the FAO Fish Price Index showed a dramatic drop in 2008/09 associated with the global recession.

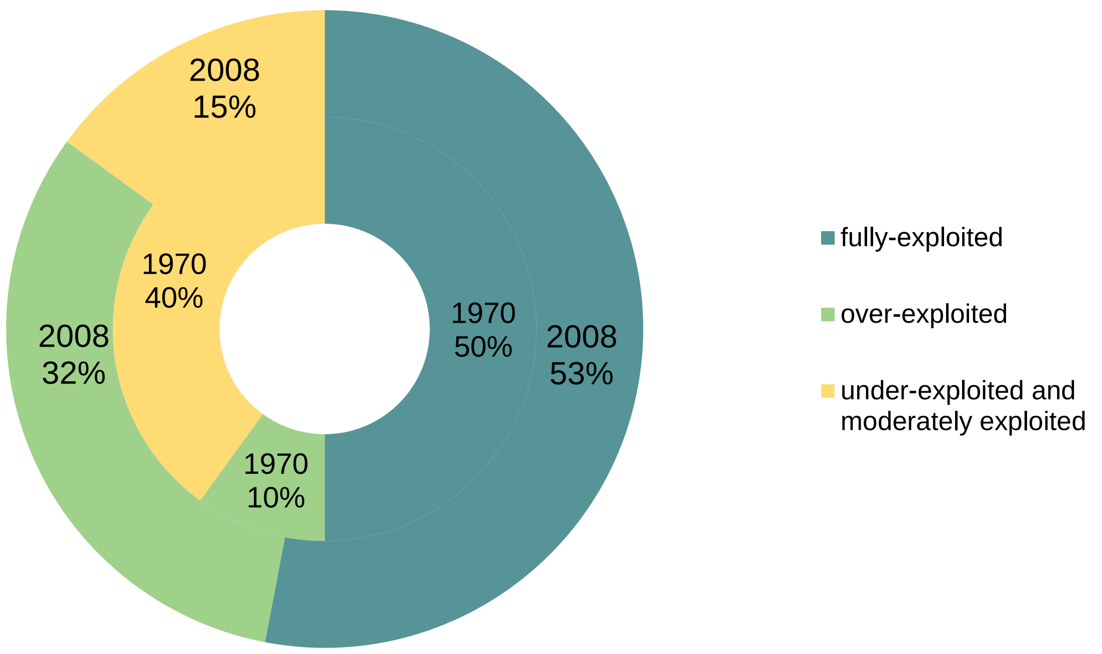
In 2008, world imports of fish and fish products totalled US$107 billion, an increase of 9 per cent over 2007 (FAO, 2010). Preliminary data for 2009 point to a decline of around 9 per cent, which is attributed to the global recession. Japan, the US and the European Union account for 68 per cent of the worlds' imports, with Japan being the largest single national importer of fish and fishery products. The EU is the single largest market representing 42 per cent of total world imports.

Figure 85. **Use of world fisheries production**



Source: FAO (2010)

Figure 86. **Changes in the status of global fisheries**



Source: FAO (2010)

Figure 86 illustrates the change in status of global fisheries. The proportion of stocks considered to be fully exploited increased slightly over the 1970 to 2008 period. In contrast, over exploited stocks increased from 10 per cent in 1970 to 32 per cent in 2008; largely the result of a drop in under exploited and moderately exploited stocks. When considered alongside flat global harvest levels, these results suggest that there is limited scope, beyond stock rebuilding, for increasing harvest from wild capture fisheries.

There can be little doubt about the importance of seafood as a source of protein and economic welfare. However, the management systems underpinning production are in dire need of repair. The World Bank-OECD has estimated the economic loss associated with poor management, inefficiencies and over fishing at up to US$50 billion per year. Aggregated over the last three decades, these losses amount to over US$ 2 trillion. According to the report the losses occur in two main ways. First, stocks are depleted, increasing the cost of harvest. Second, the benefits of fishing are dissipated by over investment in capacity (The World Bank and FAO 2009).

In summary, demand for fish products is expected to rise over the long term, driven by the protein needs of a growing global population, increased urbanisation, per capita income growth in developing nations, and the price of alternative sources of protein. Estimates of income elasticity for fish in China and South East Asia are around unity; suggesting that fish is a normal good and growth in demand is likely to be similar to income growth (Alder et al. 2010). On the supply side, evidence points to global production from wild capture fisheries levelling off and a slower rate of growth in production from inland aquaculture. An additional 27 million tonnes of production – almost 30 per cent of total production in 2009 – would be required to maintain the present level of per capita consumption in 2030. Aquaculture is seen as the main source of additional production.

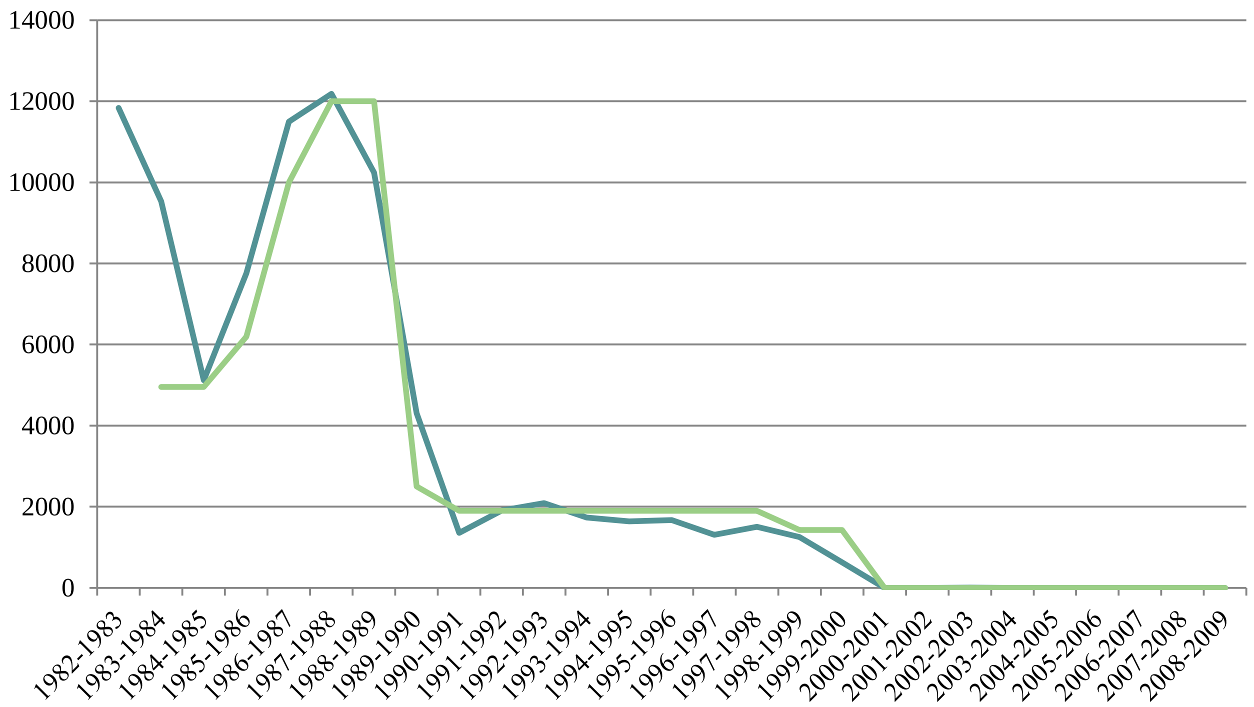
4.8.4 Case study

This section uses three case studies to illustrate green growth initiatives. The management of the orange roughly is used to illustrate an application of harvest limitations to move fish stocks toward sustainable yield. The second case study highlights opportunities for green growth arising from aquaculture development. The third case study describes the initiatives around sustainability at a publicly listed fishing company.

Orange roughy

Orange roughy live in a water column depth of between 750 and 1,500 metres. Longevity and slow growth are key sustainability issues making the species vulnerable to over fishing. Uncertainties about stock levels and productivity combine to challenge sustainable management. It is a high value species fishery where trawling methods are aimed at reducing habitat damage. Figure 87 and Figure 88 illustrate the adjustments made to TACCs to better align catch levels with stock abundance and productivity. Harvest is constrained by the TACC for both the Challenger and Plateau Chatham Rise fisheries. Total yearly catch is now approximately 60 per cent of the 1980s levels.

Figure 87. **Challenger Plateau total reported catch and TACC**



Source: New Zealand Ministry for Primary Industries

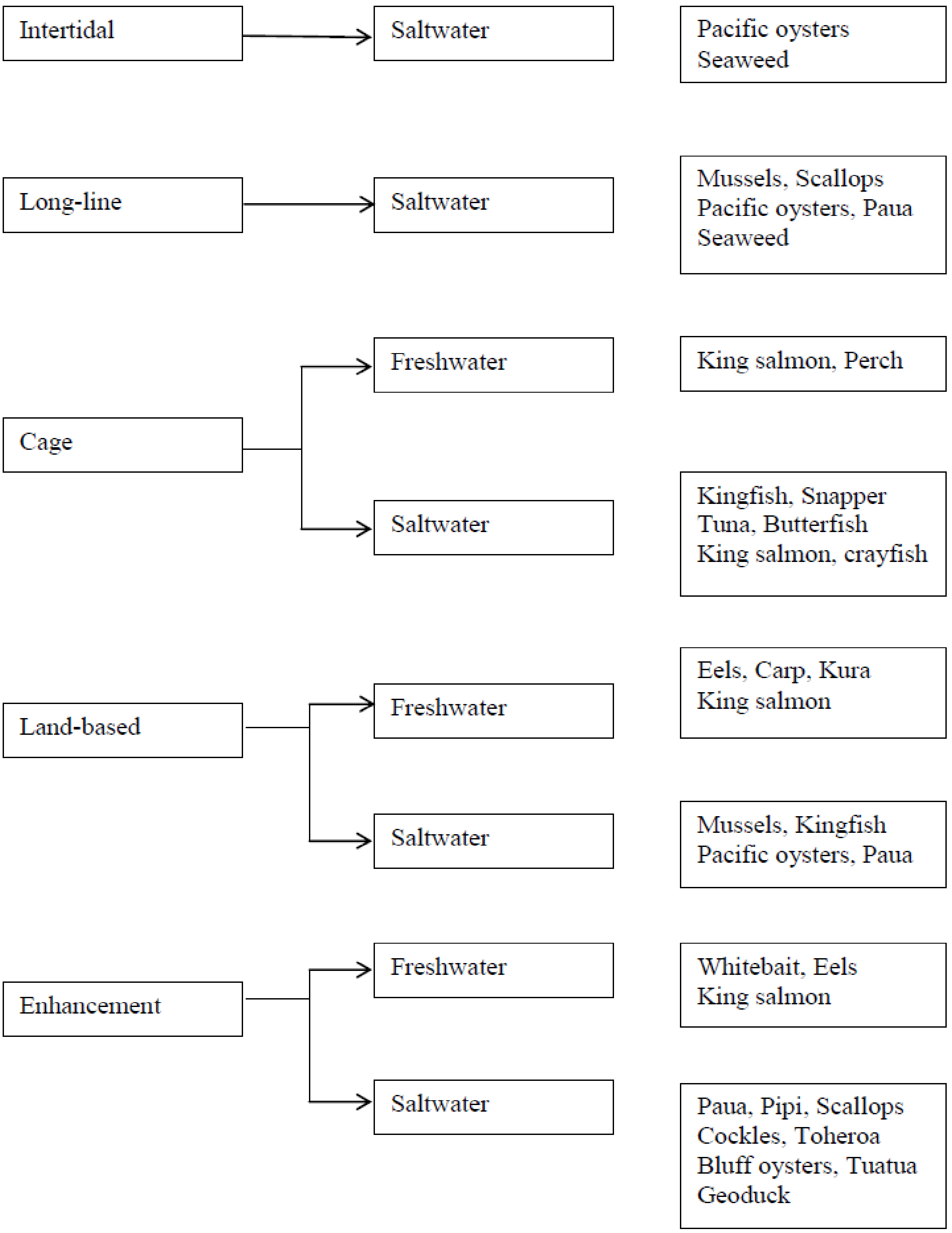
Figure 88. **Chatham Rise / Southern NZ total reported catch and TACC**

Source: New Zealand Ministry for Primary Industries

Aquaculture

Figure 89 illustrates the location, water resource used in cultivation and the feasible range of species. Mussel cultivation dominates aquaculture production. Considerable opportunity exists for the development and commercialisation of other species, such as Paua, Kingfish and Crayfish.

Figure 89. **Aquaculture, technology, location and species**



Source: PricewaterhouseCoopers (2006)

New Zealand king salmon

King salmon, also called quinnat salmon, is a native of the Northern Pacific Ocean. Attempts to introduce it as a game fish initially failed. Success came in the late 1800s when fish bred in California were released into the headwaters of rivers on the east coast of the South Island. The first salmon farm was located at Stewart Island. King salmon is the only salmon species farmed in NZ.

New Zealand King Salmon promotes its product as sustainable, disease and chemical free, with supply chain traceability (New Zealand King Salmon 2012). Annual production from five locations in the Marlborough Sounds is in the order of 8,500 tonnes, about 70 per cent of NZ's salmon production. It is the world's largest producer of king salmon, enjoys around 55 per cent of market share, earns around NZ$60 million export revenues, supporting a total of 1,050 jobs, including 455 in NZ. About half of annual production is consumed in NZ, the balance exported to Japan and Australia, 32 per cent, North America, 12 per cent, and the balance to South East Asia. Salmon is delivered to market in a variety of forms, including fresh, frozen, and smoked.

Plans to expand operations in an area prohibited by Marlborough Council's District Plan are currently before the Environmental protection Agency (EPA). According to a study by Market Economics, the expansion would deliver an additional 1,510 jobs by 2016 and sustain a total value added on $1.9 billion annually from 2012.

4.8.5 Green growth opportunities

Opportunities for green growth in NZ's seafood sector can be traced back to the policy initiatives implemented in the mid-1980s. In contrast to many, if not the majority of fisheries worldwide, the NZ seafood industry receives no subsidies and is based on the principles of sustainable management. The QMS provides the foundations for commercial initiatives within the context of sustainability and without direct government intervention.

The sector is NZ's fourth largest export earner. Patterns of international trade are diverse and vary by product. As noted earlier, the demand for seafood products is income-elastic and economic growth in developing economies, such as China, are expected to yield increased commercial opportunities in the future (Alder et al. 2010).

NZ has the opportunity to further develop this sector, realising the full potential of the Exclusive Economic Zone (EEZ) within the context of sustainable harvest levels (**green growth opportunity 16**). Steps to achieve this goal include exploring aspects of the quota management system, including quota holdings, as well as public policy as it relates to the sector, to ascertain if any of these any limit the long-term economic potential of stocks in the EEZ.

International innovation

NZ's wild capture fisheries are output constrained and there is limited scope for an increase in volume unless increases in the biomass are possible through stock re-building. Regulatory innovations have put NZ ahead as other nations struggle to control over fishing and unintended impacts on the marine environment. No system is perfect and industry and government can take further steps to minimize impacts on marine wildlife and the environment.

Despite providing the foundations for sustainable benefits, the QMS does not restrict recreational fishing. This continues to be controversial in high value inshore fisheries such as snapper and blue cod. The establishment of a rights-based framework for commercial recreational fishing in areas such as the Hauraki Gulf and Marlborough Sounds, within sustainable harvest limits, could provide economic opportunities for small scale enterprise. In the case of fisheries where the TACC is not fully caught, analysis should be directed at uncovering the reasons why the harvestable surplus is foregone. The reason could simply be that it is not economic to fully harvest the quota. However, analysis might reveal other reasons, such as exposure to commercial risk arising from the level of deemed values in by-catch fisheries and fragmented sources of quota. Fragmented small holdings of quota owned by Maori limit opportunities for commercial development and employment.

NZ is well-placed to gain commercial benefit from growing consumer awareness to buy sustainable seafood. The Ministry's vision for managing the environmental effects of fishing (New Zealand Ministry of Fisheries 2005) is consistent with sustainable use and protection of the aquatic environment. This vision, such as the protection of Hectors Dolphins and sea mounts, might foster commercial innovation and enhance the image of NZ seafood in international markets.

Commercial innovation

The regulatory environment is supportive of an open and diverse range of cost-saving innovations. New Zealand has an opportunity to lead in the development of technology-intensive harvesting systems that reduce energy use and costs. Examples are the use of smart technology to optimise fuel consumption and information systems to optimise harvest effort with respect to stocks. Industry groups, crown research institutes and universities could improve coordination with the aim of enhancing and disseminating innovations (**green growth opportunity 19**). At the same time, continuing and enhancing cooperative research programmes involving seafood industry groups, research providers and technology firms that develop technology in precision harvesting and processing methods could reduce adverse impacts on the marine environment (**green growth opportunity 18**).

New Zealand exports over ninety per cent of its wild capture harvest. Adding value to a constrained harvest is a challenge. Increasingly, consumers will demand sustainably harvested quality products at a competitive price. There may be considerable opportunity for adding value to harvest that is currently exported.

Aquaculture

There may be substantial opportunity for green growth in aquaculture (**green growth opportunity 17**). Mussel cultivation has been the backbone of the aquaculture industry and innovations are appearing on the horizon, including paua and fin fish. To encourage further expansion of this sector the regulatory environment will need to ensure that aquaculture is not at risk from land based sources of pollution, and that aquaculture development is balanced against competing uses, while also giving due attention to community concerns.

Potential growth in aquaculture has been estimated at between NZ$1.7 billion and NZ$2.2 billion per annum by 2025, provided water space is available (Ernst and Young 2009). The caveat around the availability of water space is significant. Development over the years has been erratic and controversial; largely due to policy failings and community pressure. According to Banta and Gibbs (2006), 97 per cent of the declined permits for aquaculture development can be attributed to visual disamenity and navigation. Furthermore, Banta and Gibbs (2006) suggest that regulations imposed on aquaculture in the coastal zone are generally higher than those for land-based farms. If these barriers to development in the coastal environment are to prevail then opportunities exist for land-based (Mussley and Goodwin 2012) and open ocean aquaculture (Heasman et al. 2009). Expansion into the offshore waters of the EEZ would also minimize the impact of land based sources of pollution. Although investment and variable costs of operating an open ocean farm would be considerably higher, they might be partly offset by economies of scale.

4.8.6 Conclusion

Given the sound fundamental policy settings in place, particularly in wild capture fisheries, industry is recognizing the importance of science and applied technology. The challenge is to capture greater value from the sale of fish products from the EEZ and to promote the development of aquaculture in a sustainable way. Future prosperity might arise from higher value products for local consumption and export, and lower adverse impact on the environment.

4.9 Interpretation of results

A step forwards in measuring green growth and opportunities for better outcomes

This short assessment of New Zealand's relative environmental performance at whole economy level and for selected important traded sectors is at an end. There are no unambiguous champion green sectors, nor are there any very poor performers.

This is suggestive of generally good institutional and business management, coupled with relatively unambitious historic environment policy: conditions which provide the means and scope for improving future performance. Moreover, while some of NZ's natural assets are managed well compared with international peers, their contribution to the economy and wellbeing could be enhanced if their current value and contribution was better understood. The recent endorsement of the System of Environmental and Economic Accounts by the UN Statistical Commission provides an international standard for natural capital accounting upon which countries can draw.

The assessment has been innovative in finding ways to compare New Zealand's environmental performance with those of its export rivals on a sectoral basis, selecting sectors on grounds of revealed comparative advantage. Unfortunately, some of the most relevant existing data sets are aggregated to a level which quite substantially limits the insights that can be extracted. Nevertheless, the method and results take analysis in this field forward a step or two. The natural extensions would be to value the environmental impacts and to make comparisons on a less aggregated sub-sectoral basis if and when data become available.

The results reveal no 'green champion' sectors, that is, sectors which add a lot of value to New Zealand's economy while having comparative advantage and being well-positioned across the board on environmental performance relative to their rivals. Although some sectors have strong comparative advantage, they are not clearly leading in environmental performance. Similarly, no sector stands out as being 'not green' across all its main measurable impacts, relative to its rivals.

The dairy and beef sectors achieve relatively low emissions per animal compared with rivals. This could give New Zealand further competitive advantage if and when green growth policies place a value on emissions from New Zealand's and its rivals' production. The scale of benefit would increase with the pricing of emissions. The contingency of this benefit is important: it depends upon policy decisions outside New Zealand. Unlike dairy and beef, sheep production would not benefit from emissions pricing. New Zealand is among the most methane-intensive of producers and the whole of New Zealand's agriculture is a relatively intensive emitter of N_2O, another greenhouse gas.

On the other hand, if the value of water (embedded in traded goods) and the price of fertilizer were to increase globally, which is plausible, then New Zealand might not benefit relative to global rivals because its agricultural sector is particularly intensive in the consumption of fertilizer (which is priced internationally), while the abundance of its water might give it an advantage, even though it is an intensive water user. To realise this advantage over the medium term, NZ would need to improve its allocation of water resources so that these are used by those valuing them most highly. This is because competitiveness is a function of costs, and New Zealand’s low cost of water makes it more competitive in the farming of water-intensive produce.

The data on fishing and forestry make cross-country comparisons using good measures of sustainability difficult. However, even using the blunt indicators available, the data show that New Zealand exercises effective management control over its stocks and that some of its rivals operate in a profoundly unsustainable manner. The final section of this report turns from green growth opportunities in sectors which feature heavily in NZ’s exports to opportunities in sectors which are a less- or non-traded.

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5 Green growth opportunities in less- and non-traded sectors

Challenges and opportunities in the electricity, buildings and land transport sectors

Section Contents:

Previous sections of this report have focused on how NZ could benefit from global green growth through exporting goods and services. This part of the report focuses on opportunities for NZ from importing both new technologies and ideas to enhance green growth policies and outcomes in sectors in which trade is less important. Two of these sectors (land transport and residential buildings) are essentially 'non-traded' (although the inputs, such as vehicles and construction materials are traded). These have a critical influence on the quality and comfort of daily life, and can also have spillover benefits for exports. The third of these sectors, electricity, is mixed: NZ's electricity is produced entirely in NZ, but there are also opportunities for trade in the products and services that produce low-carbon electricity, such as wind turbines or solar cells. The case study covers both of domestic power and opportunities for trade in products and services.

Opportunities in this section include adapting 'smart grid' technology to upgrade the electricity grid in NZ and drawing on international experience in financing household energy efficiency to incentivise retrofits of NZ's existing inefficient residential building stock.

'Many governments and organisations see the electrification of the land transport fleet as an important strategy to reduce CO_2 emissions dramatically by 2050'

5.1 Electricity case study

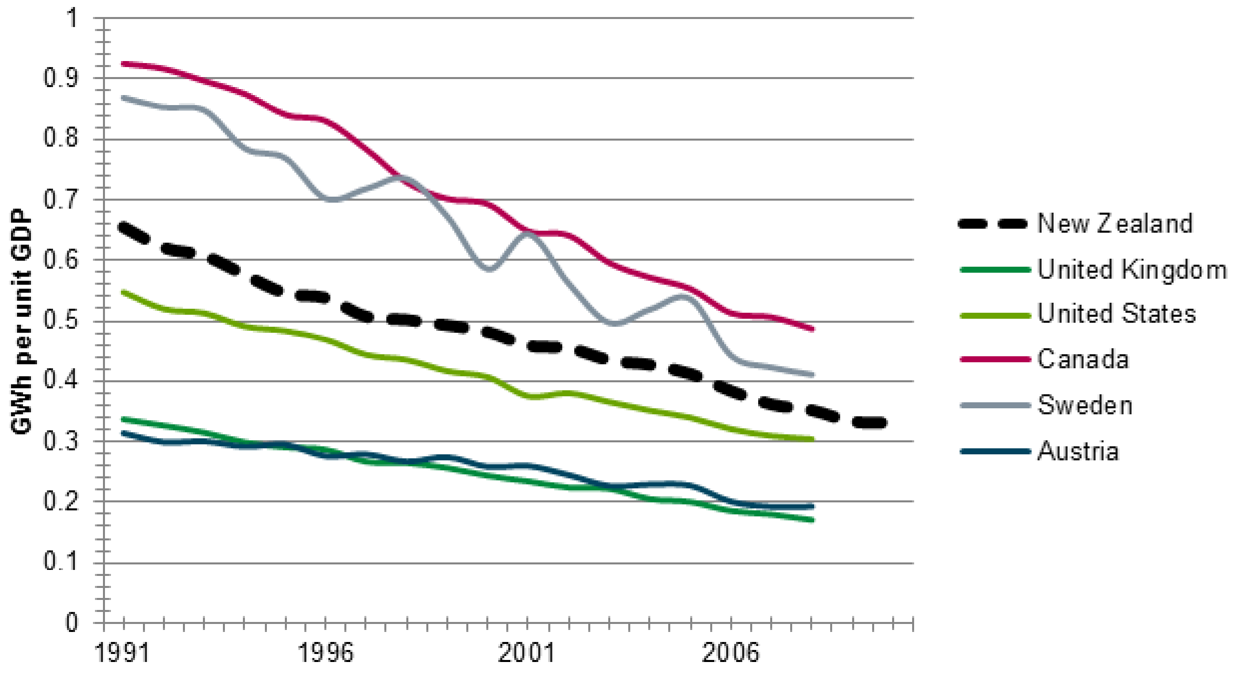
New Zealand has the opportunity to become a world leader in renewables

5.1.1 Introduction

The electricity sector is a significant component of New Zealand's GDP, around 2.5 per cent, and like the electricity sector across the world, it faces the challenge of decarbonisation. In this respect, New Zealand starts with an advantage: it is fortunate to be rich in low cost, low carbon sources of generation, including hydro, geothermal and wind. These already make up 74 per cent of New Zealand's total electricity generation (New Zealand Government 2011).

In addition to having low-carbon sources of power, in common with many other countries, NZ has been increasing the efficiency with which it uses electricity, producing more economic value from every unit of electrical energy. Figure 90 shows this pattern for a number of OECD countries (OECD 2010a). All show improving efficiency. Less can be said about absolute relative performance: the different climates and mix of industries make static cross country comparisons of performance more difficult. For example, Canada and Sweden have cold climates, which partly explain their high use of electricity per unit of GDP.

Figure 90. **Electricity use is becoming more efficient across a number of OECD countries**

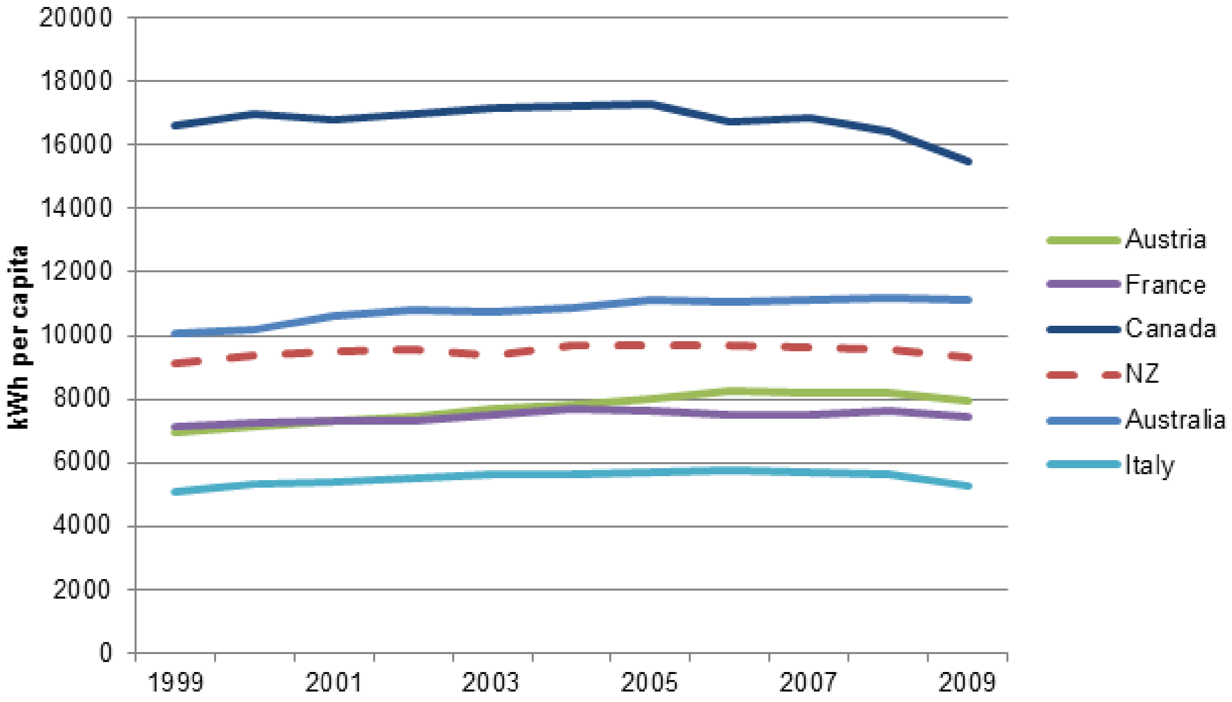


Note: GDP measured in US$

Source: OECD (2010)

Despite improving efficiency, absolute per capita electricity consumption is increasing, see Figure 91.

Figure 91. **Absolute energy use has stayed flat**

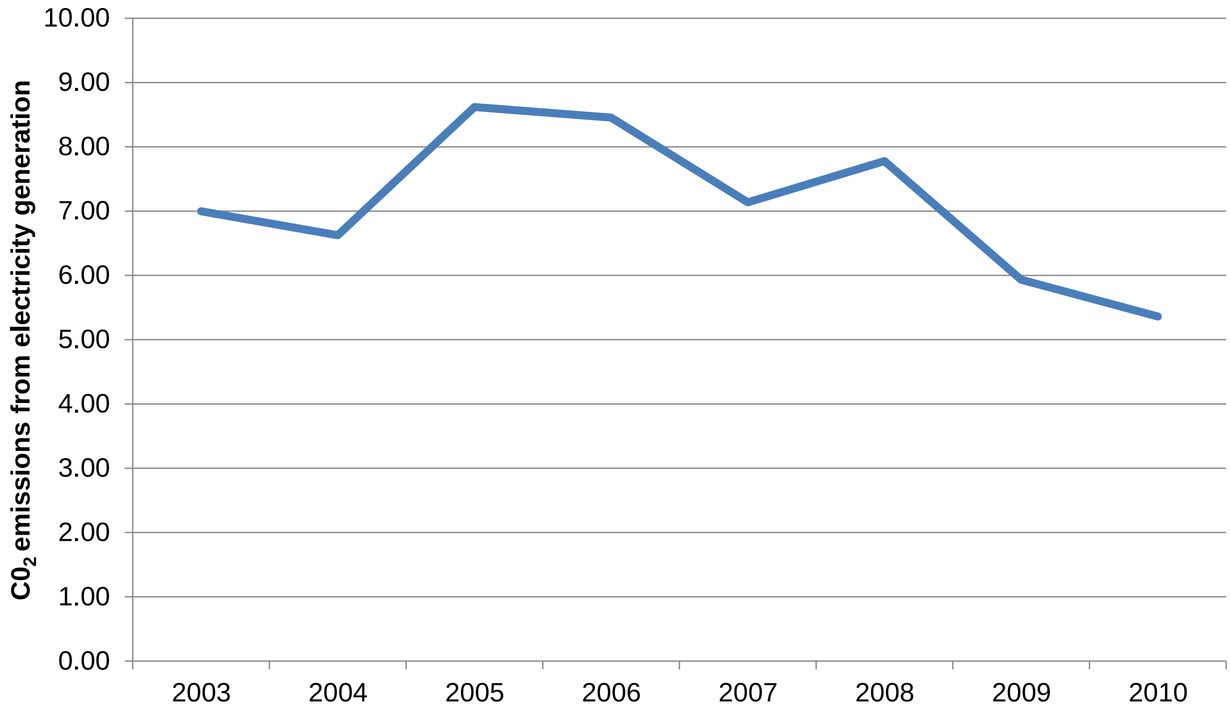


Source: World Bank (2012c)

Although most of the electricity generation is from renewable sources, the sector still contributes around 20 per cent of NZ non-agricultural gross emissions. The government aims to increase the proportion of electricity generation from renewable sources to 90 per cent by 2025 (New Zealand Ministry of Economic Development 2011).

New Zealand electricity generation is clean and green by international standards, and emissions are on a declining trajectory, see Figure 92.

Figure 92. **New Zealand's carbon emissions from electricity generation fluctuate year on year, but overall exhibit a downward trend**



Note: *$C0_2$ emissions measured in Mt*

Source: *Statistics New Zealand (2012b) and New Zealand Ministry for the Environment (2012)*

In addition to hydro power, New Zealand has significant geothermal and wind resources. The Wairakei geothermal development was the first in the world to generate electricity using geothermal liquid when it was first commissioned in 1958. Along with recent geothermal projects such as Te Mihi and Ngatamariki, New Zealand is now considered to be a leader within this niche form of electricity generation, alongside countries such as Chile and Germany.

Combined with the rapid uptake of wind generation in the last few years, 17 per cent of New Zealand's electricity generation was from geothermal and wind sources in 2010 which is an increase from 9 per cent in 2005 (New Zealand Ministry of Economic Development 2011). Forecasts show that there might be up to a six fold increase of wind generation alone in New Zealand, producing approximately 20 per cent of the country's electricity by 2030, which compares to five per cent of electricity generated from wind in 2012 (New Zealand Wind Energy Association 2012).

5.1.2 Towards a zero carbon electricity sector

Electricity demand is expected to grow on average by 1.8 per cent a year until 2020. From 2020 to 2040, demand is expected to grow more slowly at around 1.25 per cent a year (Electricity Commission 2009).

By the year 2025, the government hopes to see more than 90 per cent of electricity generation from renewable sources, and to expand capacity to meet annual electricity demand of 51 TWh, an increase of 20 per cent from today. In 2010, the Electricity Authority published its statement of opportunities. The report considers five main scenarios and models generation expansion for each until 2040. Depending on the relative prices of gas, coal prices and carbon charges, differing mixes of renewable and thermal generation emerge. Under the most rapid growth scenario for renewable energy generation, CO_2 emissions fall from 6.5 million tonnes a year to 4 million tonnes in 2025. In contrast, under the coal scenario, shown in Figure 93, there is more thermal generation, assuming a low carbon charge of $20 per tonne and considerable gas availability after 2030. In 2025, CO_2 emissions have almost doubled to 12 million tonnes a year, and by 2040 41 per cent of total electricity generation is from fossil fuels. The only scenario which comes close to delivering the government's aim of 90 per cent generation from renewable by 2025 is the 'sustainable path' scenario. By 2040 no scenario achieves more than 90 per cent of electricity generation from renewables, see Table 20.

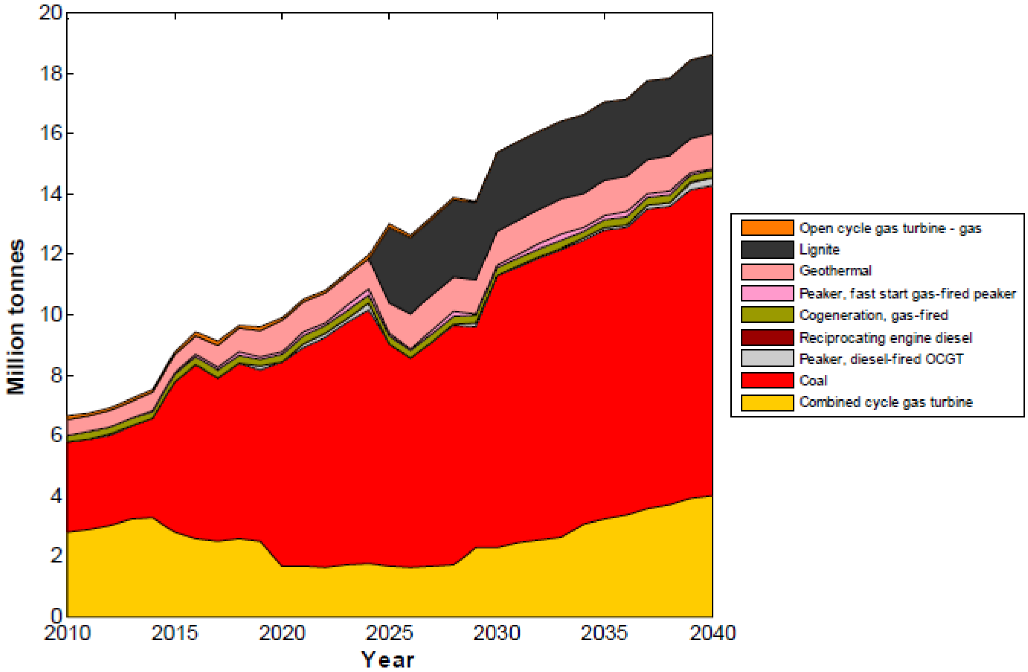
Table 20. **The sustainable path scenario is the only one which comes close to fulfilling government targets**

Scenario	Renewable share of generation in 2040, per cent
Sustainable Pate	85
SI Wind	83
Medium Renewable	74
Coal	59
High Gas Discovery	61

Note: *the left hand side shows possible scenarios for the future of NZ electricity generation*

Source: *Electricity Commission (2010)*

Figure 93. **If power generation continues to rely on coal, carbon emissions will greatly increase over the next 30 years**



Note: *The chart shows predicted emissions from power generation under the electricity commission's 'coal' scenario.*

Source: *Electricity Commission (2010)*

As well as the target for renewable electricity generation by 2025, the government has advertised its intention to reduce New Zealand CO_2 emissions by 50 per cent by 2050. The New Zealand Ministry for the Environment (2011) states that 'the Government's main policy tool to reduce emissions is an Emissions Trading Scheme (NZ ETS) that puts a price on greenhouse gas emissions.' The NZ ETS is an intensity-based scheme and does not have a strict cap. New producers are eligible to free credits. Furthermore, the price of carbon is currently capped at $25 per tonne. Currently only one credit needs to be surrendered for every two tonnes of carbon emitted which means the carbon price is effectively capped at $12.50 a tonne.

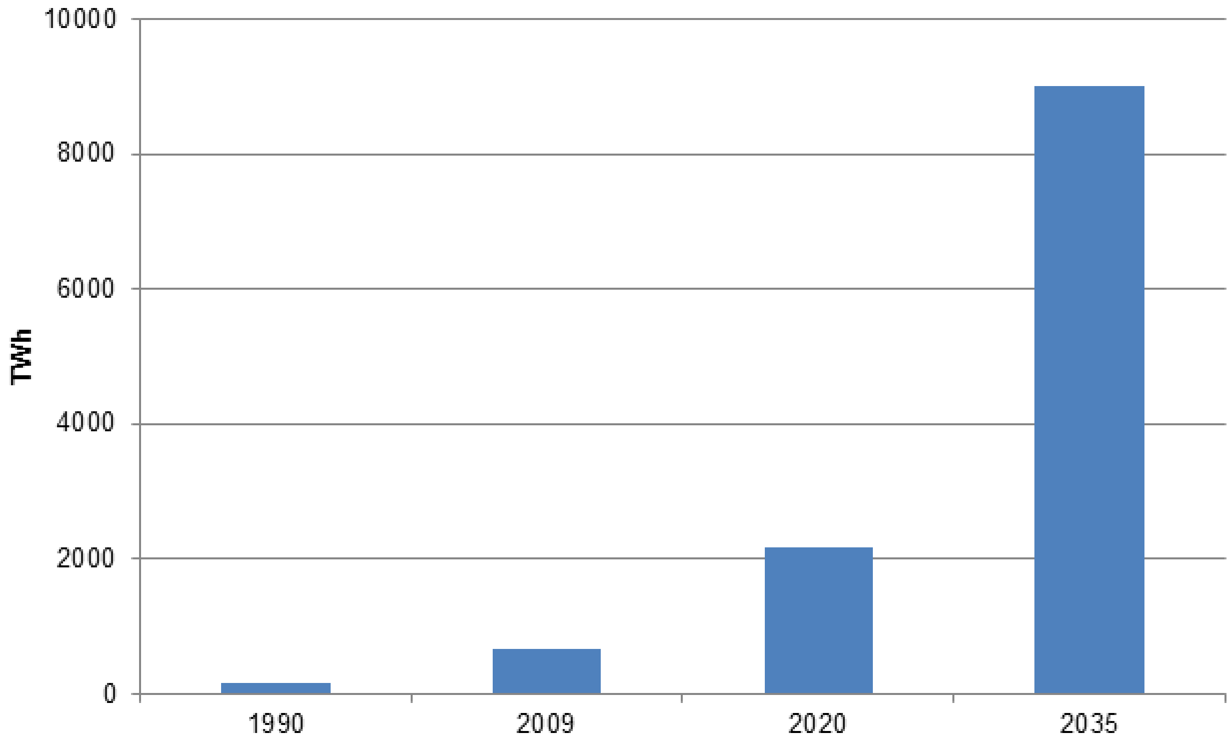
The analysis presented in the statement of opportunities report suggests that significantly higher carbon prices than this would be needed to achieve the government's targets. Indeed, Covec (2011) analysed the impact of the NZ ETS on electricity prices and generation mix and found no statistically significant change in either. Many of the scenarios developed here see significant amounts of thermal plant built over the next decade or two driven partly by low carbon prices. These plants have a working life of 30 to 40 years. The European ETS has a cap which is declining so that by 2020 emissions will be 21 per cent below 2005 levels. However, recent years has seen a low carbon price, due to oversupply caused by over-allocation, the recession and the impact of the EU renewable energy directive. The UK government has decided that the future carbon price generated by the EU ETS is too low and uncertain and hence does not sufficiently encourage investment in low carbon electricity generation. Thus, as will be discussed further below, it has mandated a rising price path for carbon in the electricity sector. Likewise a clear commitment by New

Zealand government of an increasing price on carbon over the coming decades would change expectations and investment decisions considerably in favour of renewable generation.

5.1.3 Global situation

The electricity sector has an important part to play in the drive towards reducing CO_2 emission worldwide. For example the International Energy Agency 450 ppm scenario envisages that by 2035, 28 per cent of the world electricity supply might be from renewables. The main sources would be solar PV, wind and biomass. The dramatic growth path in non-hydro renewable electricity generation envisaged by the IEA is illustrated in Figure 94.

Figure 94. **Much more energy could be generated by renewable, according to the IEA**

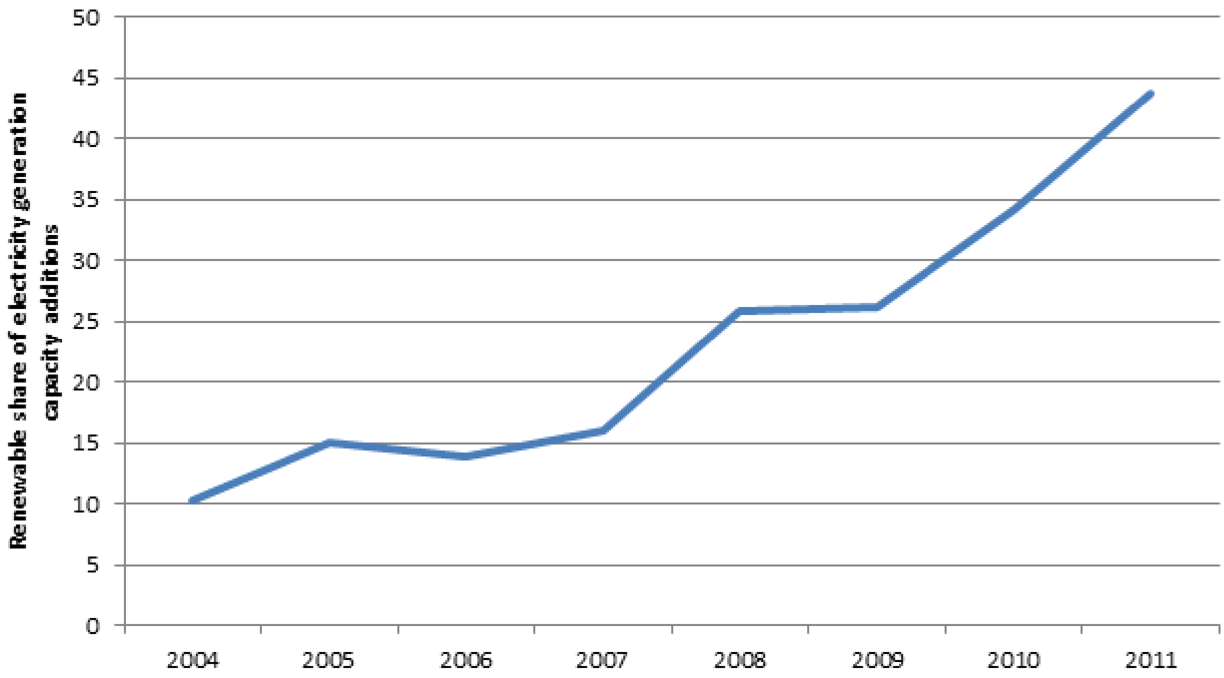


Note: The chart shows the expected level of total renewable energy generation under IEA '450 ppm' scenario.

Source: International Energy Agency (2011)

Last year, world investment in renewable electricity (excluding hydro) capacity was $240 billion, higher than the total for thermal plants of $220 billion, but the power generated would have been much smaller. Forty-four per cent of new generation capacity added last year was renewable compared to 34 per cent for the year before. With the price of solar photovoltaics decreasing and favourable feed in tariffs the amount of investment in solar photovoltaics increased by 54 per cent to $147 billion, outstripping the $84 billion investment in new wind generation (Bloomberg New Energy Finance and UNEP 2011). Figure 95 illustrates the remarkable increase in the share of generation additions each year for renewables.

Figure 95. **Renewables are becoming an increasingly important source of increased capacity**



Source: Bloomberg New Energy Finance and UNEP (2011)

Electric cars, using electricity from renewable sources, might play a key part in the move towards a low carbon transport sector in the future. Full commercial deployment is still some way off, with further investment needed in battery technology to increase the driving range and to decrease the vehicle weight and cost (Smith School of Enterprise and the Environment 2010). None the less, technology is evolving fast. Many manufacturers are rolling out electric cars in small volumes and some research effort is being devoted to establish alternatives to the existing frontier technology: the lithium ion battery. One of the most promising technologies is the lithium air battery, with a leading researcher at IBM suggesting that they these could be commercially available between 2020 and 2030 and that by 2030 'at least 20 per cent of the cars in the US will be electric'.

Many governments and organisations see the electrification of the land transport fleet as an important strategy to reduce CO_2 emissions dramatically by 2050. For example, the UK government's 2050 Pathways Analysis develops four scenarios in the transport sector. The most pessimistic sees 22 per cent of all car and van travel in 2050 as either plug in hybrid or electric vehicles. The most optimistic sees electrification of the whole fleet by 2050 (DECC 2010).

One of the key pieces of infrastructure which would enable integration of increasing amounts of intermittent renewable generation and intermittent demand such as electric vehicle charging is the smart grid (International Energy Agency 2011a).

Although much of the smart grid technology is still at the research, development and early implementation stages, depending on the jurisdiction, it is already a significant market in its own right. Smart Grid Australia

(2012) reported recently that 'the global Smart Grid market has experienced double-digit growth rates over the last five years and is expected to continue its growth momentum, reaching approximately US$57 billion by 2016 with a CAGR of 13 per cent over the next five years. Utilities worldwide will collectively invest more than US$380 billion in building electricity Smart Grids by 2030'

For the US, Joskow (2012) reports that since 2009 the US government has invested US$4.5 billion in smart grid demonstration and deployment projects with a further US$5.5 billion in matching funds from electricity firms and their customers.

China has mapped out plans for a pilot smart grid programme which leads to full scale deployment by 2030. By 2020 smart grid investments amount to over US$96 billion (International Energy Agency 2011a). Meanwhile, South Korea has announced plans to roll out a smart grid by 2030 (International Energy Agency 2011a). It is investing US$65 million to establish a smart grid test-bed in the Jeju Island. The European Union also has ambitious plans to roll out a smart grid by 2030 (European Commission 2006). Closer to home, the Australian government has invested AUS$100 million for the Smartgrid/SmartCity project involving 10,000 households.

The European Union is committed to developing an EU smart grid establishing the European Technology Platform for Electricity Markets in 2005. A research and development, deployment and implementation plan has been developed at an estimated cost of €2 billion excluding deployment 'to enable the distribution of up to 35 per cent of electricity from dispersed and concentrated renewable sources by 2020' (Smart Grids ERA-net).

5.1.4 Green growth opportunities

New Zealand might become one of the leaders in selected clean-energy electricity generation. For electricity, New Zealand has significant renewable electricity generation potential, in particular, geothermal potential and a smaller amount of hydro. Table 21 breaks down the estimated potential new electricity generation of 26,100 GWh per year up to 2030 (New Zealand Ministry of Economic Development 2007). This compares to the expected increase in demand of around 12,400 GWh. As well as potential hydro, geothermal and wind sources, New Zealand also has significant marine energy potential. Power Projects (2008) was commissioned by the Electricity Authority, the Energy Efficiency and Conservation Authority and the greater Wellington Council to investigate the potential for Wave and Tidal Energy in New Zealand. Their assessment was that approximately 7,000 MW of electricity could be generated from wave energy and a further 500 MW from tidal energy, with the crucial caveat only if the costs fall sufficiently. Current estimates for electricity generated from wave energy are approximately $300 per MWh although this is expected to reduce somewhat as the technology develops. As a result, in wind, the long run marginal cost of wind generation has fallen to NZ$60 to NZ$95 per MWh which the wind energy association claims actively competes with fossil fuels such as gas (New Zealand Wind Energy Association 2012).

Table 21. **Renewables in NZ have the potential to generate an additional 26,000 GWh per year**

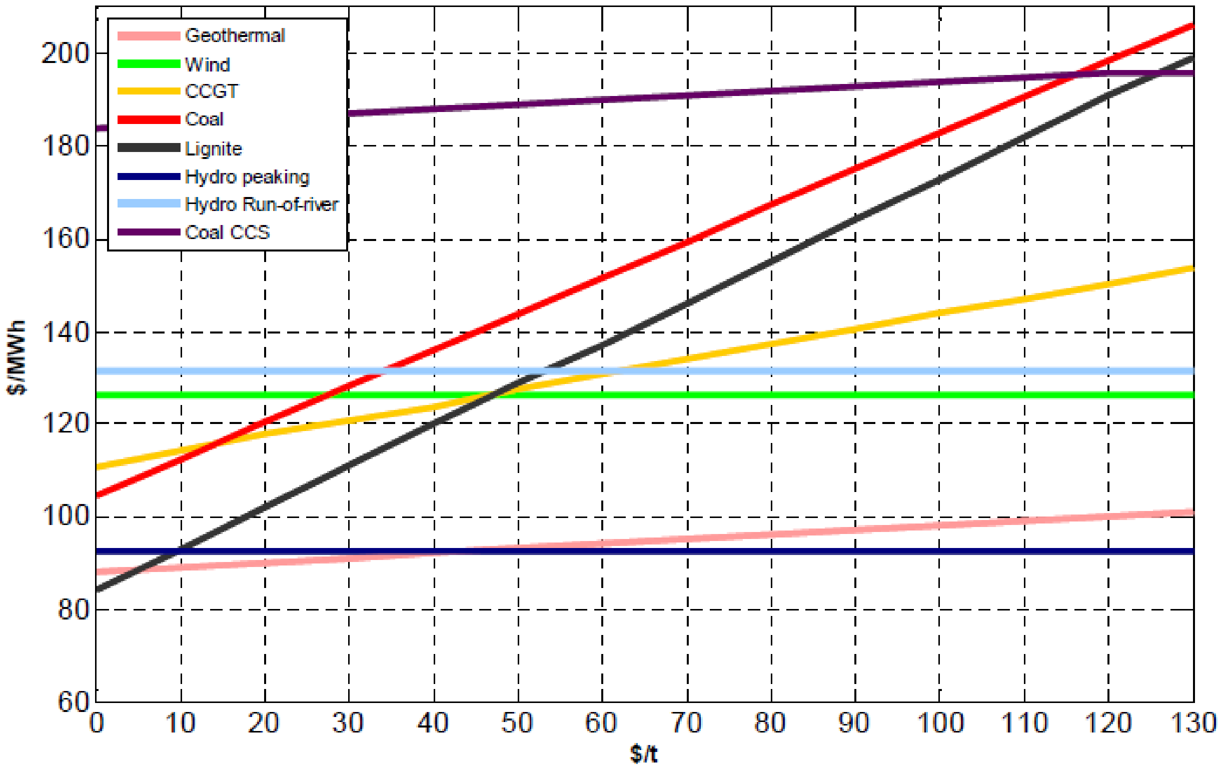
Primary energy source	Energy supplied, 2005 (GWh/yr)	Economic potential (GWh/yr)
Hydro	23,237	5,800
Geothermal	2,693	11,100
Wind	610	9,200
Total	26,540	26,100

Note: *The economic potential includes any prospective generation projects believed to be capable of development at a cost of less than 9c/kWh.*

Source: *New Zealand Ministry of Economic Development (2007)*

Figure 96 illustrates results from a model of long run marginal costs for several kinds of electricity generation. It shows how sensitive the thermal options are to the price of carbon, illustrating that an essential first step to ensure a reasonable mix of renewable generation is to have a high enough price for carbon, for example, of at least $60 per tonne.

Figure 96. **Renewable generation is less costly than coal generation once the price of carbon reaches $40 per tonne**



Note: Each line shows estimates of the long-run electricity generation costs as a function of the price of carbon.

Source: Electricity Commission (2010)

One of the key constraints in this model, known as the Generation Expansion Model (GEM) (Electricity Commission 2010), is that wind penetration is limited to 20 per cent of total capacity. The reason for this is that wind supply is interruptible, which limits its usefulness as provision has to be made for days when there is no wind. None the less, the long run marginal cost of wind may become competitive in New Zealand if the price of carbon is upwards of $50 per tonne (Electricity Commission 2010). As well as wind energy, there is potential for other renewables such as wave, tidal and solar to contribute to the mix. All these generate intermittent supply, so their output may have to be stored at certain times, and there would be costs involved. One advantage of a smart grid is that it might be to accommodate intermittent generation at a lower cost. The value of this functionality is uncertain.

5.1.5 An opportunity

The argument above is that New Zealand could develop a low carbon electricity sector with the government publicly committing to an ambitious 90 per cent target by 2025. It is likely, however, that in the absence of a strong commitment to an increasing price of carbon, NZ will not achieve the target. This is because, in the absence of high carbon prices, thermal generation is commercially more attractive. While it would be better to have a uniform price on carbon across the economy, the politics is difficult. One option, although less efficient, is to treat the power generation sector independently. The UK government has announced an intention to have a minimum price on carbon in the power generation sector which increases every year. If the EU carbon price is lower than the price floor, a carbon tax is imposed to achieve the target. Such a policy is certainly considering in the New Zealand context as a way to achieve lower carbon emissions. It might cause a shift towards gas-fired generation, and possibly nuclear power or renewables.

A credible commitment to low carbon electricity, although difficult to formulate, could stimulate innovation. As well as price certainty and a strong government commitment to a low carbon economy it would need strong research and development support, and might also require equity participation by the government.

As will be seen below there are a number of niche areas where New Zealand has natural resources and expertise which could lead, with the right policies, to economic growth opportunities.

5.1.6 Towards a smart grid

A smart grid would optimise the way the electricity transmission and distribution network operates through real time management and monitoring and the automatic response to changes on the grid using artificial intelligence. Among domestic consumers, smart meters would receive and transmit information and mange load in response to price changes via demand response (DR) management systems and market DR aggregators. An example is managing electric car charging, so that it takes place overnight when prices are low or during times when significant amounts of intermittent renewable energy is dispatched. Benefits might include: a more efficient electricity system, smoothing the load profile over the course of the day; a more reliable system which can respond automatically to grid conditions and correct for events such as major system outages; less line congestion; more efficient integration of distributed generation; the efficient management of intermittent supply; greater capability to manage intermittent demand increases. Examples include: air-conditioning systems, heating and cooking, and in the future, electric vehicle charging.

The Electric Power Research Institute (2011) defines a smart grid as:

> *'the modernization of the electricity delivery system so that it monitors, protects, and automatically optimizes the operation of its interconnected elements—from the central and distributed generator through the high-voltage transmission network and the distribution system, to industrial users and building automation systems, to energy storage installations, and to end-use consumers, and their thermostats, electric vehicles, appliances, and other household devices'*

Electric Power Research Institute (2011) contrasts the current top down network of:

> *'a large central-station generation connected by a high voltage network or Grid to local electric distribution systems which, in turn, serve homes, business and industry. In today's power system, electricity flows predominantly in one direction using mechanical controls'*

with a smart grid governed by distributed intelligence and two way communication. As well as large central power stations the smart grid:

> *'includes a substantial number of installations of electric energy storage and of renewable energy generation facilities, both at the bulk power system level and distributed throughout. In addition, the Smart Grid has greatly enhanced sensory and control capability configured to accommodate these distributed resources as well as electric vehicles, direct consumer participation in energy management and efficient communicating appliances'*

Electric Power Research Institute (2011) estimates the cost of rolling out a smart grid over the next 20 years in the US at around $338 to $476 billion with accumulated benefits of between $1,294 billion to $2,028 billion with the benefit to cost ratio of somewhere between 2.8 to 6. The population of the US is around 100 times that of NZ so a simplistic calculation for NZ based on these figures and the current exchange rate would see costs of $NZ3.4–5.5 billion with benefits of $15-$23 billion over the next 20 years.

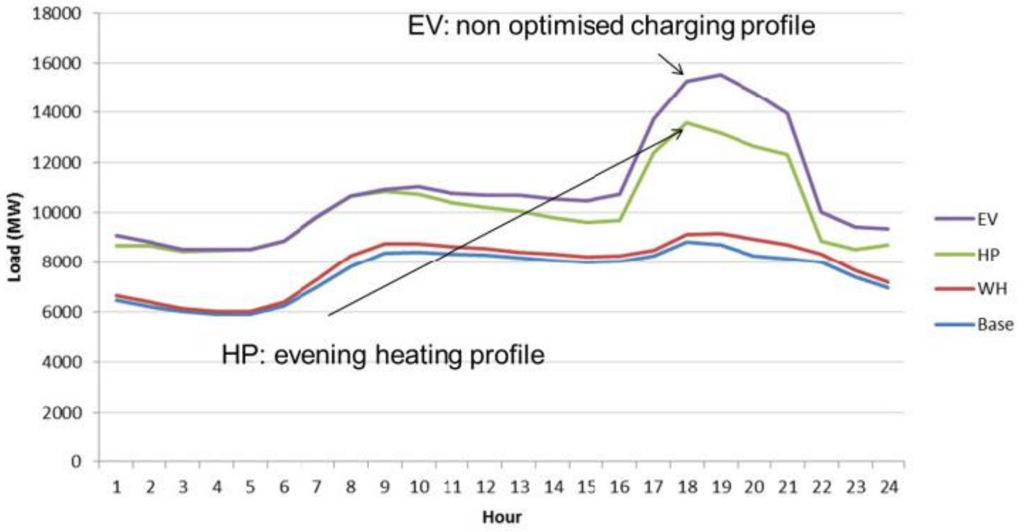
The International Energy Agency (2011) believes that smart grids are an essential component in the move towards low carbon technologies:

> *'Smart Grids are required to enable the use of a range of low carbon technologies, such as variable renewable resources and electric vehicles, and to address current concerns with the electricity system infrastructure, such as meeting peak demand with an ageing infrastructure'*

Meridian (2012) has released a study into the costs and benefits of a smart grid for NZ. The authors of the report include teams from Meridian and Imperial College, London. Their central scenario assumes that, by 2050, 70 per cent of the car fleet is electric vehicles (EVs) with a high uptake of electric pumps (HPs) which increase peak load on a cold winter's day in 2050 from around 9 GW to 15 GW, as shown in Figure 97. The smart grid would smooth the load profile by pre heating houses before people come home from work and ensuring that the electric vehicles charge overnight and during the day rather than when plugged in during the evening. The report also assumes a high amount of wind generation.

The study estimates accumulated benefits of $3.6 billion by 2030 and $10.7 billion by 2050, which is similar in magnitude to estimates obtained by using the Electric Power Research Institute (2011) study and adjusting for the different size of the US and NZ markets. The report does not estimate the costs explicitly however they do state that 'such costs are expected to be an order of magnitude lower than the benefits available.'

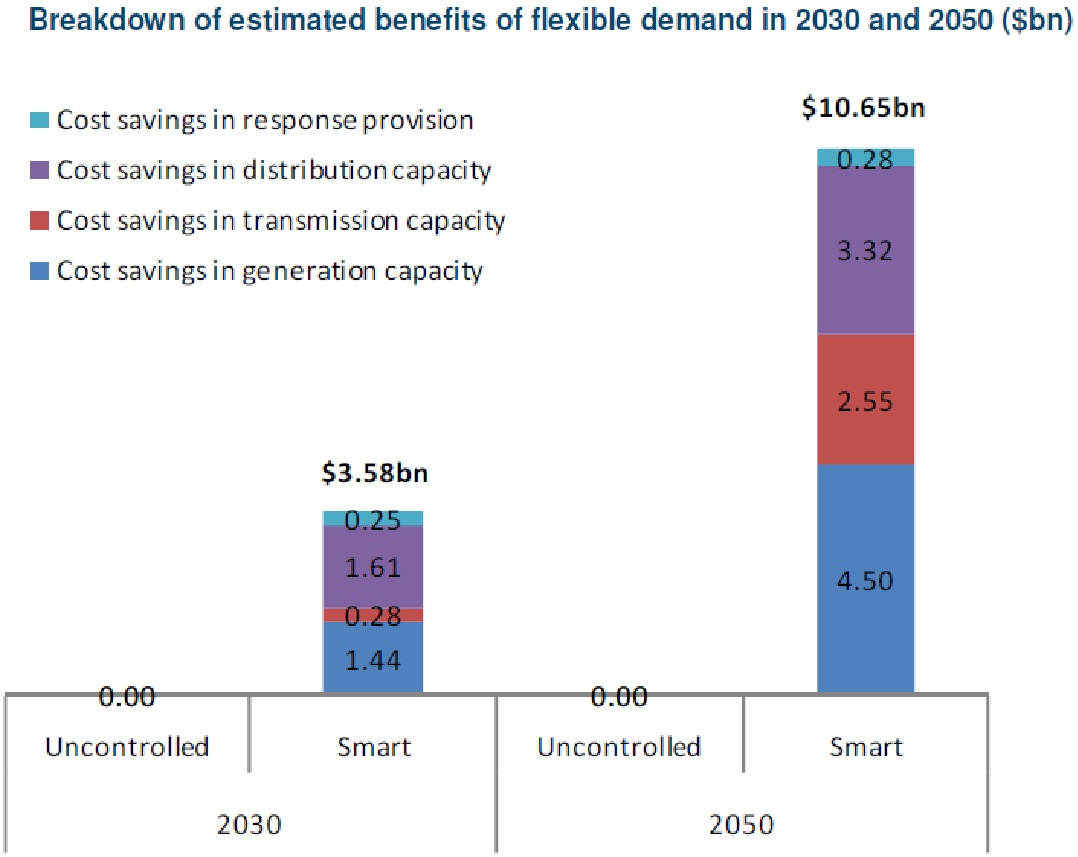
Figure 97. **Increased use of electric vehicles might lead to larger fluctuations in energy use**



Note: *The chart shows the predicted load on power network assuming that heat pump and electric vehicle energy use is not optimized.*

Source: *Meridian (2012)*

Figure 98. **A smart grid might lead to large savings in distribution, transmission and generation costs**



Source: Meridian (2012)

5.1.7 A smart grid for NZ

New smart grid systems require expertise in information technology, power electronics, artificial intelligence, and experience in managing large amounts of intermittent renewable energy generation, and variable demand. Wind generation is expected to increase dramatically in NZ over the next decade (Electricity Commission 2010). There is existing expertise in New Zealand with a number of research groups working in this area. For example, in the engineering faculty at the University of Auckland there are three active groups in the electricity space including smart grids: industrial informatics and automation, power electronics, and power systems. Significant smart grid experience also exists inside Transpower NZ Limited's system operator, which has expertise in a number of smart grid areas such as innovative consumer demand response systems, energy management and wholesale market management systems and the deployment of innovative power electronic technologies such as reactive power controllers and static synchronous compensators.

The International Energy Agency (2011) argues that 'Smart Grid technologies offer ways ... to develop a cleaner energy supply that is more energy-efficient, more affordable and more sustainable.' As well as having significant wind resources, the New Zealand coast has a huge amounts of wave energy which might be used to generate electricity as well as some tidal resources. The cost of solar power is rapidly decreasing and may well be part of the mix as the costs of these technologies reduce. All of these sources of renewable energy are intermittent and hard to manage using existing infrastructure. There is an argument that New Zealand has some advantages when it comes to implementing a smart grid and that it should attempt to develop leading expertise in developing and implementing a smart grid. For example, the chair of the NZ smart grid conference Paul Bunde (2010) writes:

> *'New Zealand could take its place among the Smart Grid leaders. Smart Grids are hugely complex and the bigger the country the more complex is the solution. The rather short decision-making lines in New Zealand and its relatively small size could turn that country into an international Smart Grid demonstration site on a national level... This would have significant economic export benefits...'*

Transpower is actively rolling out programs such as demand side management which could become key components of a smart grid. Furthermore, it is world leader in the use of user friendly displays to identify discrepancies and trends in the network, known as visualisation technology. In a recent publication it states (Transpower 2010):

> *'an early opportunity for New Zealand is to achieve the benefit of a more intelligent and integrated grid. This requires the use of smart control technologies to support a growing portfolio of variable renewable generation without massive increases in grid capacity. Achieving this is more than a technical challenge – it will require close co-operation across the industry to realise its benefit to customers'*

The smart grid presents New Zealand with an opportunity to fully utilise its renewable resources and become one of the first countries in the world to generate all of its electricity using low carbon generation technology **(green growth opportunity 6)**. Industry and government could design a roadmap on the installation of a smart grid in NZ, drawing on the IEA's technology roadmap for smart grids and its near-term actions for business and government (IEA 2011a). In particular, NZ could consider government-industry demonstration projects such as the 'Smart Grid, Smart City' project in Australia, which would gather information about the benefits and costs of smart grid technologies in an NZ context.

5.1.8 NZ clean energy potential

As argued above, the worldwide renewable energy industry is already large and is growing fast. New Zealand is well placed to capitalise on developments in this area. Here, the potential of a few key subsectors is briefly examined with some examples of New Zealand companies.

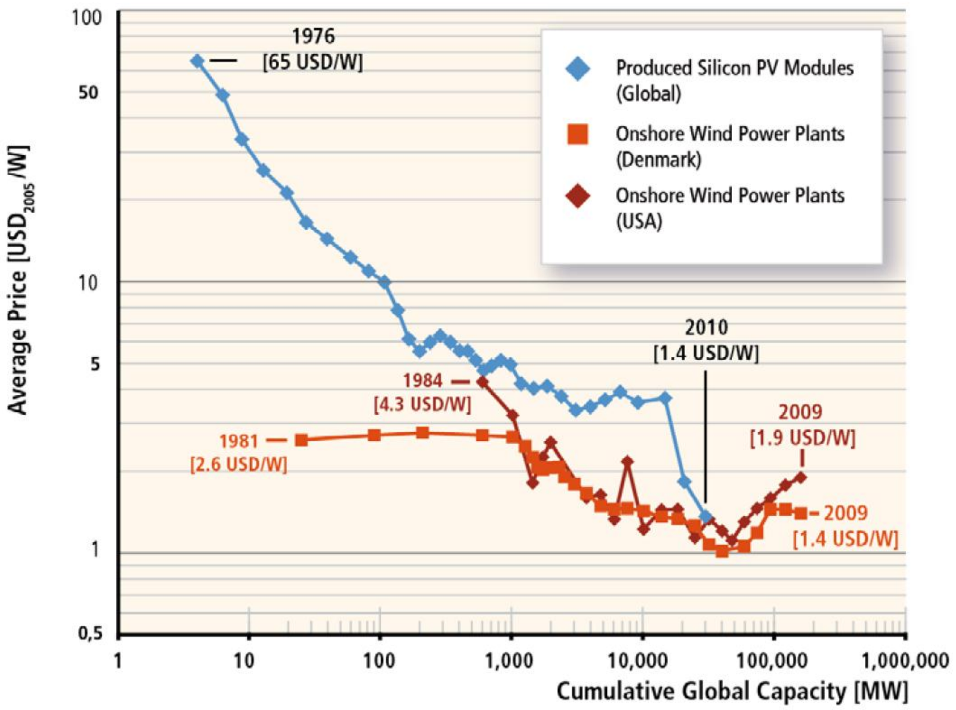
Solar

The price of solar energy is steadily decreasing, as illustrated in Figure 99 (IPCC 2011). Cost has fallen by about 20 per cent each time installed capacity is doubled in the recent past. By 2020, the IEA expects average costs of production to be between US$116 to US$232/MWh for residential systems depending on the location. In Auckland, the residential retail price is currently around $250 per MWh (US$200)

(Powerswitch). Furthermore, prices are likely to increase over the coming decades (Electricity Commission 2010). Thus depending on location solar photovoltaics are likely to be cheape4r than the residential tariff, making it economic to install solar PV on houses. Solar hot water heating also has a positive economic return.

Currently there is little incentive for distributed generation. For example, there is no legislated rate for feeding residential renewable power back into the grid. The Energy Efficiency and Conservation Authority (2008) analysed the costs and benefits of increasing DG penetration rates. They claim that net economic operating costs reduce by between 5 per cent and 25 per cent as DG penetration increases from 10 per cent to 50 per cent of load.

Figure 99. **The cost of solar power has decreased over recent decades**



Source: IPCC (2011)

If the IEA projections are correct it suggests that encouraging PV roof top installation in suitable areas is a green growth solution for New Zealand electricity generation. Customers would benefit from cheaper power, the electricity network would be more efficient, and NZ greenhouse gas emissions would be reduced. However, numerous studies have shown that upfront costs are a barrier to uptake even if there if the present value of reduced electricity payments is higher than the capital cost of installation IEA (2007). Appropriate financial instruments could facilitate uptake, perhaps, for example, where the upfront cost is paid for by a financial institution or the government with repayments made from the money saved by having reduced power bills. There is also a clear need for transparent rules surrounding grid connection and feed in tariffs.

Solarcity is a good example of a NZ company in this space. It is collaborating with 32 councils to put in place $100 million of financing for Solar Saver schemes which work in the way described above. The company provides services ‘ranging from design, product development and manufacturing to financing, installation, service and remote monitoring.’(Solarcity 2011) Currently the company employs over 400 people in New Zealand and expect this to double over the next year or so.(Solarcity 2011)

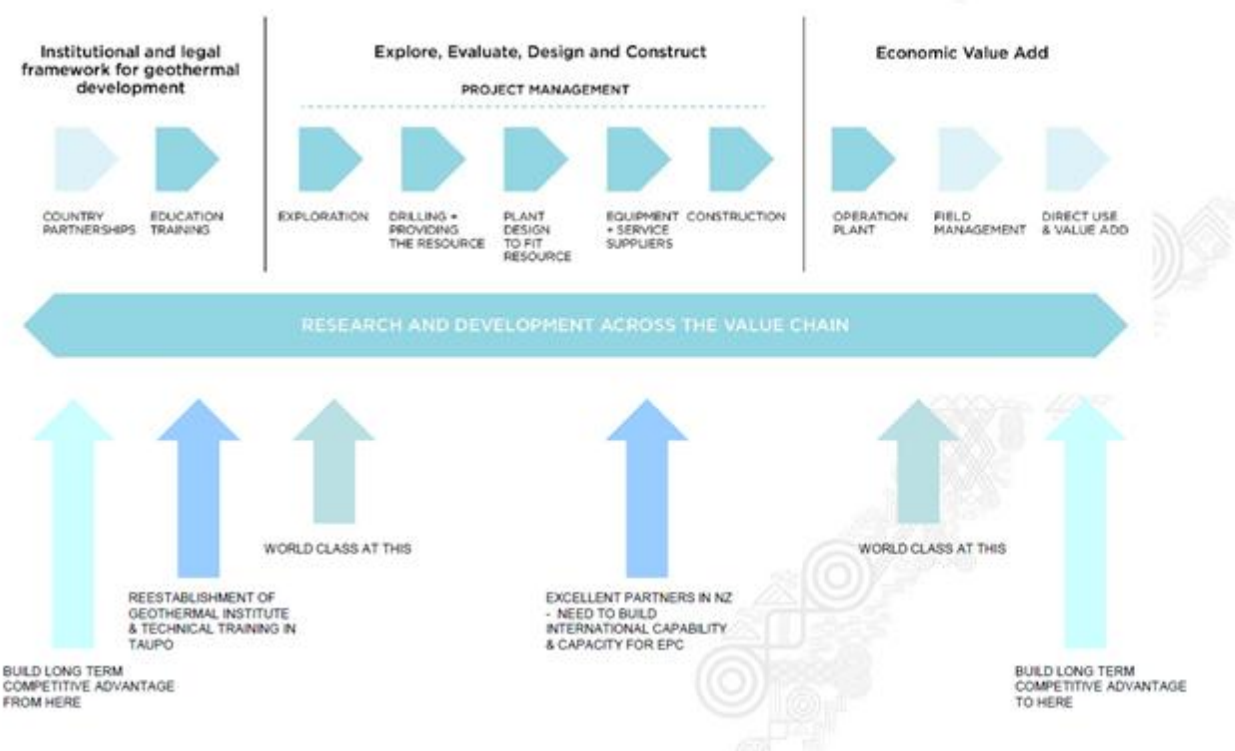
Geothermal

New Zealand was one of the first countries in the world to build large scale geothermal plants which currently contribute around 13 per cent of NZs electricity generation. Existing capacity is 730 MW. Another 270 MW is under construction with a further 300 MW consented with construction likely to start before 2015 (New Zealand Geothermal Institute 2012). Total potential generation is estimated to be at least 1600 MW (URS 2010). Worldwide, geothermal generation is increasing rapidly. Last year total investments worldwide were approximately $2 billion with growth since 2004 averaging 12 per cent per annum. New Zealand companies are at the cutting edge of developments in this area. Companies such as SKM, Hawkins, Mighty River Power and Becca are all active in geothermal developments around the world (New Zealand Trade and Enterprise 2012). URS (2010) report that SKM are world leaders in geothermal energy and have ‘worked on more than 100 geothermal resources in over 20 countries – engineering more than 25 per cent of the world’s 10,000 MW of geothermal power generation’.

New technologies are being developed to use low temperature geothermal resources for electricity generation. There is also research and development underway to develop hot rock technology, where water is pumped down to a hot layer three to five kilometres down. URS (2010) suggest that ‘the thin earth mantle under NZ, particularly north of Taupo could be a future source of energy’.

Worldwide the potential geothermal electricity production potential has been estimated in a recent IPCC publication (IPCC 2011) to be 117.5 EJ per year (4122 GW) down to a depth of three kilometres. Comparing this with current generation capacity indicates that there is substantial room for expansion. If the current growth rate continues to 2025 worldwide investment will be around $10 billion each year. New Zealand Trade and Enterprise has initiated a collaborative industry project (Geothermal NZ) with the aim of enabling NZ companies "tooffer their services in a much broader role within large scale international developments" (New Zealand Trade and Enterprise 2011b). New Zealand is well placed to achieve significant export income through Geothermal NZ initiatives, as illustrated in Figure 100.

Figure 100. **NZ could profit from exporting expertise in geothermal electricity generation**



Source: Mulcare (2011)

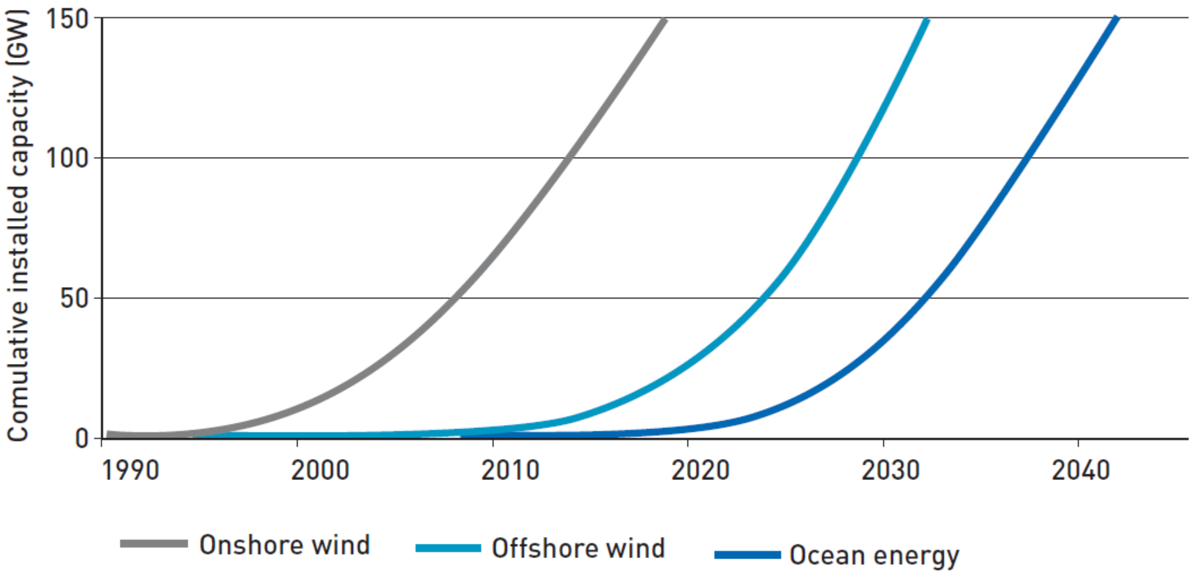
Marine energy

New Zealand has the potential to generate up to 8,000 MW from marine energy, with the majority from wave energy. NZ wave energy resources are world class: our long narrow coastline cuts directly across the roaring forties wind which generate significant amounts of wave energy. There are also some useful tidal resources with up to 500 MW of generation potentially available. Despite the technology for using wave energy to generate electricity being very much in the research and development phase, there is plenty of activity with over 20 marine energy projects proposed or underway (URS 2010). Recently, Industrial Research Ltd (IRL) announced a successful trial of a quarter size machine (IRL 2011). In March 2011, it announced that a joint venture with North West Energy Innovations to produce a half-size device. IRL predicts future sales will be worth hundreds of millions of dollars. Deputy CEO Drew Stein stated in press release (IRL 2011):

> *'the wave energy converter technology is protected by international patent applications …. IRL is anticipating all design, control and hydraulic components will be manufactured by New Zealand companies and exported around the world. Demand for clean, green energy has never been more economically important nor in more demand and therefore there is a ready-made market for this type of electricity generating device'*

Whilst it is far from certain that the venture will prove commercially successful it does illustrate that NZ is at the forefront of R&D in this area and that there are potential opportunities. IRL is establishing projects such as these through Wave Energy Technology which is a collaboration programme run by Industrial Research Limited and Power Projects Limited, a privately owned Wellington-based company. Recently they announced plans to test a half-scale prototype off the coast of Wellington with funding from ECCA (Wave Energy Technology New Zealand 2012). In Australia, Hayward and Osman (2011), using data from around the world, estimated levelised costs as low as AUS$100 per MWh for favourable sites in Australia and New Zealand.[42] CSIRO also reports that a wave farm is being constructed off the coast of Victoria with the aid of an AUS$66 million government grant. The International Energy Agency (2010) expects strong growth in the sector starting from about 2020 with installed capacity eventually comparable to onshore and offshore wind as illustrated in Figure 101.

*Figure 101.***Strong growth in ocean energy should eventually lead to capacity comparable with wind**



Source: International Energy Agency (2010)

Electric car technology

As discussed in the transport case study (section 5.3), electric car technology, particularly battery technology, is improving continuously. It is expected that by 2030 somewhere between 10 per cent and 45 per cent of the car fleet will be electric- which will increase to between 40 per cent and 100 per cent by 2050 (Meridian 2012). As described above a smart grid can manage electric vehicle charging to smooth load and better integrate renewable generation. The combination of a high fraction of the fleet being electric with the electricity being generated from renewable sources helps move NZ towards a clean tech low carbon transport sector (section 5.3). The case study also suggested that there is an economic case to advance the

[42] This put it at around 20-30 per cent higher than the levelised costs for wind and geothermal in New Zealand.

uptake of electric vehicles by increasing the subsidy they receive to a level seen in many other countries. Early uptake combined with a smart grid and fast development of a renewable electricity generation would put New Zealand in a strong position as a benchmark low carbon economy.

The worldwide electric car market is projected to grow strongly. New Zealand is in no position to compete as a mass producer of electric cars, however there is potential for being major players in small niche component markets. There is already significant activity in this area, and the wider electricity sector, which suggests that increased R&D, development of research and industry clusters combined with an innovation policy directly targeted at the sector could yield positive results.

One example of this is a group at the Electrical Engineering department at the University of Auckland is a world leader in inductive power transfer technology which allows power to be delivered to stationary or moving electric devices without direct electrical contact. Applications include wireless charging of electric cars. Licensed industrial partners include Daifuku in Japan for clean room applications (75 per cent of the world market), Conductx-Wampfler AG in Germany for car plant assembly plants, and Power by Proxi for instrumentation applications. The figure below illustrates an application (University of Auckland).

*Figure 102.***Inductive power technology has many industrial applications in addition to use with electric vehicles**

Note: photo depicts IPT powered clean room system

Source: University of Auckland

It is hard to quantify the potential of companies like these and even harder to estimate the potential size of this sector in twenty or thirty years' time if the government implemented an innovation strategy. Nonetheless the current activity in this space suggests going down such a path is may yield benefits for New Zealand. It is notable that all the examples cited above are a result of research and development at NZ universities or Crown Research Institutes. If the NZ government decided to increase direct R&D towards something like the OECD average this is an area with definite promise.

5.1.9 Realising the opportunities

NZ has an almost unique chance to lead the world in renewable energy generation. It has been argued here that a key driver is the price of carbon. If the price is high, or there are clear expectations of high prices in the future new renewable generation is favoured and, as a result, New Zealand would stand a high chance of achieving 90 per cent plus renewable electricity generation by 2025. This suggests the importance of 'price management' to reduce the volatility of carbon prices and provide clear, long-term signals for investors in long-lived capital such as electricity supply. Price management can involve both price floors and ceilings; design of price management mechanisms should take into account whether emissions reduction units from other schemes or programmes can be surrendered because this affects the integrity of a price floor (Hepburn et al. 2012).

It is also argued here that a low-carbon electricity system needs a 21st century grid. Such a grid opens up the possibility for further managing increased renewable energy generation and the increased uptake of electric cars, making NZ a world leader in clean low carbon transport and electricity generation. The government should consider developing a strategic plan to deploy a New Zealand smart grid by 2030. An ambitious aim worth considering would be to position New Zealand as the smart grid leader. First steps would be to develop capacity in this area by supporting R&D and pilot programmes. An example of this approach is the Dutch Innovation Program Intelligent Networks which includes 'pilot projects that aim to achieve learning by and teaching to consumers, producers, grid operators and commercial parties about their roles and in this way prepare stakeholders for a large-scale rollout of the smart grids based upon a shared vision and a coordinated approach of all different innovation activities'.

Two key tools will be real time pricing of electricity and smart meters to allow significant demand side response. Thought needs to be given to getting the right kind of smart meters. The ability for two-way communication with the system operator appears to be particularly important.

Increased investment costs may need to be recovered by the appropriate regulatory body, Transpower or the Electricity Authority. For example the UK regulator Ofgem has a 0.5 per cent tariff for innovation and for incentives to connect distributed generation. A feed-in tariff to encourage distributed generation may also be worth considering. Key players in the industry such as Transpower and Meridian are clearly convinced of the merits of the smart grid[43]. Transpower in particular is working on a number of projects which would be key components of a smart grid (Transpower 2010). The grid is receiving its biggest up-grade in over 25 years, much of it designed to facilitate increased amounts of renewable energy. Moving to full deployment would require considerable additional investment from market participants. Because the benefits of the smart grid are distributed widely between the transmission, distribution, generation and demand components of the network it will be important to design policies that can co-ordinate the required investments from the different players. The right mix of industry co-operation and smart government policies could see rapid development of this infrastructure in New Zealand.

Combined the roll out of the smart grid with an innovation strategy could see the electricity sector making important contributions to the NZ economy. There are a range of new prospects for New Zealand.

[43] As evidenced by Meridian commissioning the report on the benefits of a smart grid for NZ (Meridian 2012).

Geothermal looks exciting and may require little in the way of direct government support except for perhaps increased research and development and assistance with facilitating the development of consortiums for big international projects. Other technologies such as wave energy for electricity generation or electric vehicle and related technology are more in the research and development phase and may need a considered innovation strategy to increase the possibilities of success. To make sure that this innovation strategy draws on international experience in developing and deploying energy technologies, industry and government could review the national energy innovation system to assess consistency with the IEA's best practice framework for energy innovation **(green growth opportunity 7)** (IEA 2011a).

New Zealand has a long history of expertise in the marine industry and marine energy may be a natural extension to this. It could well develop the wave energy sector into a significant clean tech industry given government support, including research and development support, and subsidies for commercial deployment. Hutchinson et al. (2011) argue persuasively that Auckland should actively develop a marine research and development cluster with a marine centre of expertise and government research and development support. They suggest that the marine centre of expertise could be established with annual government investments of $4 million and private sector funding of an additional $1.2 million. The Centre would 'monitor and evaluate potential projects through all the stages of the development, from the conception to commercial development of marine and tidal energy products'. Auckland is an ideal location for such a cluster sitting in between two oceans with a strong history of innovation in the yachting industry. For example the University of Auckland has a yacht research centre with expertise in fluid dynamics and numerical simulations which could be used for modelling wave energy design. Hutchinson et al. (2011) argue that NZ is 'strong in human resources in science and technology which provides a good basis for adequate skills for an R&D cluster.'

Electric cars are likely to become an important part of the light vehicle fleet over the coming decades. Consideration should be given to policies to facilitate this, particularly as electric vehicles start to become cost competitive. Barriers to uptake include high capital costs even if the technology develops to the point that lower running costs pay for the higher capital costs over the lifetime of the car. Subsidies and innovative financing packages may be useful measures to consider here. The lack of charging infrastructure may also impede uptake.

5.2 Building sector case study

Opportunities to improve comfort and reduce energy bills

5.2.1 Introduction

Residential housing is a key part of the construction sector of the economy, employing 8 per cent of the workforce and comprising 10 per cent of all businesses. Productivity in this sector at $50,000 per year for each worker is low and it accounts for just four per cent of GDP (PricewaterhouseCoopers 2011)[44]. Output from the sector is volatile. PricewaterhouseCoopers (2011) report that this volatility does not allow the sector to:

> *'build and maintain capacity, or to plan more than a few years out because there is no certainty over any length of time. This discourages investment in skills and means that when there is a downturn many skilled workers head overseas in many cases never to return to the New Zealand workforce'.*

Households account for around 11 per cent of energy use, including 35 per cent of total electricity consumption, and 10 per cent of energy carbon emissions or 6 per cent of net emissions in NZ (Energy Efficiency and Conservation Authority 2007). New Zealand houses tend to be poorly insulated resulting in cold, draughty houses which are difficult and expensive to heat. Some New Zealanders experience energy poverty with fuel bill bills over 10 per cent of expenditure (HEEP 2010). It will be seen below that retro-fitting existing houses to make them more energy efficient could make a healthier living environment with lower energy costs and significant net benefits.

The Energy Efficiency and Conservation Authority (EECA) estimates that approximately 900,000 homes have poor insulation, which is more than half of the housing stock. The result is higher heating bills and/or cold damp houses. Health problems can be a result of living in such houses, especially respiratory illnesses. Table 22 illustrates average temperatures in NZ homes comparing recent studies from HEEP to a 1971 study. There has been little change in the average temperatures. The average indoor temperature of NZ housing varies between 14.7-16.5°C which is below World Health Organisation guidelines of minimum healthy indoor temperatures of 16°C for bedrooms and 18°C for living rooms World Health Organisation (WHO, 1987).

[44] National output per FTE worker is approximately $90,000/year.

Table 22. **Descriptive temperatures by region**

Aug–Sept temperatures (°C)	Northern North Island (inc. Auckland HEEP 2001–04	1971	Southern North Island (inc. Wellington) HEEP 1999, 2002–04	1971	Christchurch HEEP 2002	1971	Southern South Island (inc. Dunedin) HEEP 2003	1971
Living room: Mean temperature	16.5	17.7	16.1	16.6	16.1	15.2	14.7	13.6
Standard deviation	0.1	–	0.2	–	0.3	–	0.5	–
95% confidence interval	16.2–16.8	–	15.8–16.5	–	15.4–16.7	–	13.7–15.8	–
External: Mean temperature	11.9	12.0	9.3	11.0	10.3	9.3	7.3	8.6
Mean temperature difference	4.6	***5.7***	6.9	***5.6***	5.7	***5.9***	7.4	***5.0***
Sample size (count)	112	98	74	64	34	69	30	64

Source: HEEP (2010)

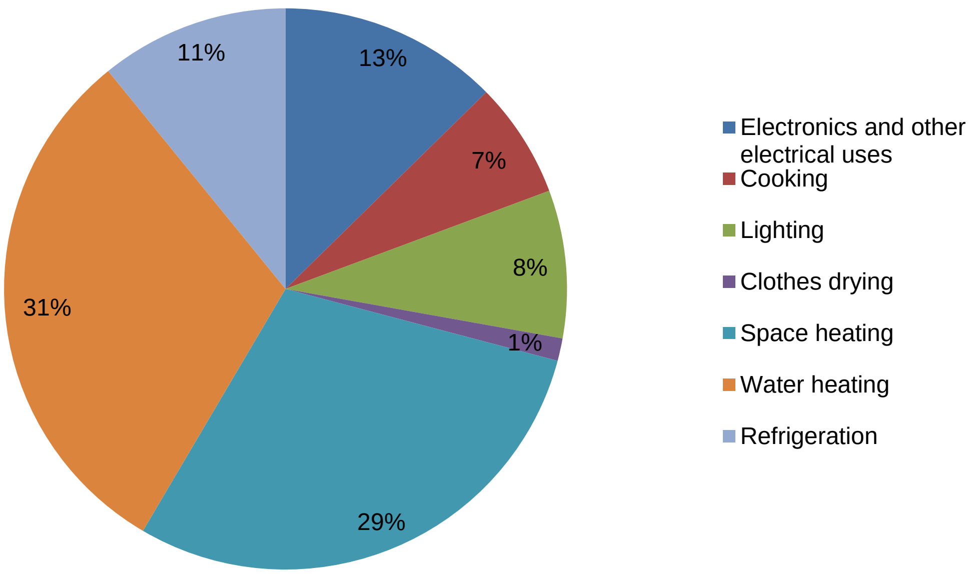
Table 22 and Table 23 show how indoor temperatures vary for different rooms and regions over the course of a winter day. It can be seen that average winter temperatures in the bedroom and living room are below, sometimes well below, the WHO minimum healthy indoor temperature recommendations of 16°C for bedrooms and 18°C for the living room.

Table 23. **Indoor mean winter temperatures**

Room (°C)	Time period Morning 7am–9am	Day 9am–5pm	Evening 5pm–11pm	Night 11pm–7am
Living room	13.5	15.8	17.8	14.8
Bedroom	12.6	14.2	15.0	13.6
Ambient	7.8	12.0	9.4	7.6

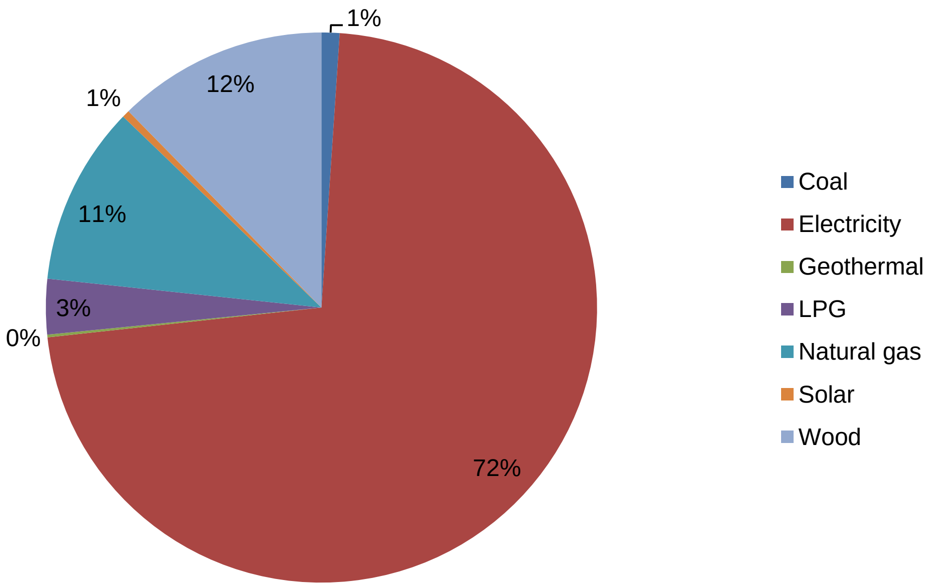
Source: HEEP (2010)

Figure 103. **Total energy use by end use**



Source: Energy Efficiency and Conservation Authority (2007)

Figure 104. **Total energy use by fuel type**



Source: Energy Efficiency and Conservation Authority (2007)

Figure 104 shows that total energy use in NZ homes is predominately electricity, 69 per cent, making up over 85 per cent of the fuel bill. The average household pays NZ$2,236 a year on energy, not including transport (Statistics New Zealand 2010b). For many low income households, annual expenditure on household energy consumption is over 10 per cent of income, a common definition of 'energy poverty'. HEEP (2010) found that 32 per cent of the poorest 20 per cent of households suffered from energy poverty. The study also found that 33 per cent of households in this group had an average living room temperature in the evening of less than 16°C.

Another study (Beacon Pathways 2007) states that:

> *'New Zealand homes are on average 6C below World Health Organization recommended minimum temperatures in winter; 45 per cent of all New Zealand homes are moldy; New Zealand has the second highest rate of asthma in the world and an excess winter mortality rate of 1600 not seen in other OECD countries; 300,000 New Zealand homes have an unflued gas heater; the air inside New Zealand homes can be more polluted than outdoor air; and cold damp homes pose serious health risks, particularly for the most vulnerable groups in the community who spend the most time at home (the young, elderly, infirm, and unemployed).'*

In response to concerns, such as those expressed in the quote above, the NZ government launched the 'Warm up NZ: Heat Smart' programme in 2009. It includes direct funding of up to NZ$1,300, intended to reduce average installation costs for ceiling and under floor insulation by up to a third. A number of banks are prepared to add the remaining cost to the home owners housing mortgage; and some local councils will fund the upfront costs and add the repayments to the rates bill. The government has committed $347 million over four years with the stated aim to retrofit 230,000 homes. So far more than 150,000 houses have been retrofitted. As noted above ECCA estimates approximately 900,000 houses need insulation. The Ministry of Economic Development has recently released a series of reports evaluating the programme using data from the first two years compared to a control group. The studies include a cost benefit analysis (Grimes, Denne, et al. 2011) and a study (Grimes, Young, et al. 2011) which examined the impact of the programme on metered energy use and found:

> *'magnitudes of the savings, while statistically significant, are quite small. Our preferred estimate (based on a cleaned dataset) finds that 0.96 per cent of average annual household electricity use is saved as a result of having insulation retrofitted'.*

Health benefits were found to be higher, making up approximately 99 per cent of the total benefits (Grimes, Denne, et al. 2011). The planned retrofit of 178,000 houses would yield total benefits of $1.58 billion compared to costs of $0.37 billion, a net benefit of $1.21 billion. The target number of houses has been increased since these figures were calculated.

There are a number of other new initiatives to make homes more energy efficient and healthy. One is Homestar which provides services to assess how homes perform in terms of energy, health and comfort, water use and waste. These range from a free online self-assessment tool to a certified assessment for a Homestar rating. Beacon Pathway has developed a set of benchmarks for sustainable housing which they call the High Standards of Sustainability (HSS). Beacon Pathway Incorporated in partnership with the NZ Housing Foundation has recently built a two story demonstration home in Auckland which meets the HSS benchmark.

5.2.2 Global situation

Energy efficiency measures in the built environment have been identified as a 'powerful and cost-effective tool to contribute to green growth strategies', and can have a short pay back periods (OECD/IEA 2011).

While energy efficiency measures are often most cost effective when implemented for new buildings, there may be green growth opportunities in retrofitting the existing residential housing stock to make them more energy efficient. Many countries have programmes in place to achieve such an outcome. For example, in the UK the government has recently passed the Green Deal legislation which is an innovative mechanism allowing consumers to pay for energy efficiency measures through their energy bills. The process starts with a registered assessor identifying for each participating household which energy efficiency improvements or micro-generation options meet the 'golden rule' – the cost of the improvements can be paid for by energy bill savings over time. The upfront capital costs are paid for by the Green Deal provider which is a consortium of 15 commercial banks and energy companies.

South Korea has introduced a package of US$6 billion to promote green homes and energy efficient lighting (LEDs) in public institutions. France has launched zero interest rate loans for residential energy efficient programmes, which contrasts with the UK scheme which has an interest rate of around 5–7 per cent. France has also introduced energy efficiency assessments and renovations for public building.

For new buildings to meet climate change and efficiency targets many jurisdictions are moving towards near zero energy design standards by 2020. In Europe the aim is to reduce greenhouse gas emissions associated with buildings by at least 90 per cent by 2020 (Buildings Performance Institute (BPI), 2011). The Energy Performance Building Directive defines a nearly Zero-Energy Building as a ‘building that has a very high energy performance…The nearly zero or very low amount of energy required should to a very significant extent be covered by energy from renewable sources, including renewable energy produced on-site or nearby’ (BPI, 2011).

In the US some states have signalled targets almost as ambitious. California has mandated zero net energy for all residential construction by 2020, and for all commercial construction by 2030, while Massachusetts plans to achieve net zero energy for all buildings by 2030 (European Council for an Energy Efficient Economy 2011). Japan also is committed to zero-energy buildings by 2020.

Since 2007 all new residential buildings in New South Wales are required to obtain BASIX certification which means that both energy and water use are 40 per cent less than comparable houses prior to the introduction of the scheme (Henry Davis York 2010).

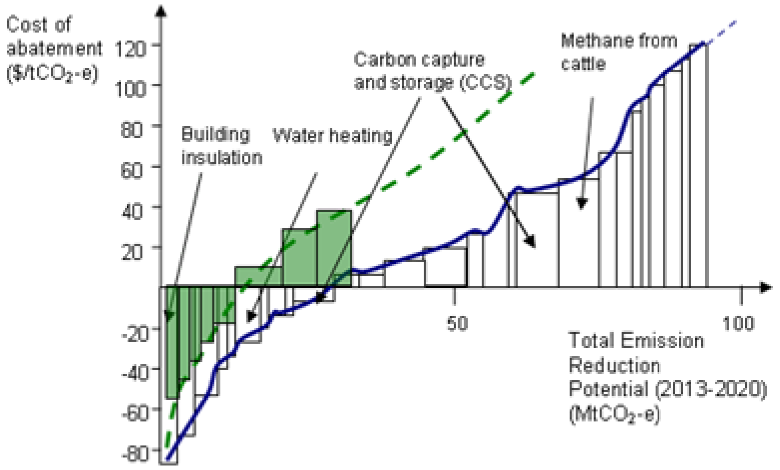
Worldwide Pike Research has published a study which predicts that revenue from net zero energy buildings will reach US $1.3 trillion by 2035 (Pike Research 2012).

5.2.3 Green growth opportunities

Retrofitting existing homes

There are comfort and health advantages if NZ homes are warmer during winter. Furthermore, there are also potential benefits in terms of lower energy bills and lower greenhouse gas emissions. The McKinsey carbon abatement curves (Figure 105) identify substantial opportunities to reduce emissions at negative cost through a range of energy efficiency measures, many of which are in the housing sector. It is worth investigating whether this is the case for NZ.

Figure 105. **Indicative abatement costs - developed countries (solid line) and New Zealand (dashed)**



Source: New Zealand Ministry for the Environment (2007)

To counter the indoor temperature problem in NZ, Lloyd and Callau (2009) concluded that the entire North Island housing stock would require properly insulated flooring and ceiling, improved air tightness and more efficient heating. South Island housing would also require such action, together with wall insulation, bulk floor insulation and good quality curtain material. They estimate that roughly 67 per cent of the existing housing stock of 1.6 million would require some renovation to align with the 1996 NZ standard for insulation. These alone would not be enough to satisfy the WHO recommended indoor ambient temperature and render the housing stock 'healthy'. Additional cost effective space heating measures such as heat pumps would also be required.

A question is how the costs of the retrofit programme recommended by Lloyd and Callau (2009) compare with its benefits. Over the last seven years, detailed research by Beacon Pathway Ltd suggests some answers. The benefits and costs were modelled for 11 different representative house types for all four climate regions in NZ (Page 2009). Three different retrofit packages were considered starting with the low cost standard package listed below in Table 24.

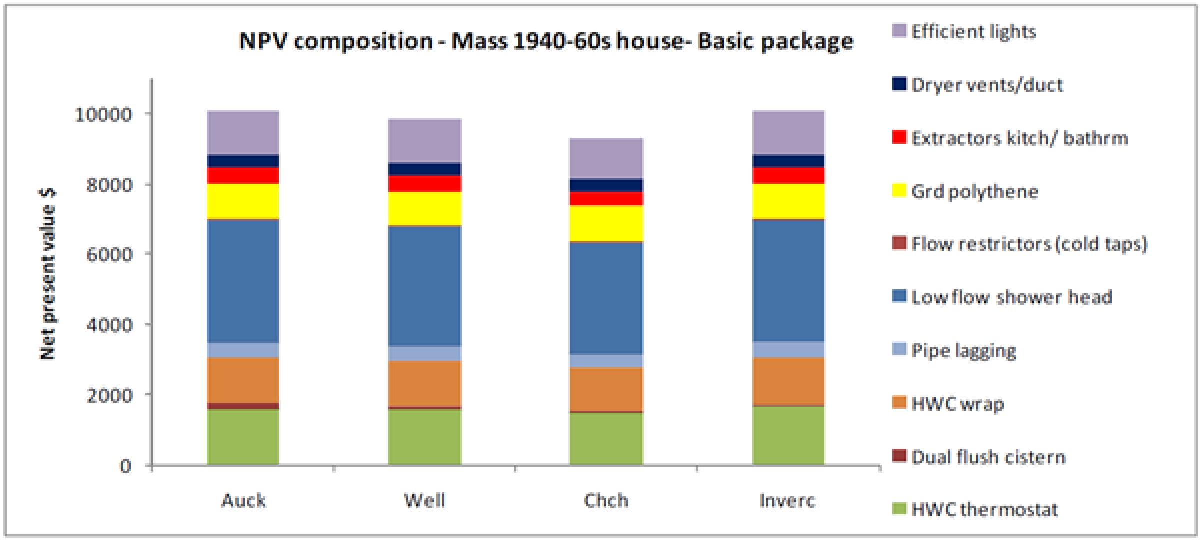
Table 24. **Details of low-cost package**

Measure	**Cost (NZ$)**
HWC thermostat adjustment/replacement	60
Dual-flush cistern	120
HWC wrap	70
Pipe lagging	20
Low-flow shower head	130
Flow restrictors on cold taps in kitchen and bathroom	60
Ground polythene	520
Extractor fans for kitchen and bathroom	500
Clothes dryer vent and ducting	70
Efficient light bulbs	30
Kitchen waste bin	120
Total	**1,700**

Source: Page (2009)

The net present values, benefits minus costs, are reproduced from the report below in Figure 106 with a benefit to cost ratio of between six and seven.

*Figure 106.***Net present value of low cost package**



Source: Page (2009)

The cost of the more expensive standard package of $8,400 includes the basic package as well as underfloor and ceiling insulation and the purchase of a wood burner. The net present value of the standard package for the same type of house varies from $20,000 in Auckland to $70,000 in Invercargill. The discount rate used is 5 per cent with an expected lifetime of 30 years, real electricity prices continue to rise at 3 per cent per annum and the rebound effect (increased energy consumption to achieve higher comfort) is assumed to be 30 per cent.

An enhanced package which at $24,000 is considerably more expensive and builds on the standard package including, double glazing, curtains, hot water heat pump, as well as other lower cost measures. The increase in net present value is much smaller for most centres or even negative (for Auckland).

Nationally, the modeling identifies 1.6 million houses for retrofit with three different packages depending on location. The authors estimate national costs of the retrofit programme to be $17.4 billion. The present value of benefits would be $49.4 billion, hence the net present value would be $32billion - a benefit cost ratio of 2.9. A retrofit programme spread over 15 years reduces the net present value to $22billion and the BCR to 2.3.

Despite the benefits of energy efficiency measure, uptake is low, reflecting a number of barriers (IEA 2007). These include information failures and financial barriers. For example, upfront capital costs can be a deterrent, and there are incentives for rental accommodation as described schematically in Table 25.

Table 25. **Incentives and benefits for energy efficiency investment for rental accommodation**

Responsibility for electricity bills	Landlord	Tenant
Landlord	Incentive to invest	No incentive to save energy
Tenant	No incentive to invest	Incentive to save energy

Source: The University of Auckland Business School

New Zealand home ownership rates have been declining steadily from 74 per cent in 1991 to 65 per cent today. There is little incentive for either the landlord or the tenant to invest in energy efficiency. Generally tenants pay the power bill and hence would receive most of the benefits if the landlord invests. Since it is unlikely that they will be renting the same property for many years, they have little incentive to invest themselves. It could be made mandatory for rental houses to comply with minimum energy efficiency standards.

The New Zealand Green Building Council (2009) list a number of other barriers to uptake. Energy costs can be a small fraction of a building's operating costs. This provides little incentive to reduce energy use, exacerbated by payback periods longer than many consumers would like. Poor information flow and lack of understanding is also an issue with both consumers and producers having little or no awareness about the performance of energy efficiency options. Unpriced externalities, particularly the social cost of carbon, mean that there is less investment in energy efficiency measures than is optimal.

The existing 'Warm up NZ: Heat Smart' could result in energy efficiency investments of approximately $1 billion; however, the above studies suggest that more could be done. The investments envisaged by Page (2009) are almost twenty times the business as usual projections.

New housing stock

New house construction in NZ averages around 21,000 a year compared to the current housing stock of 1.6 million. This means by the year 2050 over 800,000 new houses might be built, representing 35 per cent of the future housing stock if none of the existing stock is demolished. There is considerable evidence that new house designs can be made more environmentally sustainable at only modest increases in construction costs, offset by energy savings over the lifetime of the structure.

Beacon Pathway tested the design of a new home which was built in West Auckland in 2009. The performance of the building has recently been evaluated (L. Easton 2011). The net energy use of the house, which had six occupants, was 3,890 kWh per year, considerably less than the NZ average of 8,100kWh per year for 2.7 occupants. PV solar provided 200kWh of electricity with an estimated payback, using 2011 prices, of 22 years. The payback on the heat pump hot water system was quicker, at current prices, at 8.5 years. The experience of the occupants was positive, 'they appreciated the significant cost savings, and noted the clear health benefits for the whole family of having a warm, dry, well ventilated house'. The heavy insulation and double glazing reduced heating requirements to near nil.

Over the last couple of years a number of other new houses have been built which have achieved Homestar ratings of seven and even eight stars at reasonable prices.

An ambitious project is 'Little Greenie' built in the Golden Bay area in Nelson by Lawrence McIntyre in 2008/2009 with 'the intention of showing what could be achieved when you set out to make a simple, comfortable, easily maintained and 'green' house in New Zealand using accessible techniques and materials' (Ryan 2011). The building comfortably achieves the WHO minimum standards for indoor temperatures. Construction costs were higher than a code level equivalent building (NZ$2,136/m^2 compared with NZ$1,766/m^2). It achieved a 9 star Home Energy rating, compared to 4.5 stars for code compliant building. The author claims that the additional cost pays back after a 21 year period. The heating load over a year is more than 90 per cent less than that of a code compliant building, or NZ$69 at current energy prices compared to NZ$670 for a code compliant building.

New Zealand's first zero-energy house is under construction in Auckland. The aim is achieve net-zero energy bills through a combination of energy efficiency features, solar hot water and solar roof tiles which generate electricity (Fordham 2012).

To our knowledge there have been no NZ studies estimating the costs of benefits of moving to an NZ near zero energy standard for new buildings. The above examples suggest that there might be a green growth opportunity from doing so. There is a need for further research identifying the best designs to achieve near zero energy houses in NZ at least cost. Whilst there is a growing expertise in NZ in the design and build of very low energy housing there are very few examples to date. For almost any new innovation, costs of early examples are driven down with time by further R&D and learning by doing, which leads in turn to further design innovations.

For illustrative purposes, suppose that each new house is built takes advantage of energy efficiency measures which provide the same average benefit as that identified for retrofitting old houses. Discounting the net benefits between now and 2050 at the 7 per cent discount rate used by Page (2009) yields discounted net benefits if new houses were energy efficient of at least NZ$6 billion. These are the private net benefits. The social net benefits would be considerably larger as they would include the benefits of fewer greenhouse gas emissions. Furthermore there is a strong argument that a much lower discount rate should be used in evaluating climate change policies. For example the Stern report argued that the discount appropriate rate should be 1.4 per cent. Using this discount rate we calculate the net social benefits for new house builds would be greater than $13 billion.

Macro effects

A recent study (Jaeger et al. 2011) models the economic consequences of reducing CO_2 abatement from 20 per cent to 30 per cent of current levels in Europe by 2020. They find that it would:

– increase the growth rate of the European economy by up to 0.6 per cent per year;

- create up to 6 million additional jobs Europe-wide; and
- boost European investments from 18 per cent to up to 22 per cent of GDP.

Most of the reason for this is the required investment in the housing stock. They write:

> *'In Europe in the years to come, serious emission reductions imply higher growth than business as usual. The reason is straightforward: such reductions require a renewal of the built environment, and the built environment is by far the largest component of the overall capital stock. Therefore, its renewal implies larger investment and therefore larger growth. ….And there is ample evidence to the effect that investment induces productivity gains via learning-by-doing, especially in the case of new technologies like renewables or new building materials.'*

If investment is redirected away from other investment opportunities, the net effect would be smaller. Thus investment in renewal of the NZ housing stock might have a positive macroeconomic impact measured as GDP, as well as deliver net benefits. In a similar vein, Beacon Pathways' submission to the national job summit in 2009 makes the point that 'large scale renovation is big on job creation' (Beacon Pathways 2009). For every 1,000 houses retrofitted with the recommended package 151 full time equivalent jobs are created for onsite work and a further 392 full time equivalent jobs are created for products and services needed for the retrofit activity. Again, the question is the extent to which these are additional jobs or higher value jobs than those they displace.

5.2.4 Realising the opportunity

As noted above, 'Warm up NZ: Heat Smart' is an excellent programme. However, without further policy intervention most of the benefits from more efficient housing are unlikely to be realised The price on carbon in the NZ Emissions Trading Scheme will push electricity prices up and help create some incentives for energy efficient housing but on its own will not be sufficient (New Zealand Green Building Council 2012) because of the barriers to uptake and the pay-back time, which is longer than some consumers may accept.

The International Energy Agency has a number of suggestions. The EU's Energy Performance Building Directive (EPBD) (2010) also has similar advice, listed here:

- Mandatory building codes and minimum energy performance requirements which could apply to all new buildings as well as those undergoing renovations (Sahebb 2011). The EPBD recommends a number of policies including the adoption of a methodology for calculating energy performance, setting minimum energy performance requirements and calculating the cost-optimal levels of minimum energy performance requirements. (EPBD, 2010)
- Zero net energy consumption in new buildings by 2020.
- Renovation: the IEA advocates setting 'an ambitious timeline and renovation rate for cost effective reduction of the energy consumption in existing buildings'. Other suggested policies include 'energy audits, energy ratings and certification schemes, incentives to encourage investments in long lasting building envelope and system improvements, and increased market penetration of new high efficiency products' (Sahebb 2011).
- Building energy labels and certificates that provide information to owners, buyers and renters.
- Energy performance of building components and systems*:* minimum energy performance standards for windows (heat transfer coefficient), requirement for energy performance labelling of all window and glazed products as well as a policy package to reduce the energy demands of heating, ventilation and air conditioning services (Sahebb 2011).

The New Zealand Green Building Council (2009) recommends white certification schemes and accelerated depreciation for investments which increase energy efficiency.

There is little industry experience in building near zero energy houses. One policy intervention could be to invest in R&D for improved design and materials for energy efficient buildings. PricewaterhouseCoopers (2011) note that productivity has slumped in this sector over the last ten years, which suggests that a general increase R&D in this sector may be beneficial.

Newton and Hawke in their review of the Beacon Pathway project (Newton and Hawke 2010) write:

> *'The building, construction and property sectors are among the least research intensive of any sector in the economy, having a relatively low investment in R&D and compared to other industry sectors have a relatively low level of receptivity to innovation. Yet the benefits capable of being generated from this industry as a result of increased innovation and productivity are considerable, both to the*

economy (percentage increase in GDP) and the population (refer to Beacon's value cases).' (p7)

Industry levies or tax breaks could be used to fund R&D as well as direct government spending. A starting ambition might be to move towards the OECD average for the sector as a whole. Part of the funding might go to a research institute whose role would be to work with industry and crown research institutes to develop innovative and cost effective materials and design solutions for near zero energy houses in NZ.

The aim would be to move quickly to introduce design standards for NZ residential construction of cost effective energy efficient housing. The UK firm ZEDFactory is at the cutting edge of developments in this area. At a recent conference in NZ, the architect and founder of the company, Bill Dunstar, was reported to have said, 'You need a few demonstration projects which lift the game. Once developers have seen those, they realise you can't go back, you must go forward'.

To realise the green growth opportunity for retrofitting the existing housing stock on the scale proposed by Page (2009), a number of approaches might be useful.

One of the key barriers for consumers, as emphasised by the IEA, is the capital cost. The subsidy available under the current scheme is up to a third of the expected NZ$3,900 investment costs. The average cost to implement the retrofit programme recommended in Page (2009) is around NZ$10,000, so even with some subsidy, capital costs could be a major barrier. Drawing on a wealth of best practice material from overseas, government might evaluate measures for improving the energy efficiency of the current and new building stock (**green growth opportunity 8).** The review could cover financing mechanisms for reducing the barriers to residential energy efficiency retrofits, and the costs and benefits of a national energy saving schemes such as those in the UK and California and the scheme currently being investigated by the Australian government (Department of Climate Change and Energy Efficiency 2012).

The Green Deal package being introduced by the UK government has a number of features. The first part is assessment. A Green Deal advisor visits the house and conducts an energy audit before suggesting efficiency and micro-generation options which meet the golden rule. The Green Deal advisor arranges a financial package with the Green Deal provider which allows payment from energy savings on existing bills. In turn the Green Deal provider organises installation with a recognised Green Deal installer. From the point of view of the customer the whole process is relatively painless and is estimated to pay for itself. Eventually, when the loan is paid off, the home owner receives the benefit of energy bill savings. The programme aims to overcome the split incentive problem described earlier. Landlords can make energy improvements without having to pay for them upfront, while tenants will pay for the improvements through their energy bill and can enjoy a warmer home.

In addition, in the UK, Energy Company Obligations (ECOs) are imposed on household energy suppliers. It has two objectives. The first is to 'provide free heating and hot water saving measures, insulation, glazing and micro-generation technologies (except PV) to low-income and vulnerable households' (Energy Savings Trust 2012). The second is to provide at subsidised cost to any customer some insulation measures which do not meet the golden rule criteria. The third is to provide free insulation and glazing to households in deprived areas. The aim of these measures is mainly to reduce energy poverty. It is expected to benefit 230,000 low income customers with investments each year from the energy companies expected to be £1.3 billion.

The Green Deal and ECO are types of programme which could, if successful and desirable, be introduced here.

At a more local level, district plans can be a barrier to uptake of sustainable building technologies. Trenouth and Mead (2007) describe what these are and suggest ways that the district plans can encourage sustainable buildings.

In conclusion, the economic gains from improved housing stock will not be brought about quickly without government policy and industry involvement. The IEA and the EPBD indicate what that involvement might be, and other research suggests the net present value of appropriate action could be of the order of billions of dollars.

5.3 Land transport case study

Opportunities to enhance mobility while cutting emissions and fuel bills

5.3.1 Introduction

A well-functioning transport system plays a key role in underpinning economic activity and quality of life. Historically, efficient and inexpensive transport of goods and services has facilitated specialisation and trade, resulting in huge productivity increases. Fast and efficient travel to and from work increases the pool of potential workers for firms, yielding productivity dividends (Venables 2007). A key strand in this story is the rise of the city where workers are typically much more productive (Puga 2010). As well as these benefits of well-functioning transport that are reflected in markets, choices about transport and land use planning affect wellbeing by affecting the time taken to move between employment, schools, home and leisure activities.

Following commercial drilling and petroleum production in the mid 1850s the transport landscape has been dominated by the internal combustion engine powered by fossil fuels. In New Zealand perhaps more than almost any other country the emphasis has been on road transport for freight and the private car for personal transport. Two factors – increasing real oil prices and commitments to reduce emissions – are drivers for change in both the fuels used by freight and private cars and the dominance of private vehicles in the transport mix.

It is likely that oil prices will rise from their current levels over the medium term. Although there have always been divergent views on future oil scarcity and prices there is an emerging consensus that growing demand from the developing world and a steep decline in production from existing fields means that oil prices are likely to increase over the coming years. The International Energy Agency (2011) has a range of different scenarios which vary depending on global commitments to carbon reductions. Their central projection has real oil prices rising steadily to $120 per barrel to 2035. A more recent IMF report (Benes et al. 2012) is considerably more pessimistic, forecasting oil prices will double to around $200 per barrel in 2020. The authors write that the nonlinear forecasting model they have developed 'performs far better than existing empirical models in forecasting oil prices and oil output out of sample'. As well as a steady increase on average of the price of oil there is also significant risk of supply shocks driving up prices. For example, early in 2012 Iran responded to a perceived threat from the international community by threatening to close the straits of Hormuz, through which 35 per cent of the world's shipped oil passes (Congressional Research Service 2012). In a recent report, the US military state that 'a severe energy crunch is inevitable without a massive expansion of production and refining capacity' (United States Joint Forces Command 2010). As early as 2015 the shortfall in output could reach nearly 10 million barrels per day - current output is 85 million barrels per day.

The second factor that could motivate change is NZ's commitment to reduce emissions to play its part in reducing the risks of dangerous climate change. NZ, along with 167 other countries, has signed the Copenhagen Accord stating that 'we agree that deep cuts in global emissions are required... so as to hold the increase in global temperature below two degrees Celsius.' The IEA (2011) scenario which limits global temperature increase to 2 degrees sees OECD countries reduce their oil use by almost 40 per cent by 2035. The NZ government has committed to 50 per cent reductions in CO_2 equivalent emissions by 2050 (MfE 2011). Unless there are major technological advances in the sector, reducing NZ's agricultural emissions without reducing production may be challenging. This implies that reductions in transport emissions are important for meeting NZ's long term emissions reduction target. Reducing the emissions intensity of transport can also have other benefits, such as reducing dependence on imported oil and providing consumers with net savings on fuel bills.

Overview: land transport

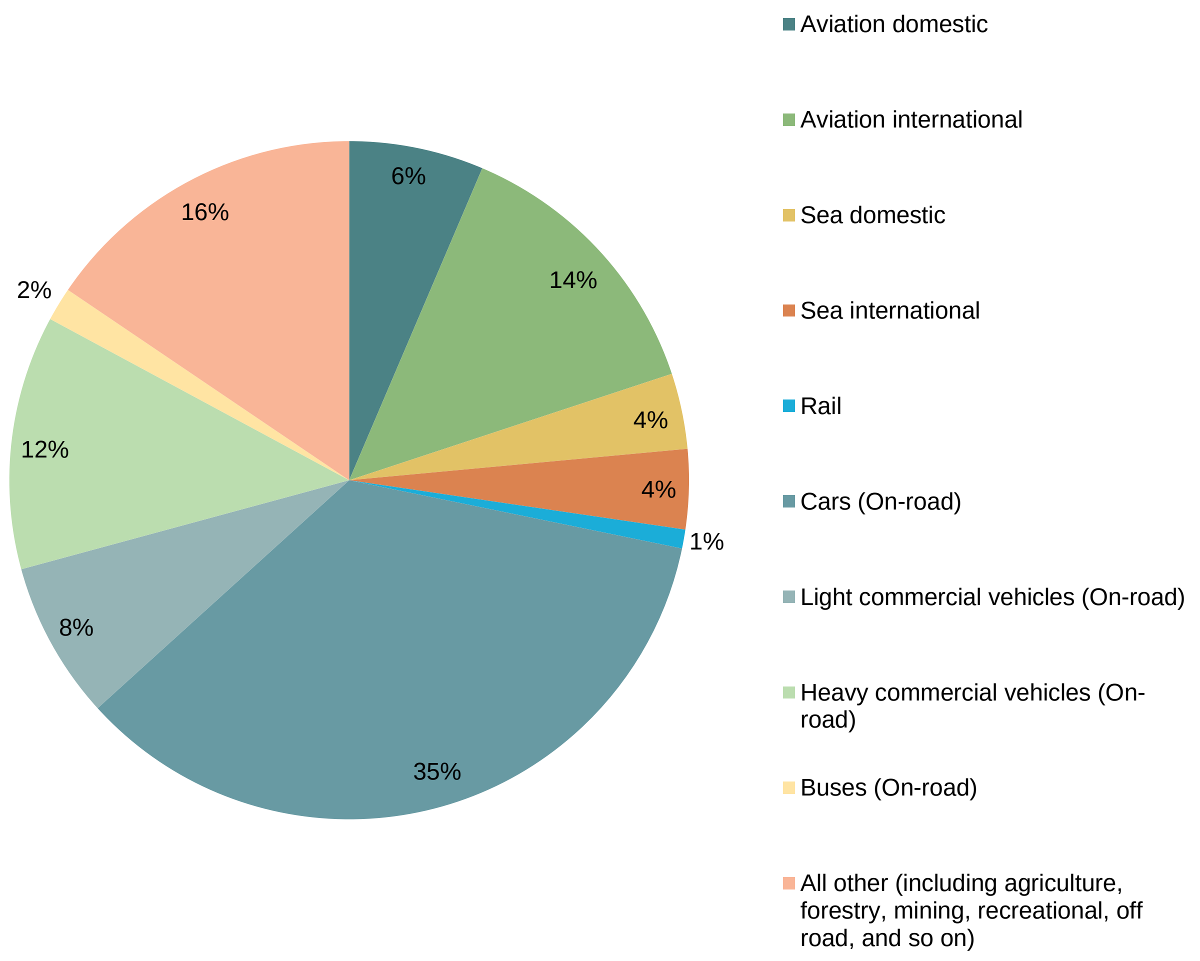
Transport and storage of goods is the eighth largest sector in NZ economy contributing 5.2 per cent of NZ GDP. Of this: 44 per cent is from the road and rail sector; 21 per cent from air and water transport sectors and; the rest is services to transport and storage. It is also an important employer with a large number of firms as seen in Figure 107. As well as the direct economic impact, private transport is an important part of people's lives for: travelling to work; shopping; business trips; and leisure activities.

*Figure 107.***Employees and firms in the transport sector**

Source: New Zealand Ministry of Transport (2011a)

Transport relies almost entirely on petroleum with road and off road transport accounting for 70 per cent of transport petroleum use. Aviation use is almost 20 per cent and sea transport around 8 per cent.

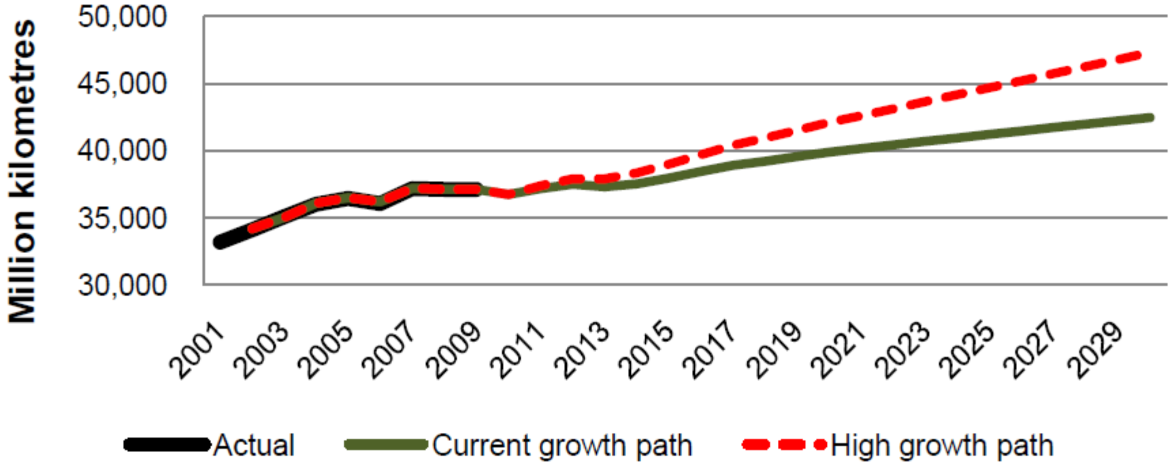
Figure 108. **Oil use by sector in NZ, 2006**



Source: Perreau (2007)

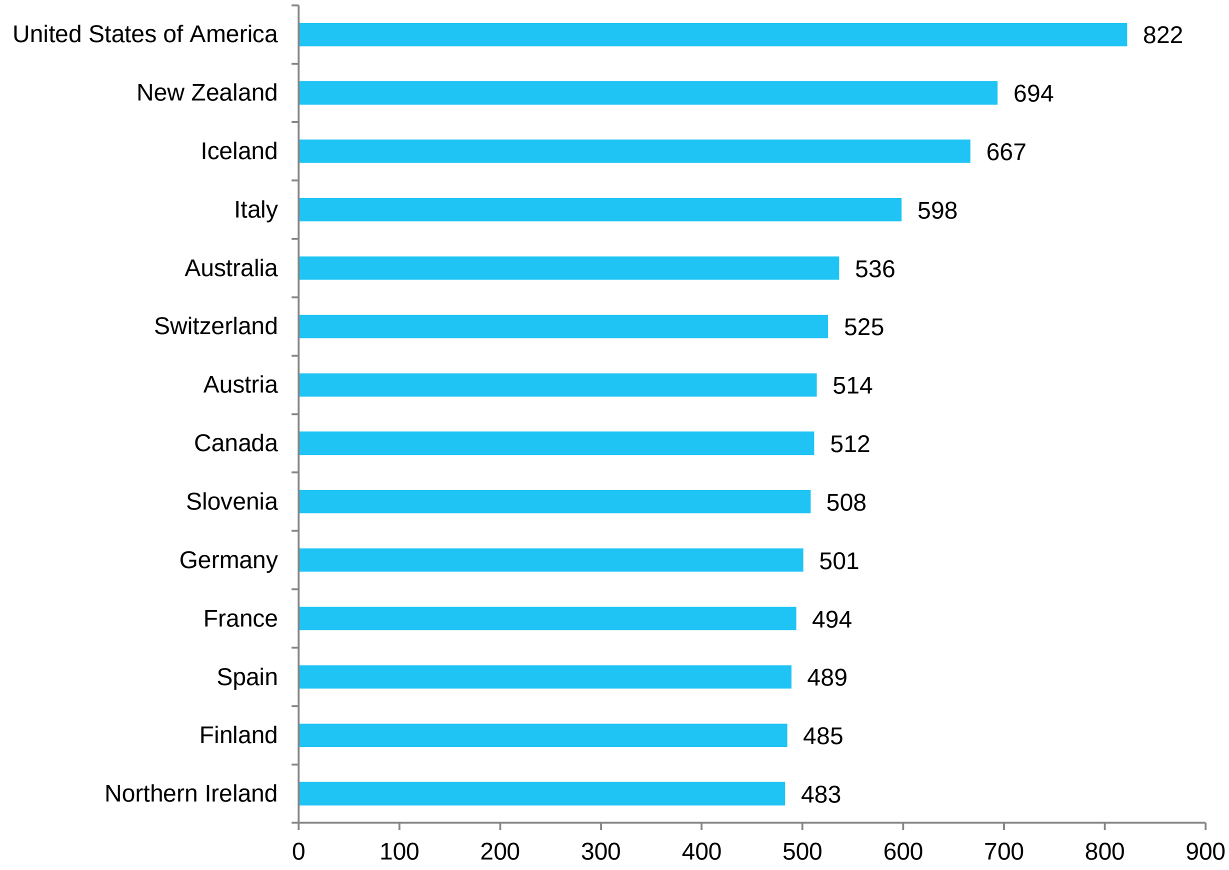
The New Zealand Ministry for the Environment (2009) observes in their transport environmental report card that: ‘in NZ, our use of road transport is intensifying. On average, we are driving further, we own more cars, they are slowly getting older, and their engine size is increasing.’ In the same report they observe that NZ vehicle kilometres travelled per capita (VKT) has increased by 12 per cent between 2001 and 2007. Well over 90 per cent of the VKT in NZ is in cars or trucks that burn fossil fuel; hence, at present, high VKT means high greenhouse gas and other pollution emissions. They also report that ‘by international standards, New Zealanders rely heavily on road transport. The latest Organization for Economic Co-operation and Development (OECD) comparison (OECD 2002) shows that New Zealand had the second highest VKT per person out of 30 OECD countries.' Figure 109 shows that VKTs are expected to increase strongly over the next 20 years under business as usual.

*Figure 109.***VKT projections under business as usual**



Source: New Zealand Ministry of Transport (2011a)

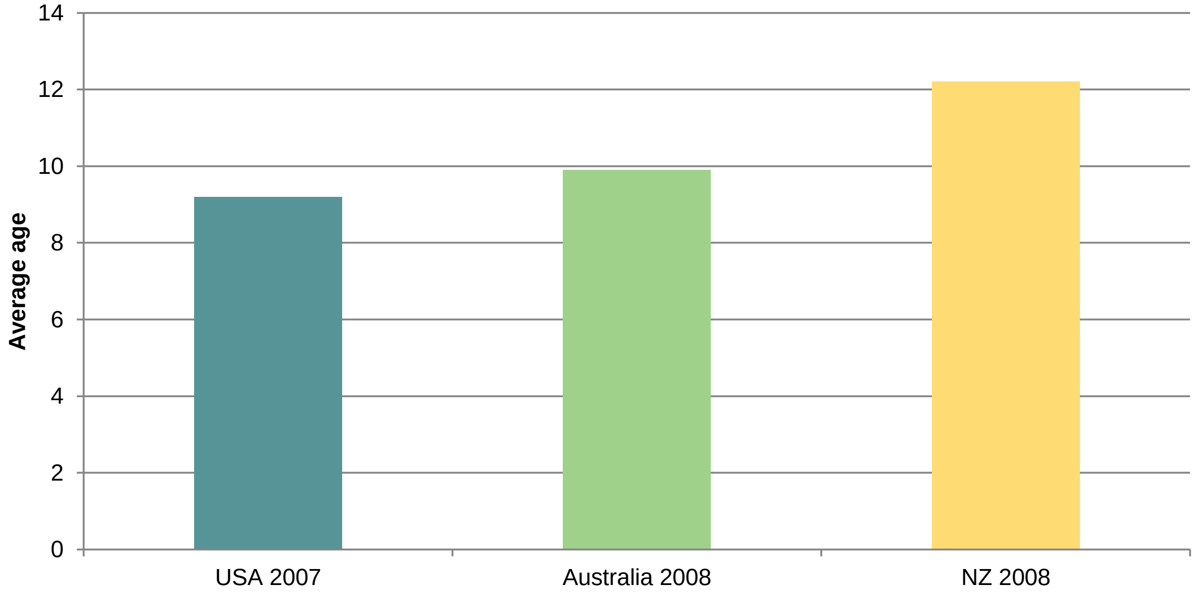
Figure 110. **Number of vehicles per 1000 population, 2008**



Source: New Zealand Ministry of Transport (2011b)

Compared with other countries NZ car ownership is high with an ageing fleet. Figure 111 compares the age of the NZ fleet with Australia and the US for selected years. According to the Ministry of Transport's recent briefing to the incoming Minister, 'at an average age of 12.7 years in 2010 NZ has one of the oldest light vehicle fleets in the world'. Over the next 10 years the age of the fleet is expected to increase further (New Zealand Ministry of Transport 2011a). The heavy road transport fleet is even older with an average age of 15.4 years.

Figure 111. **Average age of light vehicle fleet for selected countries**



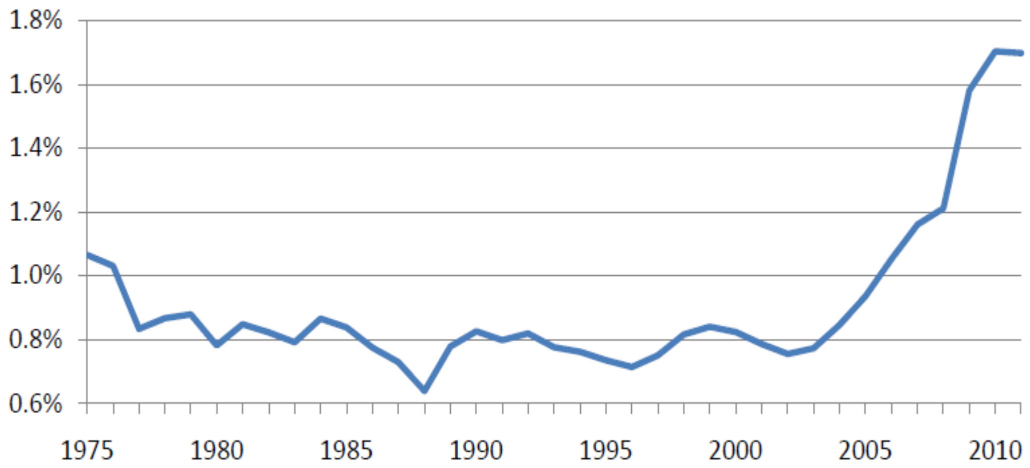
Source: New Zealand Ministry of Transport 2011b

The age of the road transport fleet has two implications. The first is that older cars and trucks are less fuel efficient and hence emit more CO_2. The average fuel efficiency of the current fleet is around 10 litres per 100km which compares to new car fuel efficiency of between 5-6 litres per 100km (New Zealand Ministry of Transport 2011b). Thus an ageing car fleet produces more transport emissions, other things equal. It also means that, in the absence of policy action, it will take a longer to transition to a different low carbon technology. For example, as electric cars become price competitive with conventional cars, the decarbonisation of the transport sector will be slower than with a stock that turns over more quickly. [45]

In recent years total NZ land transport infrastructure spending has increased (Figure 112).

[45] As well over 50 per cent of the car fleet is second hand imports, which are on average 8 years old when they arrive, the average number of years that a car is owned is less than the average age of the car fleet (New Zealand Ministry of Transport 2012)

*Figure 112.***NZ Land Transport Infrastructure spending as percentage of GDP**

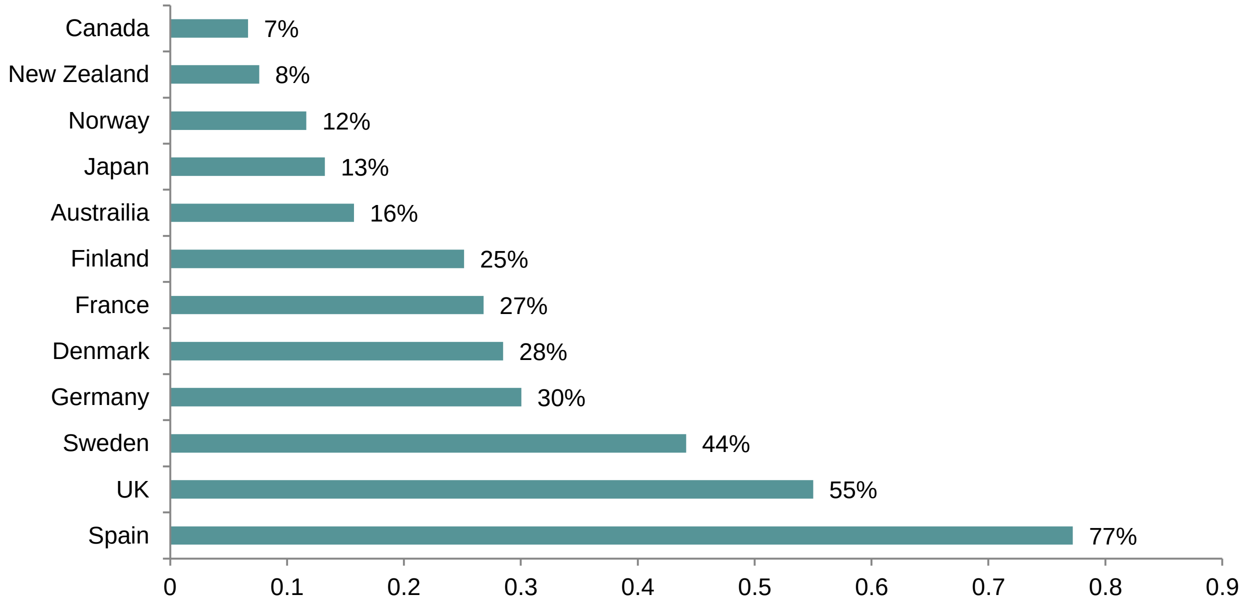


Note: *Transport spending includes NLTF, SuperGold Card, KiwiRail Turnaround Plan expenditure, metro rail expenditure and other non-NLTF expenditure. Excludes costs associated with the purchase of KiwiRail.*

Source: *New Zealand Ministry of Transport 2011a; New Zealand Transport Agency 2008; Statistics New Zealand 2012b*

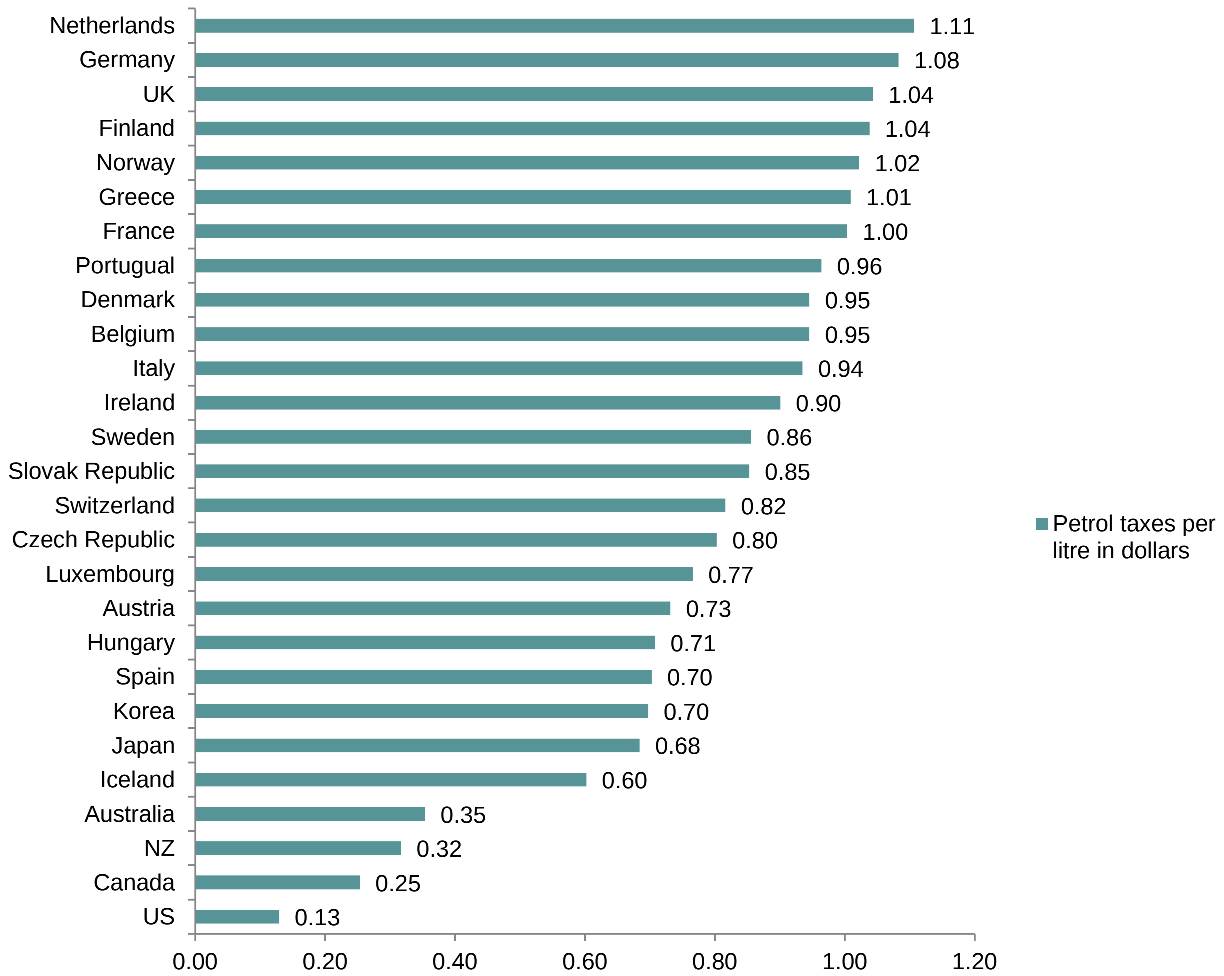
Most of the investment is on roads reflecting the NZ transport policy emphasis on road infrastructure spending with only a small amount spent on rail infrastructure. As Figure 113 suggests, NZ infrastructure spending on rail, at 7 per cent of the total, is considerably below that of many other advanced nations. Of course there may be peculiar features about NZ that makes this spend optimal. However as will be seen, there is some evidence that, in the face of high and uncertain oil prices, considerable welfare gains could be made if public transport investment was a higher fraction of the total. Petrol taxes are very low in NZ compared with much of the rest of the OECD (Figure 114) which further promotes the private car as the dominant mode of road transport.

Figure 113. **Rail infrastructure as a percentage of total of road plus rail infrastructure spending for selected countries, 2008[a]**



Note: [a] *The figures are from OECD (2011b) and for 2008 except for Norway where the latest figures are from 2007. The New Zealand figures are University of Auckland Business School calculations from the New Zealand Ministry of Transport (2010). Road infrastructure spending includes the categories 'new and improved infrastructure' and 'renewal' spending. The spending for rail is an upper bound as only public transport infrastructure is reported. In the latest GPS 2011 (New Zealand Ministry of Transport 2012) public infrastructure spending declined to just 3 per cent of the total.*

Figure 114. **NZ petrol taxes are amongst the lowest in OECD**



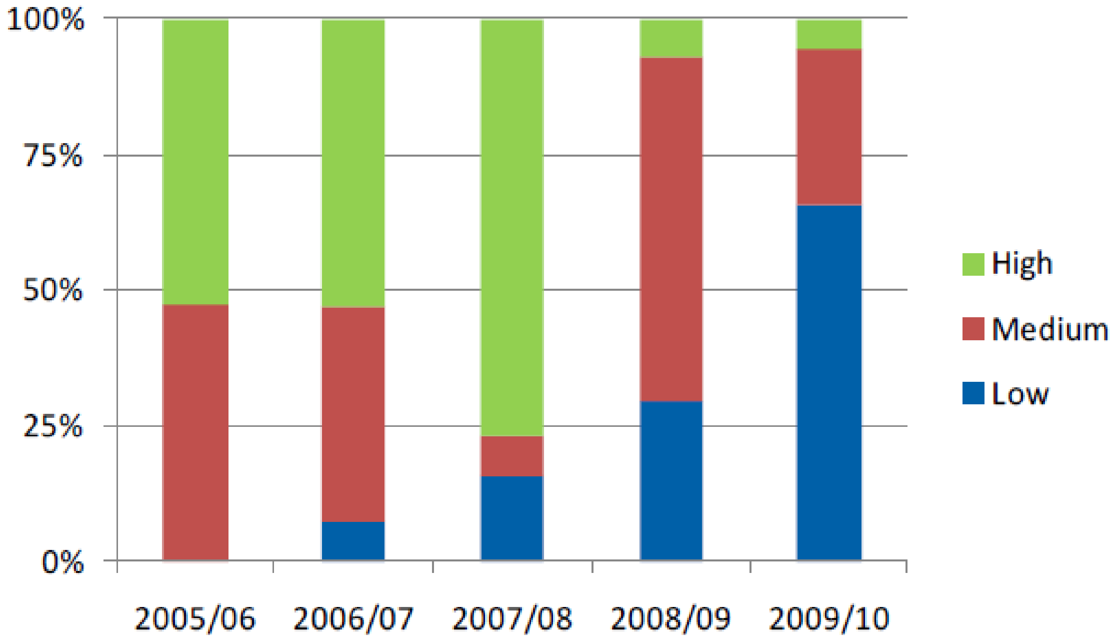
Source: New Zealand Ministry of Transport 2011a

Projects with low Benefit to Cost Ratios (BCR) are increasingly dominating the project mix (Figure 115)[46]. The latest plans are to spend $11 billion over the next ten years on 'Roads of National Significance'. Oram (2010) writes that in 2009 a consultant's report found 3 of these 7 projects have benefit to cost ratios of less than one.[47]

[46] Any project with a benefit-cost ratio of greater than one will yield net benefits to society if all costs and benefits have been included in the calculation. If Government resources are scarce, not all projects with ratios of greater than one can be implemented and alternative transport infrastructure projects may have higher social returns. For example the BCR for an Auckland City rail link (Auckland Transport, 2011) has been estimated to be in the range of1.1-2.3.

[47] The benefit/cost ratio for the Puhoi to Wellsford project was 0.4; the Waikato Expressway's was 0.5; and the Wellington Northern Corridor 0.9. The Ministry then asked for another analysis which was only allowed to report on the benefit/cost ratio for all seven projects combined. The new report found an overall BCR of between 1.5-1.9.

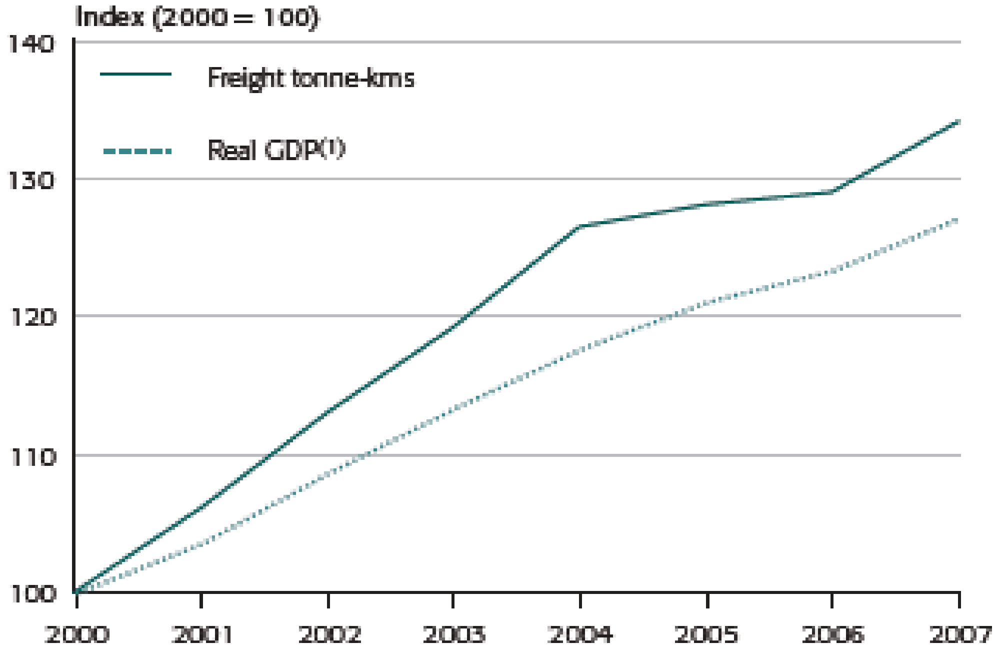
Figure 115. **Benefit Cost Ratios of approved state highway projects**



Source: New Zealand Ministry of Transport 2011a

The modal share of cars for journeys to work (see Figure 118) continues to increase, as does road freight intensity, reflecting in part the emphasis that successive New Zealand governments have placed on road transport. Seventy per cent of freight is by road. Rail and shipping account for fifteen per cent each. Road freight is generally less energy efficient and generates more greenhouse gas emissions than rail or shipping (NZ Ministry for the Environment 2009a).

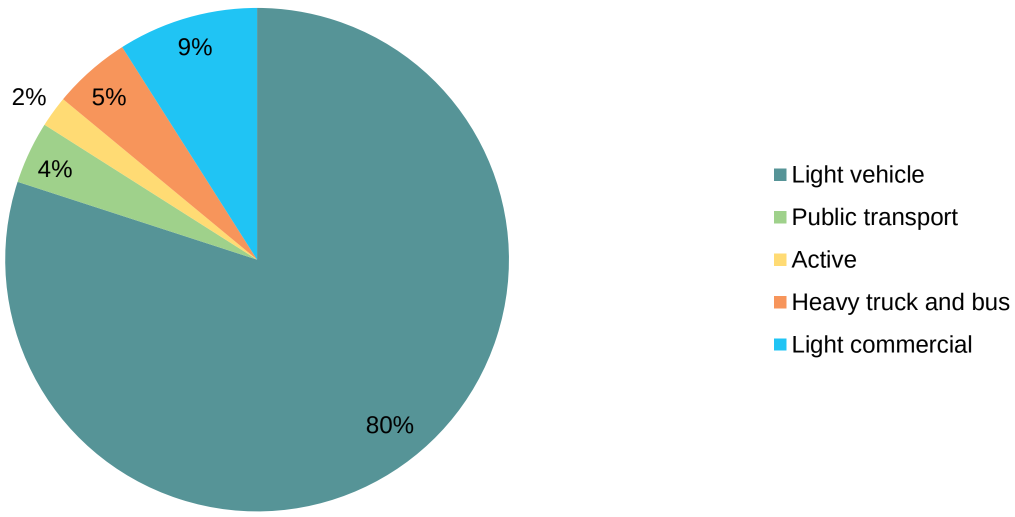
*Figure 116.***Road transport intensity of the economy**



Source: Statistics New Zealand (2008b)

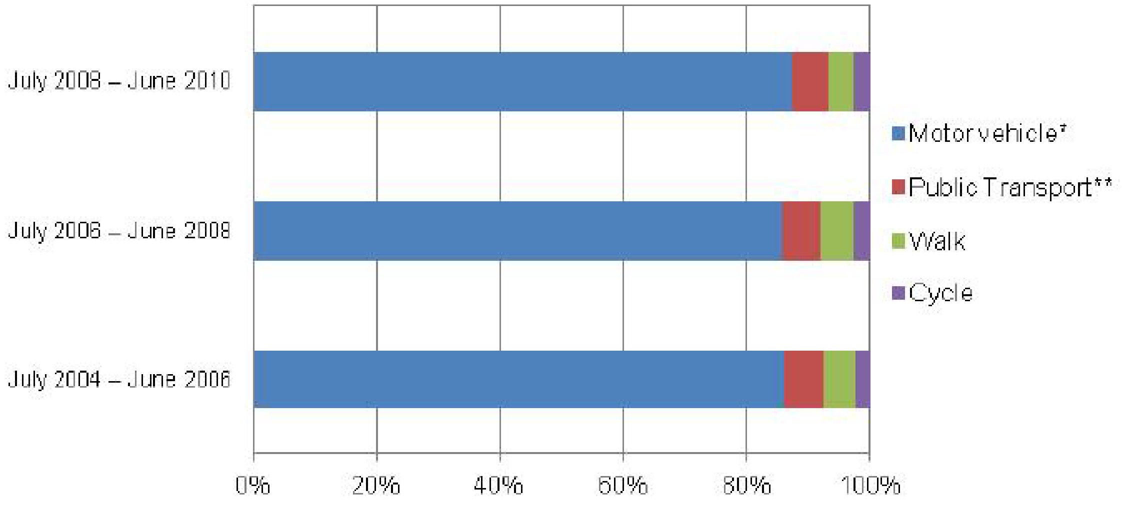
Not surprisingly given the emphasis on road infrastructure public transport accounts for a very small share of trips in NZ. Figure 117 breaks down the total Passenger Kilometres Travelled (PKT) for the different modes, while Figure 118 examines journeys to work. Figure 118 suggests that the share of work journeys via car may have been increasing slightly in recent years.

Figure 117. **Passenger Kilometres Travelled by mode**



Source: New Zealand Transport Agency (2008)

Figure 118. **Share of journeys to work by mode**

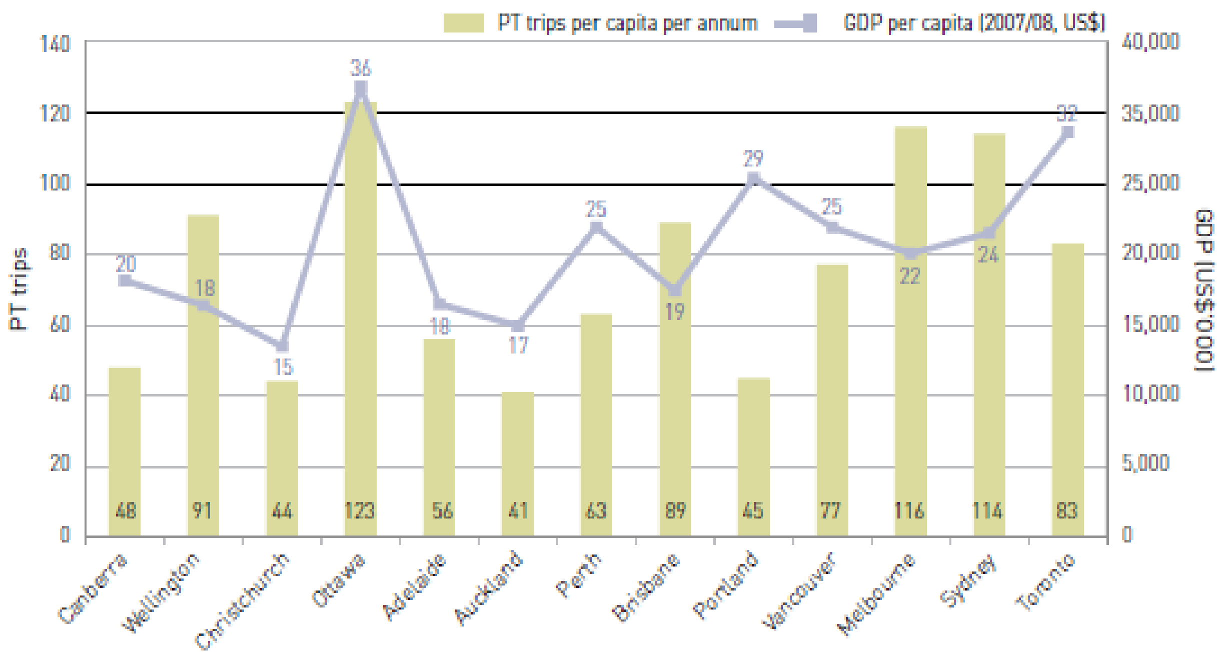


Note: Motor vehicle includes motorcycles, private vehicles and passengers in private vehicles; public transport includes journeys which may involve driving, walking or cycling to and from public transport centres

Source: New Zealand Ministry of Transport (2011a)

It can be seen below that there are arguments which suggest that a fast, efficient public transport system can make a substantial contribution to increasing the productivity of a city. Figure 119 illustrates two aspects. The first is that key NZ cities (and Auckland in particular) have fewer public transport trips than comparable cities in the US, Australia and Canada. The second is that successful cities (GDP per capita) often have a high number of public transport trips per capita. Of course, this correlation does not by itself indicate that higher public transport use cause higher GDP per person: more detailed analysis is required to establish causality. A recent benchmark study by the Auckland City Council (2011a) placed Auckland last amongst 14 comparable Australian and North American cities[48] for the number of public transport trips per annum. The study also found that Auckland fares were the highest of all the cities studied. For example Ottawa with a population of 0.8 million has 3.6 times as many public transport trips per person each year as Auckland. The system includes a rapid bus transit network which seldom intersects directly with normal traffic and travels at full speed (70-90km per hour) even during rush hour. There is also a light rail network (Mercier 2008).

Figure 119. **Public Transport Trips and GDP per capita**



Source: Auckland Regional Council (2010)

To conclude, NZ has a heavy reliance on roads for land transport- far more than many other countries. Private cars are far and away the preferred means of personal transport and heavy trucks dominate land freight movements. New Zealanders own more cars and drive more VKTs than virtually any other comparable country. The NZ fleet is old and inefficient and use of road transport for personal movement and

[48] European cities tend to have significantly higher public transport trips each year and were not included in the study.

freight has intensified in recent years. Petrol taxes are very low and public transport fares are very high. Public transport spending and use is very low compared to other OECD countries.

Current Account Deficit

One of the key macroeconomic vulnerabilities for NZ is its international net investment position. Over the last few decades NZ has run consistently large current account deficits. These are necessarily matched by capital account surpluses, or a net inflow of capital into NZ.

Oil imports is the highest component of NZs import bill with vehicles the second highest. [49] Oil imports have risen steeply since 2005 reflecting the increase in international oil prices. In the 2011 year to June NZ gross oil imports were $7.1 billion with exports totalling $2.0 billion. At the time of writing, [50] the price of Brent crude had been around $US112 per barrel for over a year. Whilst forecasting the price of oil is notoriously difficult, there is certainly some risk of oil prices rising in the short to medium term.[51] Vehicle[52] imports are another important component of merchandise imports at $4.8 billion a year.

*Figure 120.***NZ oil exports and imports nominal**

Source: Statistics New Zealand (2012b)

[49] After aggregating the sub categories of vehicles; cars, buses and vans; and motorcycles.

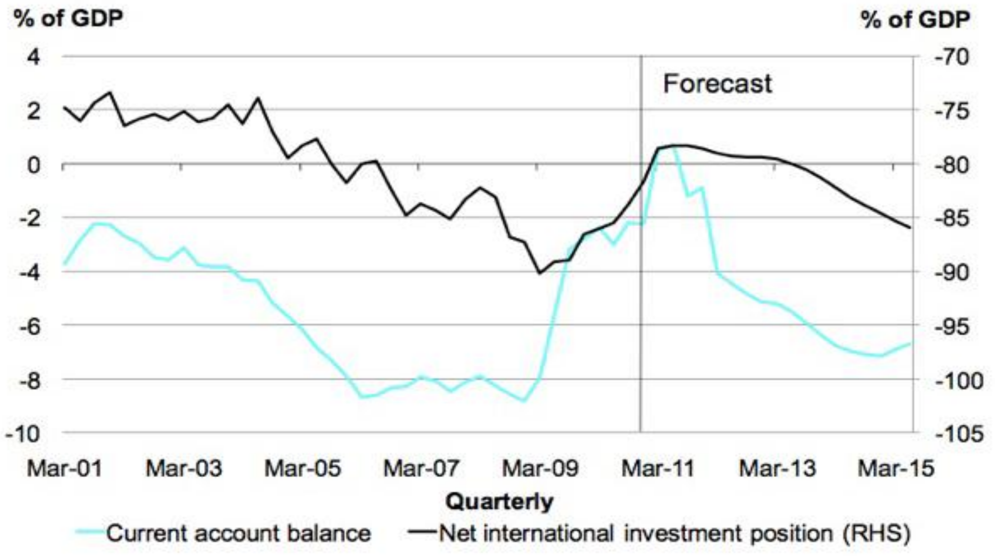
[50] August 2012

[51] See for example NZTA (2009). They have three scenarios. The high oil price scenario has oil reaching $200 per barrel quite quickly and remaining over that price for the next two decades. They put the chance of this happening as 25 per cent. The world IMF (Benes et. al., 2012) put the chances of oil being above $200 per barrel in 2020 at around 25 per cent as well.

[52] These include buses, trucks, vans, motorcycles, vehicles and accessories.

Due to the recession the recent current account deficit has been much smaller than the norm; however the position is expected to rapidly deteriorate once growth picks up (Figure 121). The large contribution that oil imports make to the current account deficit (Figure 120) means that any gains in the efficiency of the NZ transport fleet are likely to improve our current account deficit and ameliorate a key macroeconomic vulnerability.

Figure 121. **Current account and net international investment position**



Source: New Zealand Treasury (2012)

CO_2 emissions

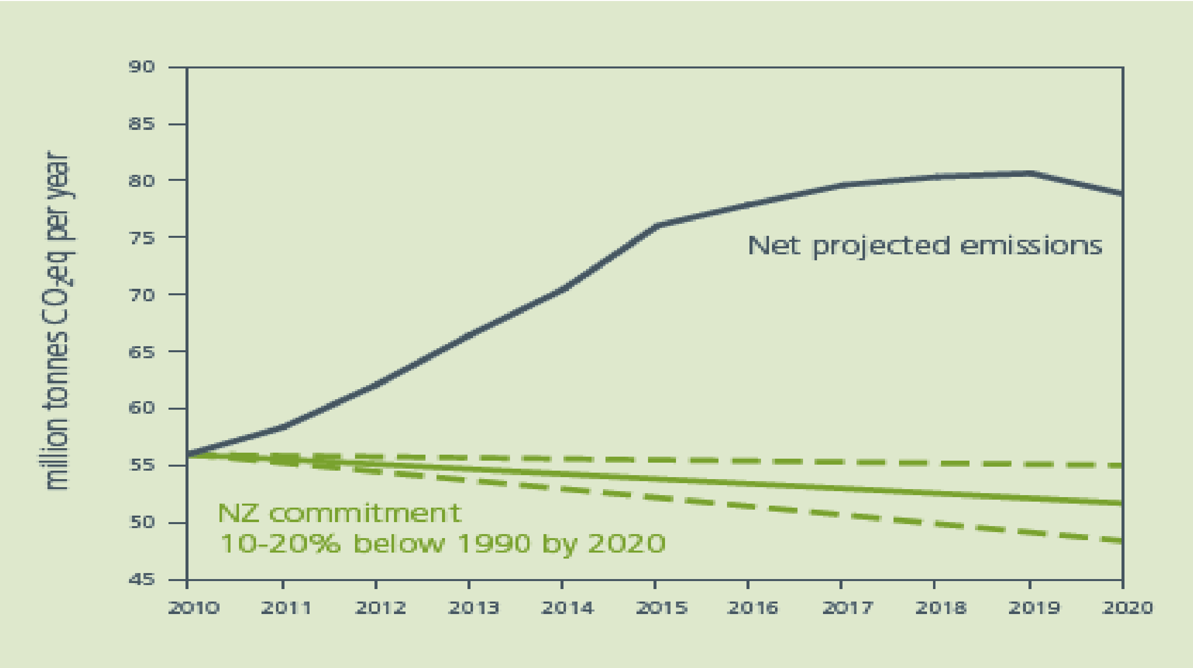
The NZ Government has gazetted its 2050 target of 50 per cent reduction from 1990 levels of CO_2e emissions (MfE 2011). The latest report from the NZ government (MfE 2012) reports NZ total gross emissions at 70.6 million tonnes.[53] Of total transport emissions of 13.6 million tonnes, more than 12.2 million tonnes are from road transport with aviation accounting for most of the rest (0.9 million tonnes). Agricultural emissions are almost 46 per cent of total emissions. Unless there are major technological advances in the sector, reducing NZ's agricultural emissions without reducing production would be challenging. This implies that reductions in transport emissions are very important for meeting NZ's long term emissions reduction target.

The interim 2020 target is for a 10 per cent to 20 per cent reduction from 1990 levels. As forests planted in the 1990s are due to be cut down (Figure 122), increasing net emissions, targets in this range are unlikely to be achieved without the purchase of international emissions reduction credits. In 2010, the Parliamentary Commissioner for the Environment estimated that the probable price range of CO_2 in 2020 would be

[53] Net emissions are 43.8 million tonnes as land use, land use changes and forestry is a net carbon sink.

between $35 to $200 per tonne with an expected price of $50. At $50 per tonne the cost of buying credits would be between $1.2 billion and $1.5 billion a year. For $200 per tonne this would rise to around $6 billion annually. The Sustainability Council of New Zealand (2012) has obtained Treasury documents under the Official Information Act which 'project that NZ's emissions will exceed its targets by 1.1 billion tonnes of carbon between 2013 and 2050. In order to still satisfy those targets, the Treasury shows NZ paying $28 billion to import carbon credits at $25 per tonne – a price far below UK government forecasts for the period.'

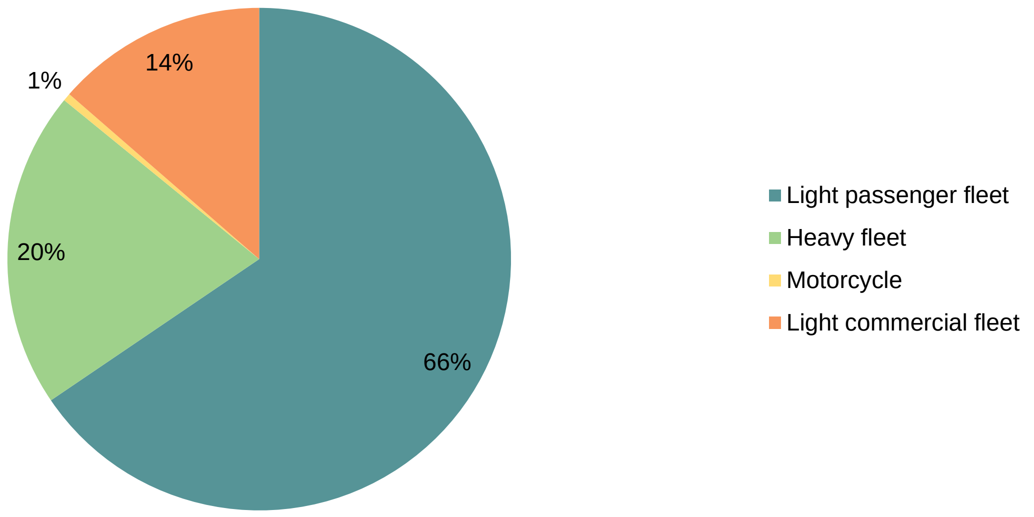
Figure 122. **Projected CO_2e emissions compared to NZ's 2020 target**



Source: Parliamentary Commissioner for the Environment (2010b)

This analysis suggests that for NZ to meet its commitments cost-effectively, emissions produced in NZ should be reduced where the cost of doing this is less than the expected cost of international emissions reductions. Realising cost-effective emissions reductions in the transport sector can play a key part in this. As noted above, more than 90 per cent of the emissions in the transport sector are from road transport so cutting NZ transport emissions means targeting road emissions. Figure 123 shows the composition of emissions from road transport.

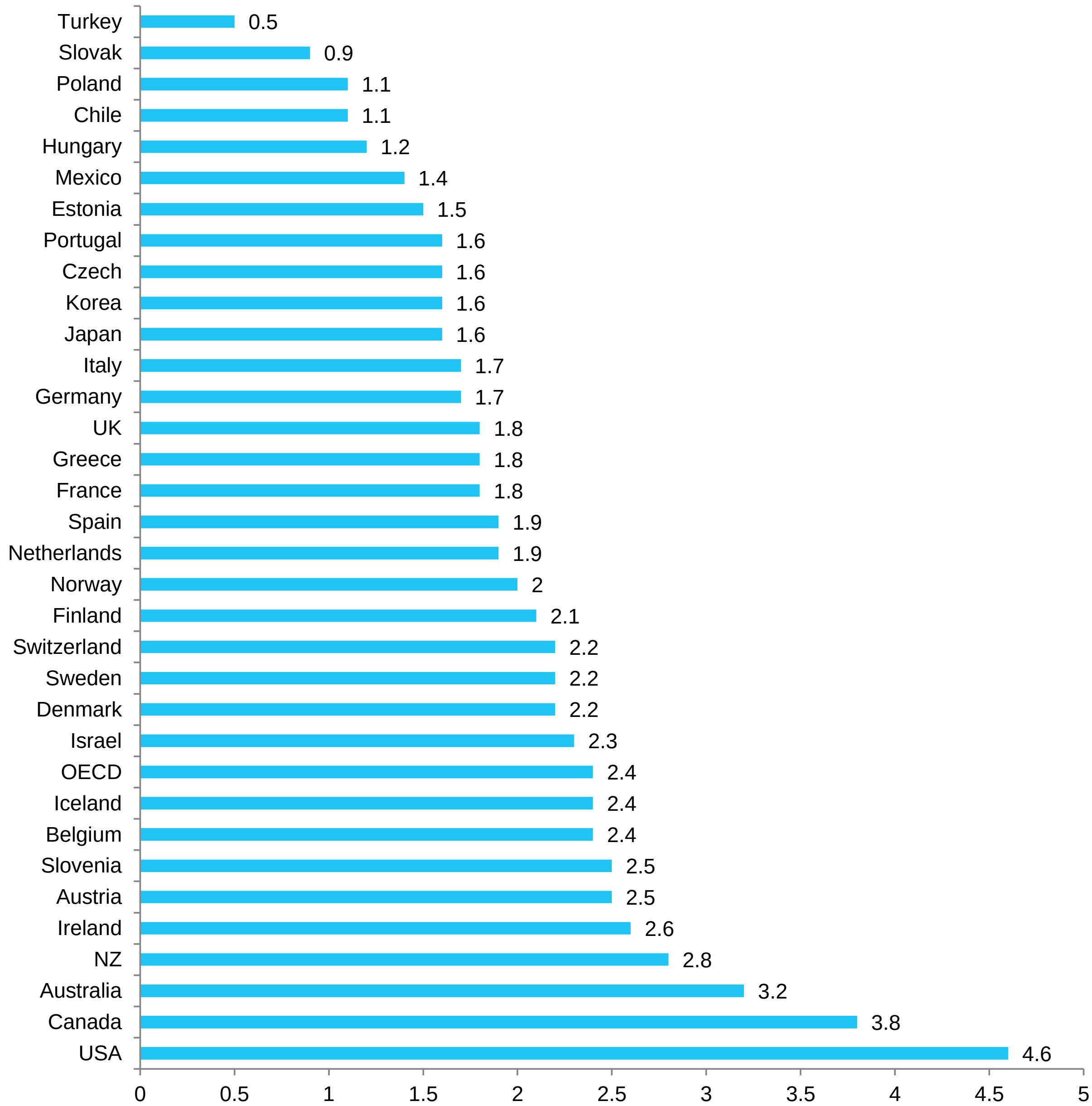
Figure 123. **Greenhouse gas emissions from road transport in NZ, 2010, CO_2e**



Source: New Zealand Ministry of Transport (2011b)

NZ road transport emissions per capita are 5th highest out of the 34 OECD countries. Only the USA, Canada, Australia and Luxembourg emit more per capita (Figure 124).

Figure 124. **Road transport emission per capita, tonnes of CO_2, selected OECD countries**



Note: Graph excludesLuxembourg with per capita emissions are 12.2 tonnes per person

Source: International Energy Agency (2011d)

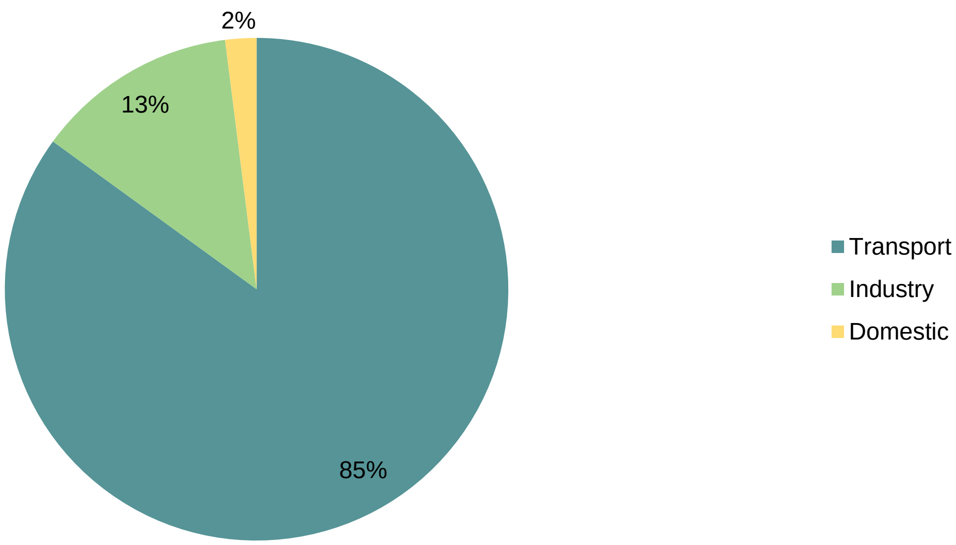
Other pollutants

As well as CO_2, cars emit other pollutants, many of which are harmful to humans. The most toxic include very fine particulates (10 microns or less) inhaled directly into the lung which exacerbates respiratory conditions and leads to increased mortality. Carbon monoxide can cause heart problems and learning difficulties. The detrimental health impacts are worse in big cities (HAPINZ 2012). Figure 125 shows that in Auckland transport is the source of the vast majority of carbon monoxide pollution. NO_2 levels for some sites in Auckland exceed the NZ ambient standards (New Zealand Ministry of Transport 2009).

The Ministry of Transport (2007) quotes studies which suggest that approximately 400 people die each year from exposure to exhaust emissions. A more recent study (HAPINZ 2012) estimates total costs of $4.28 billion due to ill health or death from anthropogenic air pollution each year in NZ - transport is responsible for 22 per cent of the total anthropogenic air pollution or $1 billion of these health damages.

In 2007 emission standards were introduced to reduce harmful vehicle emissions. As an example it was proposed that new petrol cars manufactured between 2005 and 2011 have to meet the Japan 2005 standard. Modelling by Covec (2007) suggests that the standards would have a modest impact with fuel consumption falling by 3 to 4 per cent over 10 years with similar reductions in CO_2 and particulate emissions.

Figure 125. **Carbon monoxide sources- whole year–Auckland City**



Source: New Zealand Ministry of Transport (2009)

5.3.2 Global situation

It will be argued below that there are substantial green growth opportunities which will result over time in more efficient land transport for NZ. There are also clear opportunities in the 'Clean Tech' area. Section 1.3 analysed IEA projections for the potential global opportunities in clean transport, power and renewables under an ambitious low carbon trajectory, showing that the market to supply low-carbon power, transport and building technologies could be worth more than $3 trillion by 2050 and that investments in liquid biofuels could be worth $300 billion. Given NZ's natural resources, biofuel production may be a possible green growth driver for NZ. The arguments for this proposition are developed in the following section. It will be seen that there are also other green growth opportunities in the land transport sector with a real possibility of NZ profitably reducing its carbon footprint and fossil fuel dependence.

5.3.3 Green growth opportunities

NZ's '50 by 50' emissions target suggests the need to implement cost-effective emissions reductions in the transport sector. As transport infrastructure choices 'lock in' emissions pathways for decades, choices made in the near term will affect transport emissions, positively or negatively, for many years to come.

The argument is made here that NZ is in a strong position to establish itself in the renewable energy market with abundant forestry resources which, in principle, could supply much of the country's transport fuel. Furthermore NZ already has some expertise in this area, with a number of small companies emerging with significant growth potential.

Fuel efficiency

The benefits of decarbonising land transport in an efficient way are potentially very large. NZ spends \$7 billion on oil which has a major impact on the current account deficit which increases NZ's economic vulnerability by exposing it to oil supply and price shocks. Current estimates are that NZ would need to purchase 14 million tonnes of CO_2 in 2020. In 2010, the likely cost of this purchase was estimated at between \$680m and \$2700m (Parliamentary Commissioner for the Environment 2010b). If agricultural emissions are not easily reduced, reductions in NZ's greenhouse emissions must be made by reducing emissions in the electricity sector (10 per cent of total emissions), planting more forests (currently a large sink but after 2016 becomes a source of CO_2 emissions) and/or reducing transport emissions. Each tonne of CO_2 emission reduction achieved in the transport sector is likely to lead to a one for one reduction in carbon credits that NZ would need to purchase on the international markets. Current CO_2 road transport emissions are around 12m tonnes, with business as usual, these are expected to increase to 15 million tonnes in 2020 (MfE, 2009b). If the growth rate remains at 0.8 per cent for the following five years road transport emissions will be 15.6 million tonnes by 2025 (New Zealand Ministry for the Environment 2009b) .

Increasing the efficiency of the transport fleet results in multiple benefits: fuel bill savings; less reliance on imported oil; and reduced payments for international carbon credits. As an example, suppose that the land transport fleet was 30 per cent more efficient in 2025 compared to business as usual. Likely fuel savings would be \$1176m and NZ would need to purchase 4.7 million fewer tonnes of carbon credits which, using carbon prices from Parliamentary Commissioner for the Environment would save between \$1340m and \$2116m.[54]

Would it be possible to achieve these kinds of efficiency gains? Given the relative inefficiency of the NZ land transport an obvious thing to look at is policies to improve fuel efficiency and security by implementing cost-effective mandatory light vehicle CO_2 emissions standards.

The European Union has introduced regulations that mandates new cars should have an average fuel efficiency[55] of 5.6 L per100km by 2015 and 4.1 L per 100km by 2020 (Eads 2010). In 2009 the US president announced standards requiring the average fuel efficiency of new cars to be 6.7 L per 100km by 2016 (Smith

[54] Using current price of oil and assuming land transport is responsible for 52 per cent of oil consumption (Figure 108). The expected higher oil price would mean higher savings. Carbon credits would be 30 per cent less than the projected figure of 15.6m tonnes discussed in the text (which is 4.7 m tonnes). The carbon price is taken to be between \$35-\$200 per tonne (Parliamentary Commissioner on the Environment, 2010). Lower carbon prices would result in smaller monetary savings.

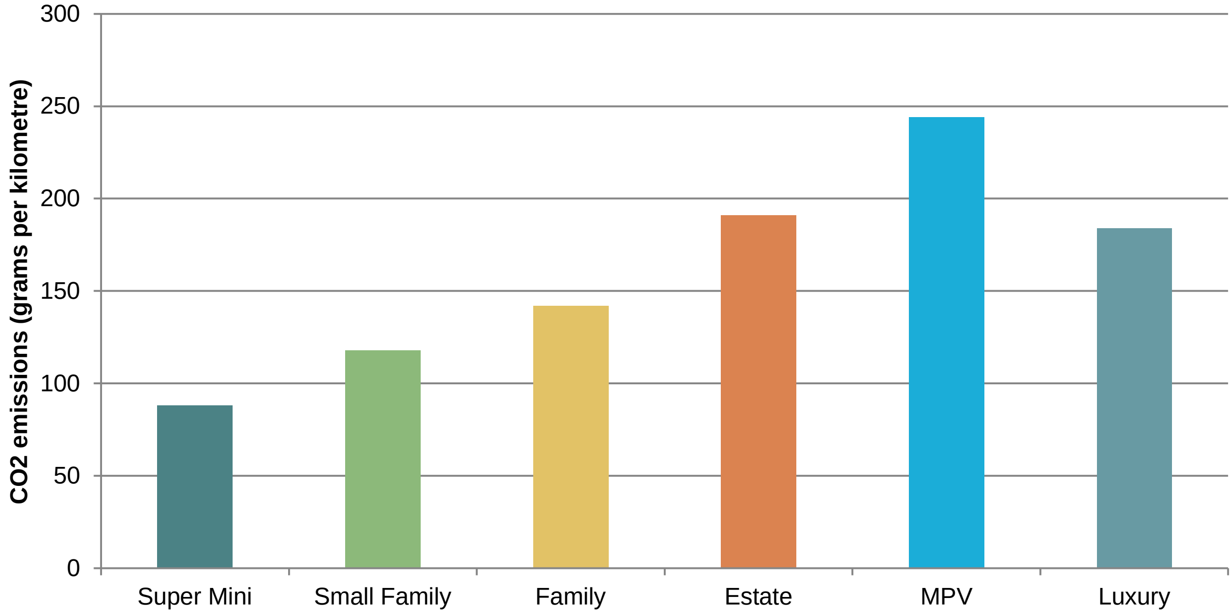
[55] The EU policy is actually a CO_2 target which is equivalent to the fuel efficiency standard quoted.

School of Enterprise and the Environment 2010). Earlier this year President Obama announced even tougher standards of 4.3 L per 100km by 2025 (Vlasic 2012). To place this in context, the average fuel efficiency of the NZ car fleet is around 10 litres per 100km (although new cars in NZ will be more efficient than the overall NZ fleet average). The current European average fuel efficiency is already 30 per cent more efficient than NZ (International Energy Agency 2008). Many countries have introduced fuel economy standards. Figure 127, from a recent study (United Nations 2011), shows anticipated new car fuel economy standards. The graph uses miles per gallon (mpg). For comparison the average fuel economy in NZ is 23 mpg. Clearly NZ will eventually benefit from the standards introduced in other countries particularly Japan; however, as the average age of imported cars is eight years, improvements will take a long time to flow through to the NZ market.[56] There is a clear opportunity for NZ to move more quickly towards a more fuel efficient land transport fleet. On the face of it, given the fact that average new car fuel economy in Europe and Japan is 50 per cent higher than the current NZ average fuel economy, given the right policies a 30 per cent increase in fuel efficiency over time for the car fleet is quite plausible. The aim would be to achieve a target fuel economy across the entire fleet which depends on the technology for each type of car and the mix of car types in the fleet. A recent study compared the fuel efficiency of the US (11 L per 100km) and French (5.5 L per100km) car fleets and found that the difference was almost entirely due to the mix of vehicles with technology accounting for only around 2.5 per cent of the difference. Smith School of Enterprise and the Environment (2010) presents figures which show that CO_2 emissions from cars produced by a single manufacturer range from 88g per km for a small car though to 284 g per km for a luxury car as illustrated in Figure 126. Clearly creating incentives so that the car fleet has a different mix of types is also important. As for new car technology the European Commission claim that their ambitious CO_2 emission targets will lead to significant benefits to consumers with expected fuel savings more than compensating for possible small increase in the purchase price.[57]

[56] The emissions standards introduced in 2007 will over time improve the performance of the fleet but as noted above the impact on average fuel economy is likely to be small compared to business as usual.

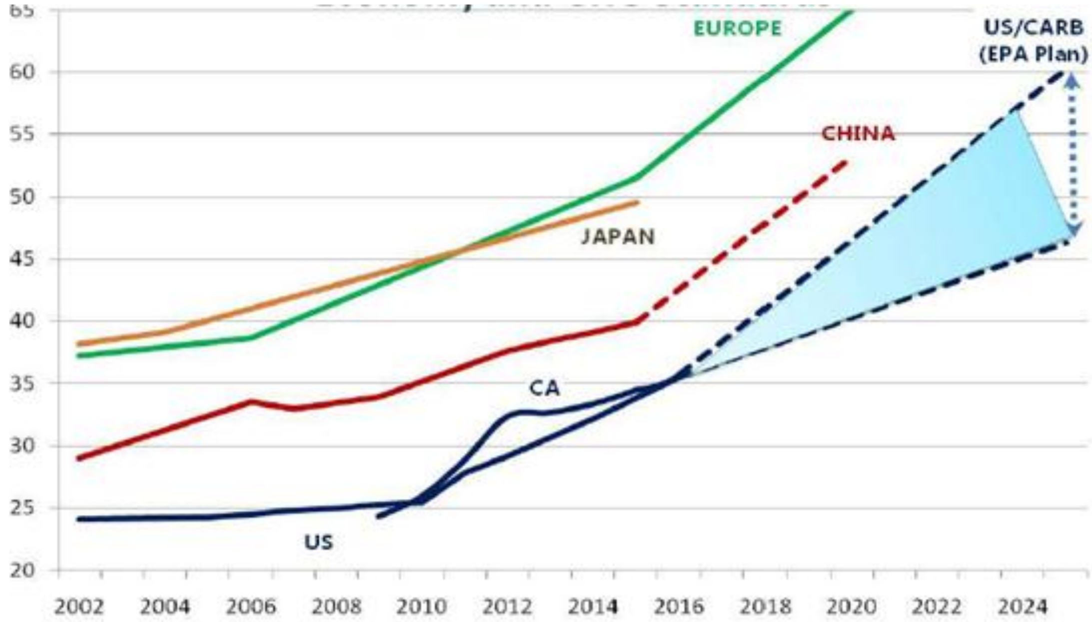
[57] The EU commission believes that in fact there may well be no increase in the purchase price of cars.

Figure 126. **CO_2 emissions from different car types**



Source: Smith School of Enterprise and the Environment (2010)

Figure 127. **Comparison of International Fuel Economy Standards**



Source: United Nations (2011)

In conclusion, NZ is one of the few developed countries without mandatory vehicle CO_2 emissions standards and analysis from organisations such as the IEA (2010) demonstrates that feasible improvements in emissions provide consumers with net financial benefits while reducing transport emissions **(green growth opportunity 9)**. Australia is currently consulting on the introduction of a mandatory standard (Department of Infrastructure and Transport 2012) and, given the history of common energy performance standards across the two countries, this is an opportunity for NZ to reflect the level of ambition in Australia. NZ could introduce mandatory light vehicle emissions standards for new vehicles with a goal of matching or exceeding any Australian standard, should one be introduced. NZ could also investigate efficient mechanisms for improving the emissions performance of imported used vehicles which make up a large share of vehicle imports. For example the US has a 'gas guzzler' tax on new cars which increases from zero for fuel efficient cars to US$7700 for the least efficient cars. The actual welfare gains by 2025 and beyond would need to be quantified with detailed modelling which takes into account new and used cars entering and older cars exiting the fleet. However, the arguments presented here suggest that the potential gains to the economy from fuel savings and reduced carbon credit purchases, of $1.3 billion to $2.1 million by 2025 may be achievable.[58]

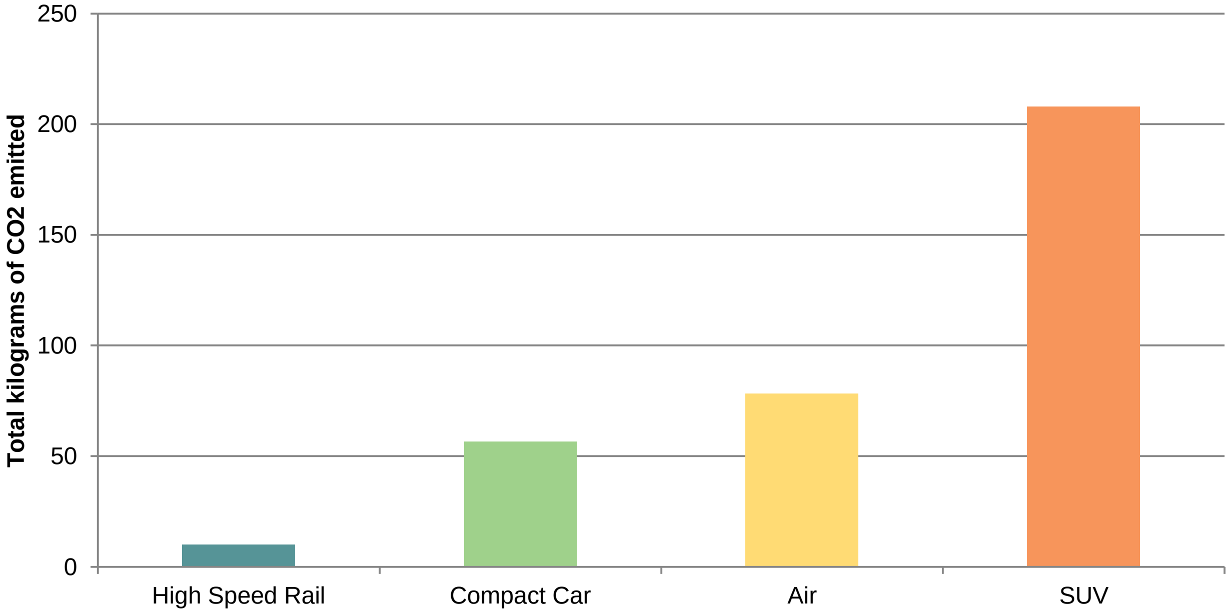
Public transport

As seen above, government policy over the last few decades has been oriented towards building roads for private cars. NZ spends much less on public transport than comparable countries. This of course could be because of some features unique to NZ such as population density and isolation. However the argument advanced here is that there could be welfare gains if NZ moved to promote public transport and more active modes of transport such as cycling and walking. Cost-effective investment in public transport infrastructure can yield welfare gains because public transport is more efficient and results in lower greenhouse gas emissions. Figure 128 compares CO_2 emissions for various modes of transport for a trip between London and Edinburgh (Smith School of Enterprise and the Environment 2010). Clearly rail is a more efficient option.[59]

[58] It should be noted that the current government has considered and rejected introducing a Vehicle Fuel Economy Standard, stating that net costs could be between $250 million and $900 million (Office of the Ministry of Transport, 2009). It is not clear how they arrived at these estimates.

[59] The rail figure is for a high-speed train. A lower-speed train would have even lower emissions.

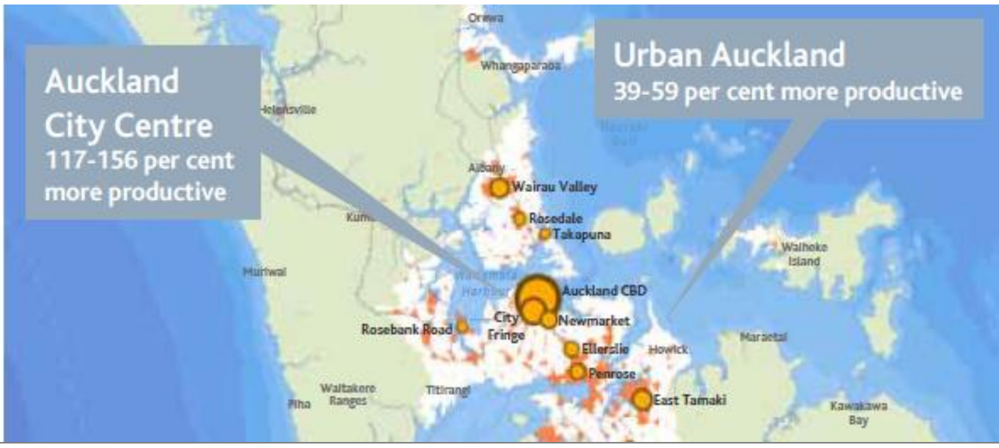
Figure 128. **A comparison of CO_2 emissions for various modes of transport for a trip between London and Edinburgh**



Source: Smith School of Enterprise and the Environment (2010)

Another reason for thinking that increased spending on public transport could be a green growth option is the economics of agglomeration. Traditional cost benefit analysis ignores agglomeration benefits. More recently there has been a focus of agglomeration benefits – for example, knowledge spillovers – flowing from externalities associated with spatial clustering of business, underpinned by factors such as infrastructure. The empirical evidence in favour of agglomeration benefits is mixed (see section 2.2.4). Some recent work suggests these productivity benefits are large - up to five times more than traditional travel time benefits (Venables 2007). Figure 129 from Auckland City Council (2011b) illustrates this for Auckland. Workers in the city centre are more productive than those in the suburbs who in turn enjoy a productivity advantage over the rest of the country (Auckland City Council 2011b). A rapid more efficient public transport system expands the pool of workers who can work in the inner city which in turn could increase their productivity and hence the productivity of Auckland and the country as a whole.

Figure 129. **Productivity advantage of Auckland City**



Source: Auckland City Council (2011b)

Research quantifying the impact of agglomeration economics is relatively new. There are no studies which attempt to quantify these benefits in the NZ context.[60] A recent Australian report on productivity concludes that: 'it seems clear from the current studies that increasing agglomeration (measured by job density) results in a significant productivity boost to Australian cities and by implication maintaining or increasing job density is important to improving productivity' (Australian Government Department of Infrastructure and Transport 2010).

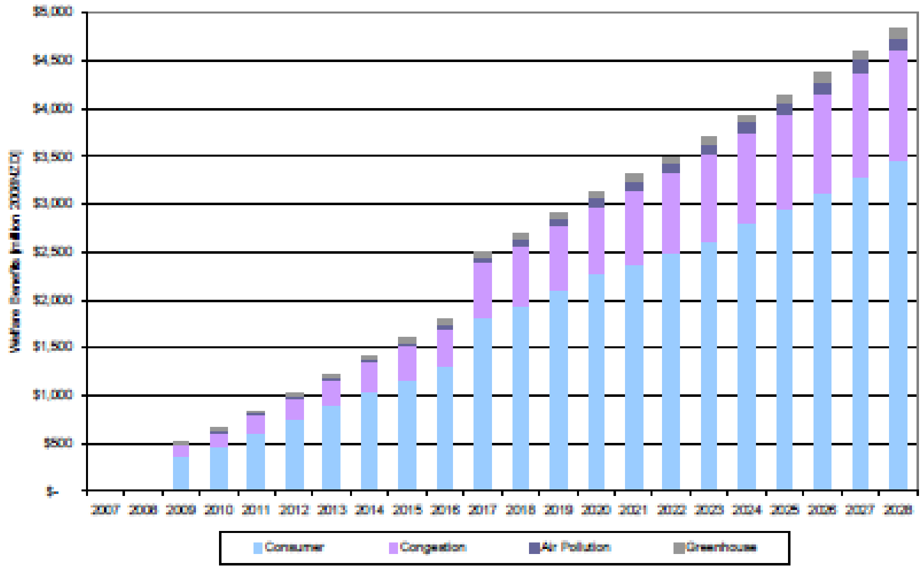
Even if the possible benefits due to agglomeration economics are put to one side, there are other potential benefits from a shift to increased public transport use, including through reduced exposure to oil prices given the expected upwards trend outlined above.

A report for the New Zealand Transport Agency (2008) considers how central and local government should respond to rising oil prices.[61] It suggests a wide range of measures to encourage modal shifts from cars to public transport and more active modes. The responses include: land use changes; direct and efficient pricing; infrastructure investment; educational campaigns to encourage behavioural changes; and freight management. The result this work is the finding that these measures will result in considerable benefits. The benefits are mainly reduced fuel bills for consumers. Other benefits include less congestion, and less emission of air pollutants including greenhouse gases. They find that per capita dependence on oil is likely to be reduced by 20 per cent. The report finds that by 2028 net benefits are of the order of $5 billion a year (see Figure 130).

[60] The NZ Land Transport Authority is reported (Hazledine 2012) to be in the process investigating this issue.

[61] The report considers three oil price path scenarios finishing in 2028: a low price scenario where prices are around $50 per barrel; a likely scenario with average prices approximately $100 per barrel; and a high price scenario with prices consistently around $200 per barrel. The low and high price scenarios are given a weight of 25 per cent and the most likely scenario a weight of 25 per cent. They make a very important point concerning the economics of risk. Suppose the government is considering building public transport infrastructure. The benefit to cost ratios is calculated as: 2.50 if oil prices are high; 0.90 if oil price are as expected; and 0.50 if oil prices are low. Considering the most likely price only, the BCR is 0.9 which suggests not building, however this is not correct. The correct approach is to calculate the expected BCR, weighting each alternative by its expected probability. This yields a BCR of 1.3 which is positive so the government should proceed and build even if three quarters of the time *ex post* the realized BCR is less than1. They apply this approach in their analysis. It also applies in the wider context as will be seen below.

Figure 130. **Welfare benefits if proposals are followed**



Source: New Zealand Transport Agency (2008)

To conclude it is likely that investing in public transport infrastructure combined with a variety of other measures could yield substantial benefits. These could be higher if agglomeration benefits increased productivity are also realised.

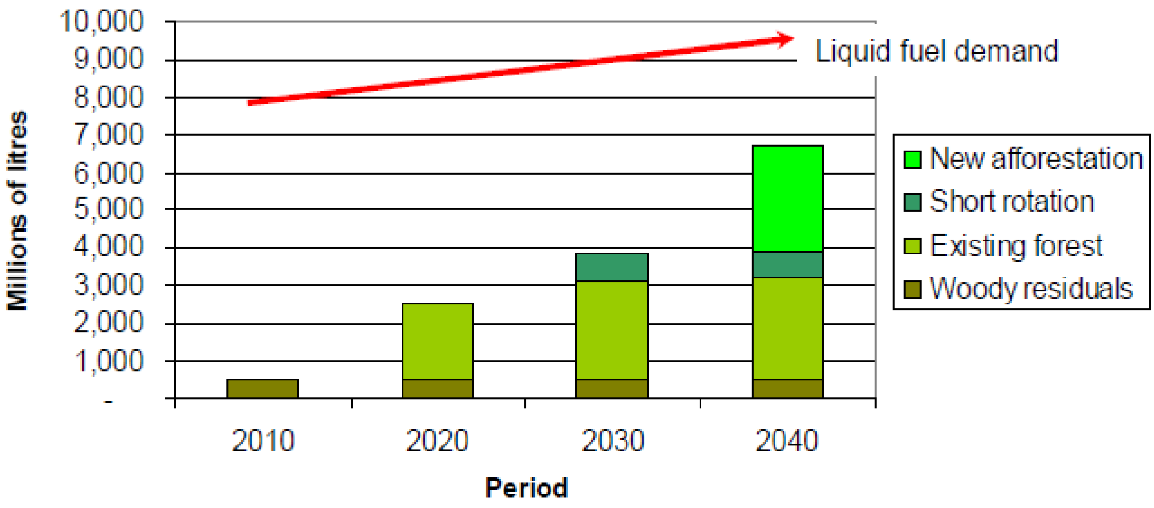
Biofuels

Second generation biofuels are an emerging technology which uses woody plant matter (lignocellulosic biomass) to make liquid fuel. The Smith School of Enterprise and the Environment (2010) detail the significant advantages second generation biofuels have over first generation biofuels, which can provide only small gains in terms of greenhouse gas emissions once the full life cycle emissions of the fuel are taken into account. In contrast second generation biofuel production can deliver emissions reductions. Furthermore they have the potential to act as a net sink of GHGs depending on land use changes associated with the feedstock.

Scott-Kerr et al. (2009) provides a comprehensive list of all the proposed or existing bio refineries around the world. As of Feb 2009 these include 30 pilot or demonstration plants and nine commercial plants.

The crown forestry institute SCION (Hall and Jack 2009) has studied the potential for second generation biofuel production in the NZ context. They identify the potential land area that can be used for afforestation for feedstock to bio-energy production. Surplus wood from the 2010 harvest excluding sawn timber (residues, chips, MDF, export logs) could supply between 12-23 per cent of NZ's existing fuel needs. Hall and Jack (2009) examine a number of scenarios to increase biofuel production with afforestation increasing from 0.8m hectares to 4.9 hectares. As more marginal land is brought into production the costs increase; however, in principle they show it is technically possible for biofuels to supply 100 per cent of NZ's liquid fuel needs, 100 per cent of NZ's heating needs and 85 per cent of NZ's electricity. Their preferred scenario is to start with existing forests, as dedicated plantings would not come on stream for 25 years, and to plant an extra 1.4 million hectares of forest on marginal land. Figure 131 illustrates how biofuel production can be ramped up over the next 30 years if afforestation started today. If only L-grade (pulp and paper) wood is used the new forests could supply biofuels equivalent to 42 per cent of NZ's current petrol and diesel demand. If all wood including S-grade logs were used this would increase to 81 per cent of current liquid fuel demand. The proposed forests would sequester 500 million tonnes of CO_2 which adds further value to the forests. From 2040 onwards there is no net increase in the carbon sink of the forests, however until this time the sequestered carbon could represent an additional income stream.

Figure 131. **Biofuel production scenarios for NZ**



Source: Hall (2009)

In the executive summary, Hall (2009) states:

> *'Given the cost of feed stocks from the current harvest, it is estimated that liquid fuels from wood could compete with fossil oil at US$117-212 per barrel, depending on the tax regime, currency exchange rate and carbon price. At this oil price there are also clear macroeconomic benefits for NZ from having energy production as another option for the log harvest, due to reductions in greenhouse liability and an increase in terms of trade. The risks associated with the oil price dropping below the cost of producing biofuels in the short term are quickly outweighed by the benefits when oil prices rise again.'*

They commission Info-metrics to carry out a computable general equilibrium analysis of liquid biofuels and find possible small net benefits under a scenario where oil prices are volatile. However, in general, Info-metrics find that with the cost estimates from Hall (2009), production costs are too high to give net benefits to the economy. The cost estimates used by Infometrics are $2.8 per litre (US$2.27) for bio-ethanol compared to a wholesale price for petrol of $1.0 (US$0.8) per litre at an oil price of US$100 per barrel rising to $2 (US$1.6) per litre at an oil price of $200 per barrel.

A more recent study (Parliamentary Commissioner for the Environment 2010a) has considerably lower costs of $1.85 (US$1.48) per litre of biofuel. The breakdown of the costs presented in the report is reproduced in Table 26. Most of the costs are feedstock costs.

Table 26. **Cost breakdown for production of biodiesel in New Zealand**

	Contribution to cost (NZD)
Growing wood	0.44
Logging	0.54
Hauling wood	0.50
Chipping	0.07
Feedstock total	**1.55**
Capital repayment	0.11
Maintenance	0.08
Labour	0.03
Gas cleaning	0.01
Electricity	0.07
Processing total	**0.30**
Production cost	**1.85**

Source: Parliamentary Commissioner for the Environment (2010a)

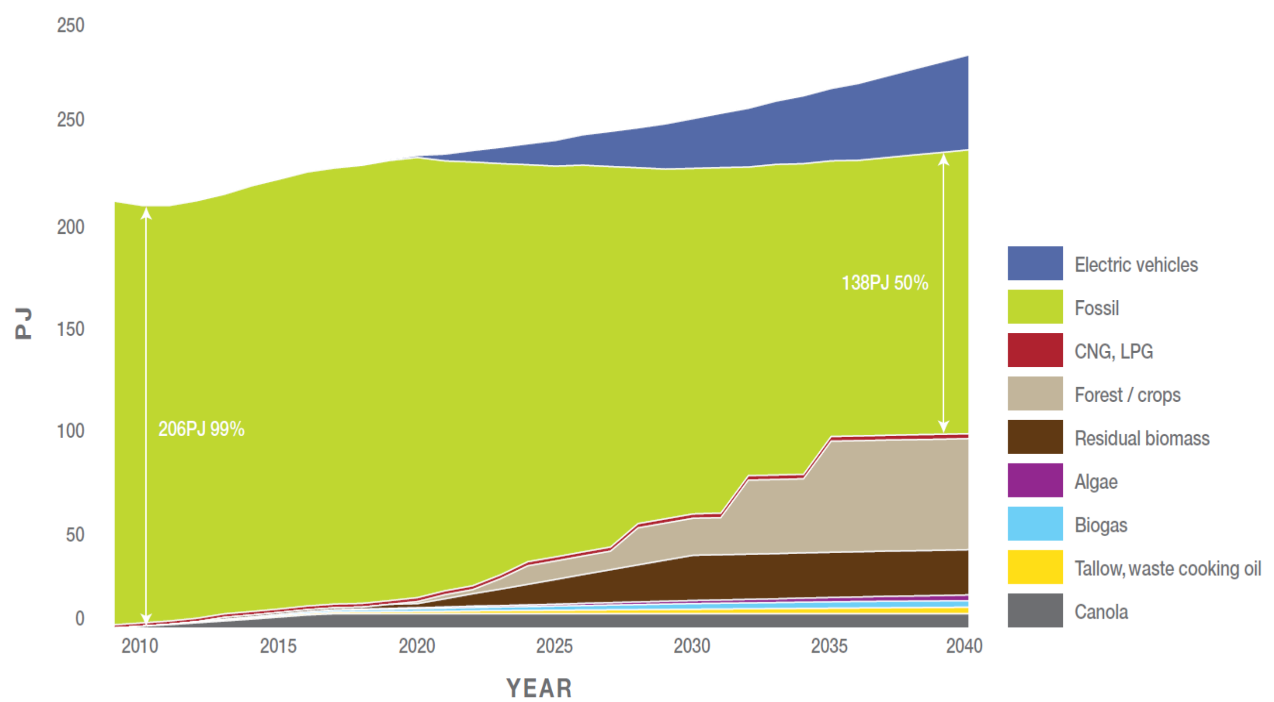
A further study (LanzaTech and Scarlatti 2008) commissioned by the Energy Conservation Authority estimates the cost of producing ethanol in NZ from a thermal chemical process from woody material at \$0.7 per litre of ethanol which translates to \$1.21 per litre of gas equivalent (US\$1.0).

The latest cost estimates from the (IEA 2009; IEA 2011e) and the US Department of Energy, if correct, could dramatically change the economics of biofuel production in NZ, as will be seen below. Given the importance of the cost estimates to the economic viability of large scale biofuel production in NZ, further work should be undertaken to understand the differences between estimates.

Proposed bio-energy strategy

The Bioenergy association of NZ has produced a comprehensive strategy ('New Zealand Bioenergy Strategy,' 2010) to achieve ‘economic growth and employment built on NZ’s capability and expertise in forestry, wood processing and bio energy production leading to new business opportunities which by 2040 supply more than 25 per cent of the country's energy needs, including 30 per cent of the country’s transport fuels’. The strategy is not only focused on liquid fuels but also includes bio gases from municipal and industrial waste, and wood fuel for heating. The report calls for six bio-refineries producing diesel and ethanol, each similar in size to Kinleith. The capital costs of each bio refinery are estimated at \$1 billion.

*Figure 132.***Potential supply of transport fuels from bioenergy**



Source: New Zealand Bioenergy Strategy (2010)

The Bioenergy strategy has been analysed by Business and Economic Research Ltd (BERL) (2011) using a computable general equilibrium model. Their model differs from the Infometrics study (Hall and Jack 2009) in a number of ways. The first is the time frame which looks forward to 2040 compared to the SCION scenario modeled which was for 2020. Another difference is that the BERL model does not hold employment constant. The production cost figures are also lower than those in the SCION study. For example, for diesel their cost is $1.03 per litre, which is broadly in line with the (IEA 2009; IEA 2011e) estimates and higher than the DoE projection of US$0.62

BERL (2011) project that the Bioenergy strategy adds 1.2 per cent to business as usual GDP in 2040, an increase of $6.1billion in 2010 dollars. Furthermore, the trade balance is projected to improve by $1.9billion and employment by 28,000 in 2040. As BERL observe:

> *'As a gauge to the scale of this impact, the direct contribution to GDP of the combined dairy, meat and other food processing sectors in 2010 totalled $6.4 billion. ...the meat processing sector in 2010 directly employed approximately 25,500 full-time equivalent positions'*

They argue that:

> *' ...liquid fuel production from the perspective of the individual operator is at best marginal in terms of financial viability, given our current knowledge and the assumptions made. The financial return although positive is unlikely to be sufficient for the risk faced for an investor. We note however, this assessment could well alter in future years as research into potential technologies proceeds'*

However, their modelling:

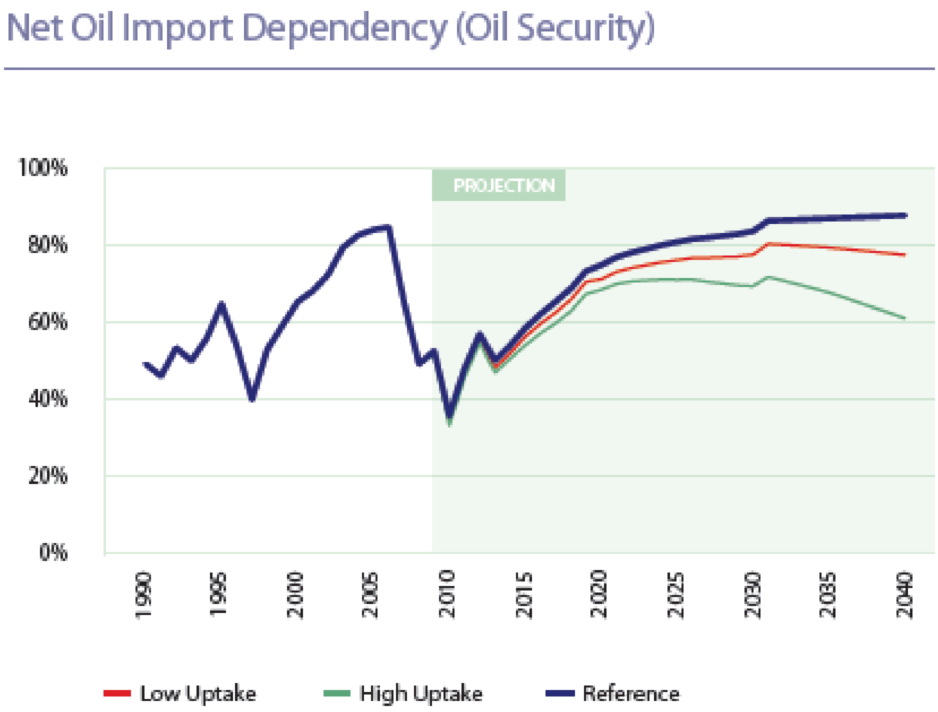
> *'suggests there are potentially significant wider economic benefits in terms of critical macroeconomic indicators. Arguably, the macroeconomic impact of the Strategy of greatest significance is that on the trade balance. The past three years has seen the global economy weary and wary of debt'*

The Bio-energy strategy also anticipates further benefits including

> *'increased regional prosperity; future proofing NZ's energy supply and cost through less reliance on imported fuels; strengthening NZ's international green trading advantage; reduced environmental impacts to air, soil and water; and economic benefits linked to waste reduction'*

The NZ Ministry of Economic Development (2009) develops a market model where biofuel development and uptake of electric vehicles are driven by market price signals. They assume that there is a high carbon price of $100 per tonne post 2012 combined with oil prices rising to $180 per barrel by 2030. Under these assumptions, they project that, by 2040, 25 per cent of the country's primary energy supply would come from biomass, which is similar to the results of the bio-energy strategy. Figure 133 illustrates the resulting decrease in oil import dependency.

Figure 133. **Projected net oil imports with a high carbon and oil prices**



Source: New Zealand Ministry of Economic Development (2009)

The economics of biofuels depends on two important factors. The first is the price of production with the latest estimates suggesting that production costs are likely to be at or below the equivalent of US$100 per barrel. The second factor is the price of oil.

Barriers to biofuels

The forestry case study (section 4.7) argued that, despite clear opportunities to improve the performance of the industry as a whole, NZ forestry companies are increasingly producing logs for export rather than adding value in NZ. While some of the bigger NZ companies such as Carter Holt Harvey are following the developments overseas in biofuel development technology they are not currently planning to invest themselves (Ryder 2012).

One of the key strands of the Scion Scenarios is for large scale afforestation on marginal lands. The physical and time scales of doing this means that realistically only direct government action would lead to the kind of area being planted annually that the scenario envisages. Long lead times forests which need to be planted now for harvest for biofuels in 25 years with significant uncertainty mean that private industry is unlikely to develop the forests on the scale required. R&D support is essential to help companies develop and commercialise technology. As will be seen below, a familiar story is that new companies with promising technologies in this area start up but then fail to develop further, often due to capital constraints. Well-designed policies and government interventions coupled with increased investment can stimulate R&D in energy to a socially optimal level. The nature of activity and the nature of market failures are different at different stages of the process, and well-designed innovation policy should take this into account. For technologies which have passed through the demonstration phase, policies which increase demand can help to increase earlier stage research by creating more certainty around demand for a technology, and also lower unit costs as firms learn by producing and installing the technologies.

Electric cars

The green growth suggestions outlined in the first sections of this case study could lead to reductions of NZ's transport emissions and hence oil purchases by up to 80 per cent by 2040[62]. To complete a transition to a zero-carbon transport sector, electric vehicles powered by electricity generated using renewable resources can also be an important part of the vehicle mix. Currently electric cars are not cost effective but the technology is evolving rapidly. The Ministry of Economic Development (2009) scenario with high carbon and oil prices estimates that approximately 50 per cent of vehicle fleet would be electric by 2040 (see Figure 134).

As above for biofuels, electric cars reduce oil consumption, the current account deficit and likely carbon credit purchases (even more so if the electricity is generated entirely from renewable resources). Increased use of hybrid and electric cars when oil prices are volatile and increasing could make economy more efficient and resilient.

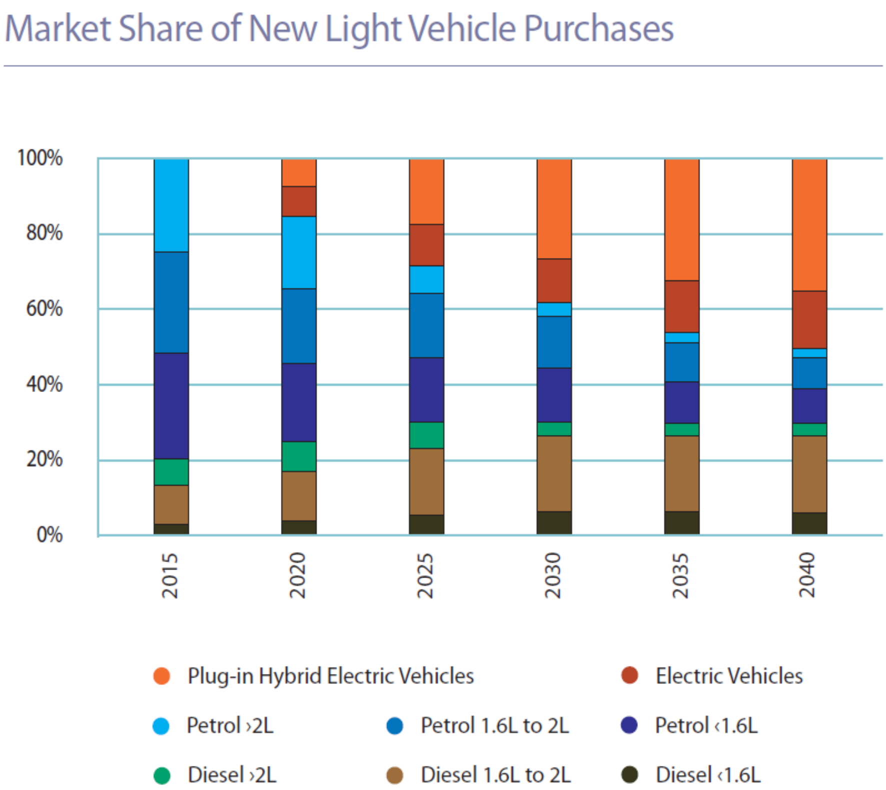
Given this opportunity it will be important make sure NZ is prepared for an eventual increase in the deployment of electric vehicles **(green growth opportunity 10)**. Given NZ's low emissions intensity of electricity, EVs could eventually play an important part in reducing emissions from transport. The costs for vehicles would be expected to fall as deployment of the technology increases globally, and NZ can prepare to take advantage of this by ensuring that the grid and other systems necessary for smooth adoption of EVs are in place as the technology matures. Electricity suppliers, business, government and consumer organisations could prepare for increasing EV penetration, including codes and standards for charging, metering arrangements, integration with smart grids (see green growth opportunity 7), recharging infrastructure, and so on, drawing on the near-term actions for EVs in the IEA's technology roadmap (IEA 2011b).

The electricity case study (section 5.1) also argued that as the world transport fleet starts to see significant electric vehicle penetration there may be green growth opportunities for NZ companies in associated niche markets.Many countries subsidise the high capital costs of electric cars. For example in Ontario, Canada subsidies vary between US$5000-US$8000 (Ontario Ministry of Transport, n.d.) with similar amounts in the UK (United Kingdom Department for Transport 2010) and France (European Automobile Manufacturers

[62] As discussed above, a realistic aim for increased fuel economy measures would be to see a 30% decrease in oil use for the land transport fleet; increased public transport and measures to encourage more active modes of transport could reduce oil use by 20 per cent; and bio-fuel production could make up 30% of transport liquid fuels

Association, n.d.). In the US cars such as the Nissan Leaf electric vehicle and the Chevrolet Volt plug-in hybrid are eligible for a grant worth up to $7500 (IRS 2009). Currently new electric cars in NZ are exempt from paying road user charges of $48 per 1000km.

*Figure 134.***Projected electric and hybrid car penetration with high carbon and oil prices**



Source: New Zealand Ministry of Economic Development (2009)

Examples of green growth companies in the transport sector

There are a small number of NZ companies which have been actively involved in developing biofuel technologies. In an environment with a strong biofuel industry cluster and a comprehensive government strategy including an afforestation programme, with R&D and start up support, companies such as these would have a much better chance of thriving in NZ.

LanzaTech has developed a biotechnology to convert carbon monoxide waste gas to ethanol. An initial pilot plant at New Zealand Steel has proved that the technology is successful. It is developing similar projects in China to implement the technology at steel plants there. Furthermore it is developing an integrated bio-refinery using forestry waste in the US (LanzaTech 2012a). It has won numerous awards including the prestigious 2012 Global Cleantech 100 - the third year in a row it has achieved the honour (LanzaTech 2012b). It has recently been awarded US federal funds to develop aviation fuel from ethanol. It is actively researching using its technology to produce biofuels.

Macro impacts

As discussed in Box 2, the GDP impact of increasing production of in a sector such as biofuels depends on a number of factors including what proportion of the employment for biofuels production is diverted from other sources and what proportion of people would not have been employed in the absence of the biofuels facility. If all people employed in biofuels switch into the industry from another job, a new biofuels sector would increase employment in that sector but must reduce employment in other sectors. A first order estimate of the change in GDP is then the increased production in the biofuels sector minus the loss of production from the sector where workers used to be employed. However, if there are unused resources in the economy and less than full employment, then the increase in GDP may well be more than the increase in production due to multiplier effects. Workers paid in the new industry will use some of their wages to buy goods which will increase demand in the economy and, in turn production, as other firms respond to the increase in demand for their goods. As some of the extra employment generated by a biofuel development strategy will be in regions with relatively higher unemployment or underemployment, it is possible that overall employment could increase.

In combination with improved vehicle fuel efficiency and investments in public transport, the transport measures outlined in this section could provide cost-effective emissions reductions, reduce congestion and provide savings to consumers through lower fuel bills.

5.3.4 How do we get there?

We have argued that over the next 10-40 years NZ should act to decarbonise transport and that oil prices are expected to rise. There is some NZ oil production but reliance is mostly placed on imports which will make a large and increasing contribution to the current account deficit.

Reducing our dependence on oil could yield a green growth dividend. This could be achieved through increasing biofuel production, increasing the efficiency of the car fleet, investing more in public transport and encouraging transport modal shifts,. Some of the possible policy options to realise these have been discussed above.

For fuel efficiency possible policy interventions could include standards for new and imported cars or a graduated tax on new and imported cars. Inefficient cars could be taxed with the revenue used to subsidise fuel efficient cars creating an incentive for consumers to buy cars which travel further on each litre of petrol. Increasing petrol prices to those approaching the OECD average would also create incentives to reduce fuel use.

The policy options to encourage a transport modal switch from private cars to public transport, walking and cycling (**green growth opportunity 11**) are presented in the NZ Transport Agency (2008) report. The responses include: land use changes; congestion charging; infrastructure investment; educational campaigns to encourage behavioural changes; and freight management.

Large-scale second-generation biofuel production could, if successful and cost-effective, improve greenhouse gas emissions while reducing oil imports and improving NZ's energy security. The economics of large scale biofuel production depend on expected input and oil price paths. As discussed in the forestry case study (section 4.7), other income streams can complement biofuel production from woody matter, helping to make a facility more profitable. A full policy analysis or road map is outside the scope of this report. However, it is clear that realising green growth opportunities would require both government and business action. Some key elements that could feature in a successful approach are briefly discussed below **(green growth opportunity 12**).

Industry and government could continue to assess the expected net benefits developing large-scale second-generation biofuels in NZ, and develop a strategy for large production if net benefits are expected. This strategy could include support for R&D; pilot plants, commercialisation of the technology; and large-scale afforestation.

The biofuel scenario discussed above relies on a comprehensive afforestation programme over the next thirty years; for this to be successful, sufficient incentives for private land owners to plant trees would have to be in place.

On the demand side, once second generation biofuels are available, a carbon price which internalises more of the social cost of greenhouse gas emissions and which rises over time could help to create incentives for renewable biofuels. Alternatively, a differentiated fuel tax which was considerably higher for fossil fuels could have a similar impact.

Creating incentives for a strong biofuel industry cluster with increased R&D and start up support could well be socially beneficial. Crown Research Institutions such as Scion could be given a stronger mandate (with matching funds) to launch pilot biofuel projects. The next step would be to turn successful pilot projects into commercially successful operations. Joint venture initiatives with industry in NZ and/or overseas may be a cost-effective way for NZ to increase innovation activity to socially beneficial levels –particularly for commercially unproven technologies. Once the technologies are proven to be competitive there will be strong incentives for existing forestry companies to make substantial investments in bio-refineries which could help to create momentum towards sustainable transport fuel production on a larger scale.

6 Conclusions

Growth, wellbeing, and opportunities for NZ

Growth matters because it is associated with opportunities for higher levels of consumption which can lead to higher levels of wellbeing, and the improvement of human wellbeing is a worthy objective in itself.

Growth comes about as a result of technical change, certainly over the long run. Yet, conventional measures of growth are incomplete, either failing to take into account long-term effects or failing to capture impacts that are felt outside economic markets. The missing elements are changes in the stocks of assets, such as minerals, changes in the supply of public goods such as landscape, and pollution of the atmosphere.
A green growth framework is more ambitious. It takes account of some assets and non-market goods, so that improvements in growth come about through genuine improvement, not by trading off one measured benefit at the expense of an excluded cost.

In an economy, if individuals, firms and governments were to take account of asset stocks and non-market goods in all their decisions about consumption, production and policy, there would be no distortions which favour resource depletion or the creation of negative externalities. The full costs and benefits of every choice would be taken into account. However, this is not the reality, and it is the role of government and to some extent managers voluntarily to set policy to prevent the worst of these distortions. In a trading environment, similar distortions occur in markets in which many countries operate. Here the effects may occur overseas or globally, and good policy might avoid the worst of them.

A good place to start to understand green growth is in the measurement of changes in assets and non-market impacts. Once the measurement is in place, policy can follow. One can look at distortions within the domestic economy or in trade. The measurement issues are essentially the same, except that in the production of traded goods there is the harder task of making comparisons with trade rivals.

This report has used available data to contribute to this measurement task, adding to the understanding of NZ's relative environmental performance to and of opportunities to raise that performance while enhancing New Zealand's (NZ) economic prosperity. The results of our analysis have suggested 21 valuable, feasible opportunities for NZ. The detailed calculations necessary to estimate the expected benefits of these opportunities and to create a quantitative ranking are beyond the scope of this report. However, preliminary expert judgement of the opportunities against the criteria of potential impact and lead times suggests that the following specific actions may be among the highest priority: improving water allocation and management; raising the average share of R&D in GDP, especially in sustainable and low-carbon agricultural technologies; and improving the energy efficiency of land transport and buildings. The New Zealand Green Growth Research Trust now plans to work with local stakeholders to subject this preliminary judgement on priorities to further scrutiny, and to refine and select opportunities from the set identified here.

7 Appendix

Additional information

Section Contents:

This Appendix contains further information on data sources, calculated Balassa Index values, lists of export rivals, and estimates of performance on a selection of environmental performance metrics.

7.1 Sources of data

Trade data

7.1.1 Balassa index of revealed comparative advantage

The competitiveness analysis draws on a detailed and comprehensive international trade database. For the year 2009, global trade data was extracted from the UN COMTRADE database and the associated International Trade Statistics Yearbook (ITSY). Data for the year 2010 data are not yet complete. At the relatively detailed level chosen, the data cover 258 commodities, grouped into ten main categories, see Table 27.

Table 27. **Main categories of the Standard International Trade Classification**

Variable	Unit
0 – food and live animals	5 – chemicals and related products not elsewhere specified
1 – beverages and tobacco	6 – manufactured goods classified chiefly by material
2 – crude materials, inedible, except fuels	7 – machinery and transport equipment
3 – mineral fuels, lubricants and related materials	8 – miscellaneous manufactured articles
4 – animal and vegetable oils, fats and waxes	9 – commodities and transactions not classified elsewhere
0 – food and live animals	5 – chemicals and related products not elsewhere specified

Source: UN COMTRADE database

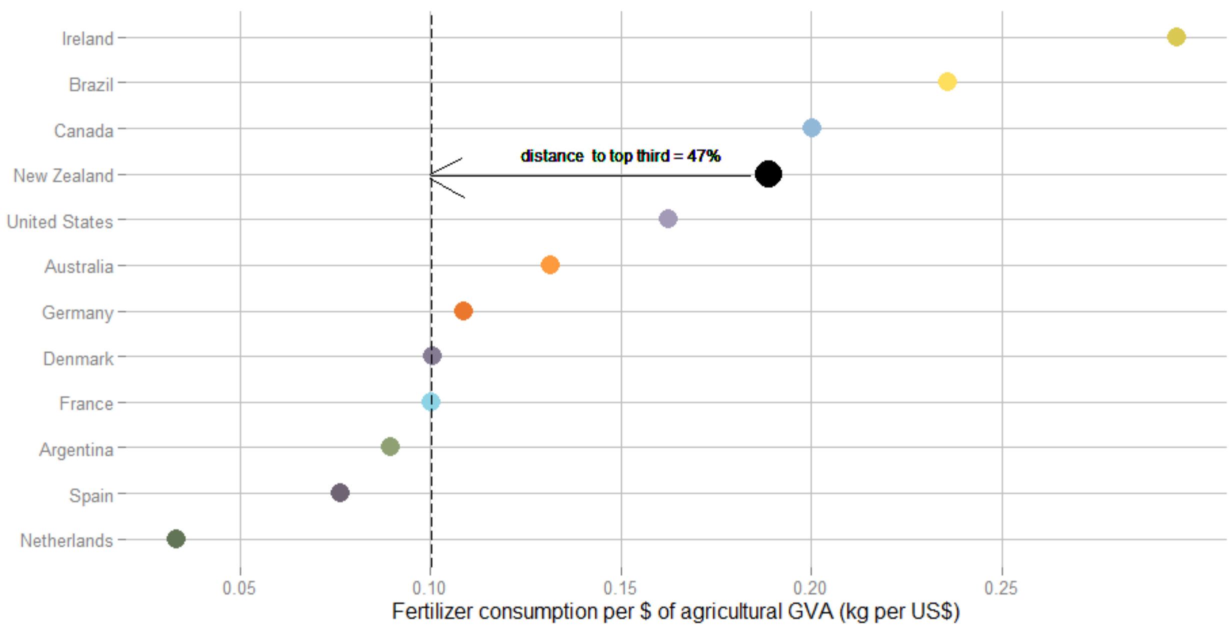
7.2 Comparisons of fertilizer and water use

Comparing performance at aggregated agriculture sector level

7.2.1 Comparison with meat sector rivals

New Zealand is such an intensive user of fertilizer in agriculture that its performance on this metric would have to improve by 47 per cent to catch up with rival meat-producing countries in the top third of performance.

*Figure 135.***Fertilizer consumption per US dollar of agricultural GVA, 2007, among meat rivals**

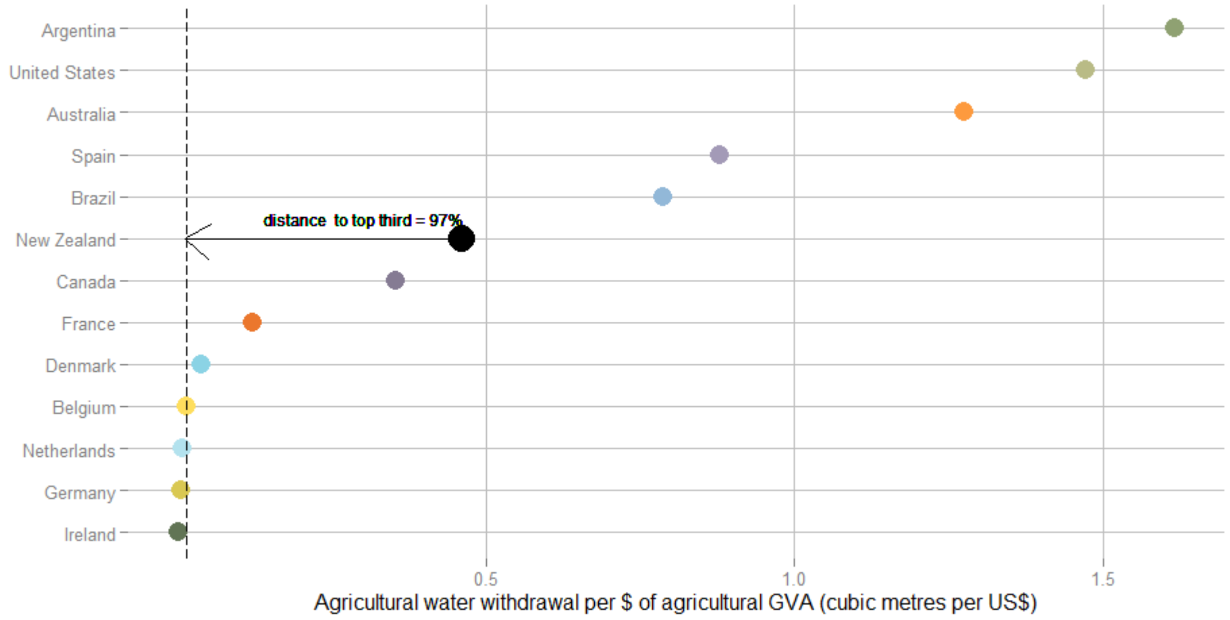


Note: distance to the top third' is calculated for rivals in the global meat market. Countries (in this case, only Canada) which are rivals in NZ's main export market but not the overall global market are included in the graphs but not in the 'top third' calculation data are a three year moving average (2006-2008)

Source World Bank (2011b)

New Zealand relies quite heavily on water withdrawals in its agriculture relative to some of its rivals. On this measure the data shows a great variation of water intensity in agriculture among countries who are its rival meat producers. The measure of water withdrawals excludes rain which falls on agricultural land. Some countries have near-zero water withdrawals, so a simple calculation of NZ's distance to the leaders shows that NZ would have to cut water abstraction by 97 per cent to catch up with the leading players.

Figure 136. **Agricultural water withdrawal per US dollar of agricultural GVA, among meat rivals**



Note: *latest available year (see Appendix for country details) 'distance to the top third' is calculated for rivals in the global meat market. Countries (in this case, only Canada) which are rivals in NZ's main export market but not the overall global market are included in the graphs but not in the 'top third' calculation*

Source *FAO AQUASTAT and OECD (2010b) for New Zealand*

7.2.2 Comparison with horticulture sector rivals

Relative to other horticulture producers, total agricultural water withdrawals are lower (better) and fertilizer use is higher (worse) but declining (improving). New Zealand's intensity of water and fertilizer use may be driven by other agricultural sub-sectors other than horticulture.[63]

While New Zealand's water withdrawals for agriculture per dollar of agricultural output are low relative to global rivals they increased between 1999 and 2006. New Zealand's high fertilizer consumption per dollar of agricultural value added may be due to the application of fertilizer to dairy pasture rather than any high use in horticulture.

[63] More detailed result can be obtained by examining fewer countries in more detail, for example Saunders, Barber, and Taylor (2006) conduct a detailed comparison of energy and fertilizer use in apple and onion production in NZ and the UK.

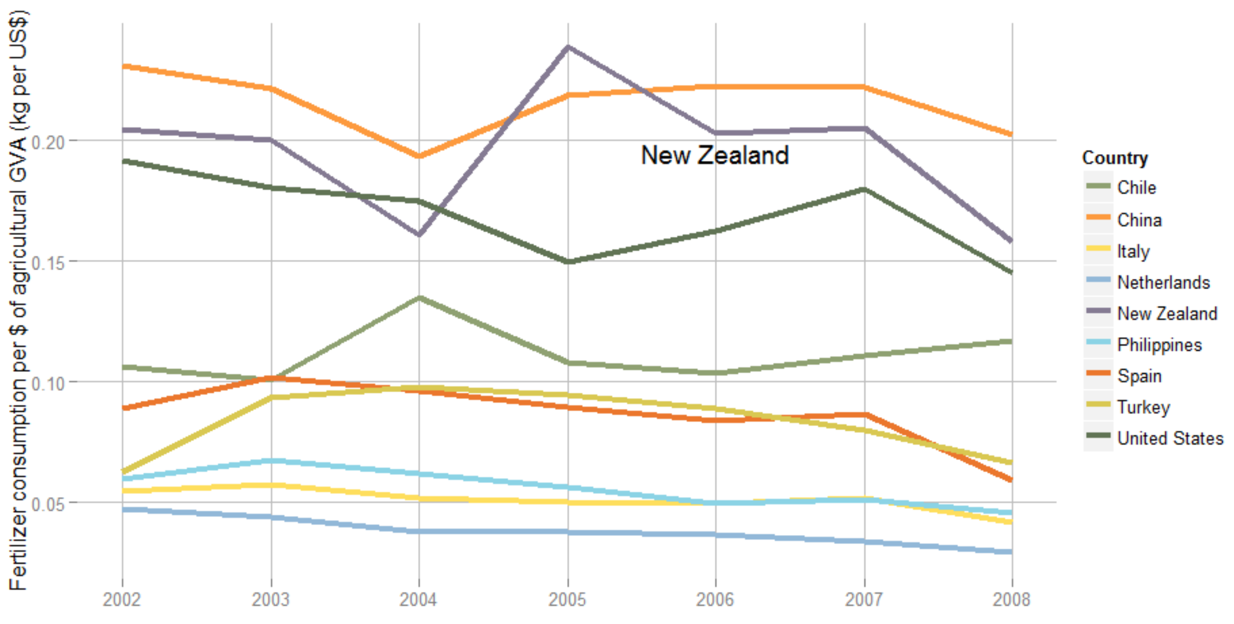
Table 28. **The horticulture industry can only be judged against its rivals using aggregated agriculture metrics**

Performance relative to rivals	Performance deteriorating	Performance steady or improving
Relatively green	*green with risks* • annual freshwater withdrawals for agriculture (l/$GVA)	*Green* • *water quality* • *gas/diesel oil consumed in agriculture (l/$GVA)*
Not relatively green	*not green, could worsen* • N/A	*not green, may improve* • fertilizer (kg/$GVA) • N_2O emissions (kg/$GVA)

Source: *Vivid Economics*

The intensity of NZ's fertilizer use has declined from its peak but is still high relative to rivals in the global fruit and nut market. NZ has reduced fertilizer consumption by 23 per cent over the period 2002-2008.

Figure 137. **Fertilizer consumption per US dollar of agricultural GVA, among fruit and nut rivals**

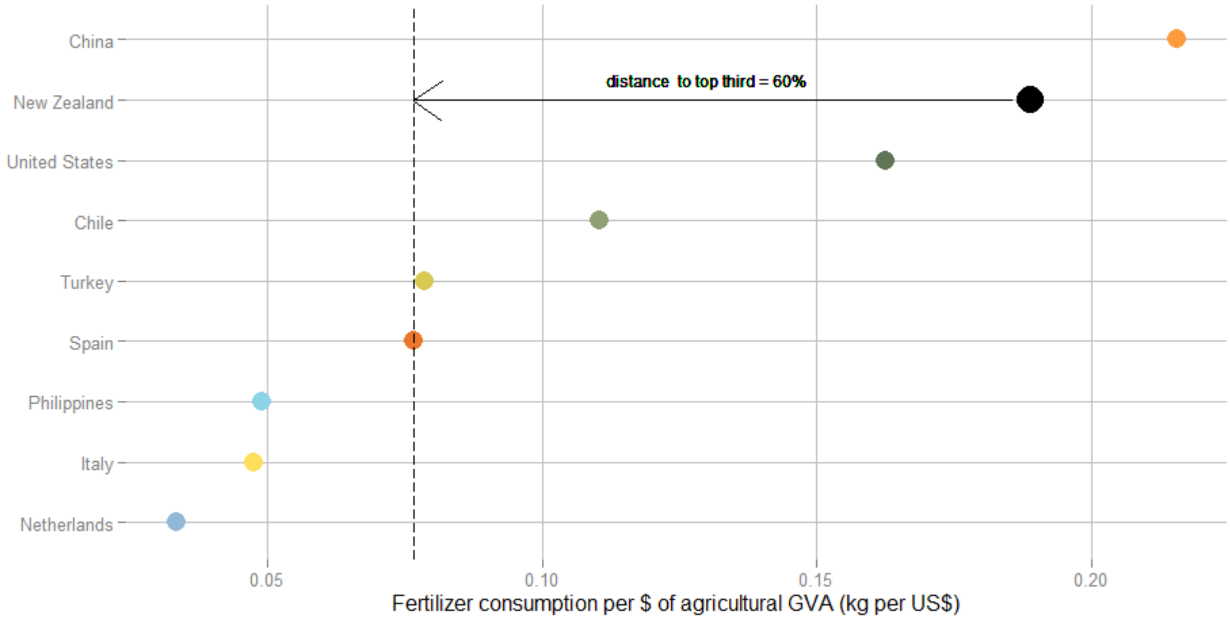


Note: *data for Belgium are not available*

Source *World Bank (2011b)*

Relative to rivals in the global fruit and nut market, NZ beats only China in terms of the efficiency of agricultural fertilizer use. New Zealand would have to improve its performance by 60 per cent to reach the top third.

Figure 138. **Fertilizer consumption per US dollar of agricultural GVA, 2007, among fruit and nut rivals**

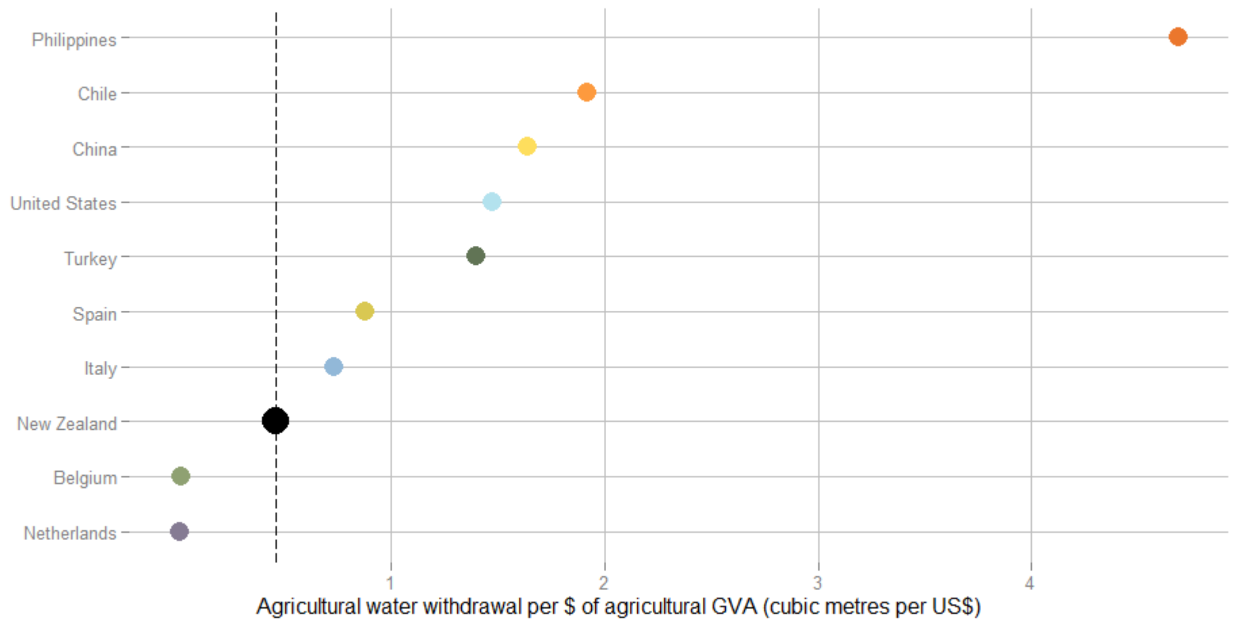


Note: *data are a three year moving average (2006-2008) 'distance to the top third' is calculated for rivals in the global fruit and nut market. Countries (in this case, only the Philippines) which are rivals in NZ's main export market but not the overall global market are included in the graphs but not in the 'top third' calculation*

Source *World Bank (2011b)*

Compared with rivals in the global fruit and nut market, NZ uses its total agricultural water withdrawals relatively efficiently, see Figure 139.

Figure 139. **Agricultural water withdrawal per US dollar of agricultural GVA, among fruit and nut rivals**



Note: *'distance to the top third' is calculated for rivals in the global fruit and nut market. Countries (in this case, only the Philippines) which are rivals in NZ's main export market but not the overall global market are included in the graphs but not in the 'top third' calculation*

Source *FAO AQUASTAT and OECD (2010b) for New Zealand and Turkey*

7.3 Estimates of revealed comparative advantage

Identifying New Zealand's sectoral specialisations

In 2009, New Zealand had a revealed comparative advantage, evidenced by a Balassa Index of greater than unity, in 58 sectors representing 75 per cent of total NZ merchandise exports.

Table 29. **New Zealand's top ten sectors by revealed comparative advantage**

BI value	Rank	Commodity name
99.3	1	Butter and other fats and oils derived from milk
58.4	2	Milk and cream and milk products other than butter or cheese
42.2	3	Wool and other animal hair (including wool tops)
30.4	4	Wood in the rough or roughly squared
19.6	5	Other meat, meat offal, fresh, chilled, frozen (for human)
19.5	6	Meat of bovine animals, fresh, chilled or frozen
18.9	7	Starches, insulin and wheat gluten; albuminoidal substances; glues
18.8	8	Cheese and curd
16.6	9	Crude animal materials, n.e.s
12.4	10	Hides and skins (except furskins), raw

Note: *n.e.s. stands for "not elsewhere specified"*

Source: *Vivid Economics*

Table 30. **The second rank of New Zealand's sectors by revealed comparative advantage**

BI value	Rank	Commodity name
10.7	11	Animal oils and fats
9.2	12	Wood, simply worked, and railway sleepers of wood
9.2	13	Edible products and preparations, n.e.s
8.5	14	Dyeing and tanning extracts, and synthetic tanning materials
7.8	15	Fruit and nuts (not including oil nuts), fresh or dried
7.3	16	Crustaceans, molluscs, aquatic invertebrates; flours and pellets
6.2	17	Pulp and waste paper
6.0	18	Alcoholic beverages
5.4	19	Fish, fresh (live or dead), chilled or frozen
5.0	20	Veneers, plywood, particle board, and other wood, worked, n.e.s

Note: *n.e.s. stands for "not elsewhere specified"*

Source: *Vivid Economics*

Table 31. **Further sectors in which New Zealand has some comparative advantage**

BI value	Rank	Commodity name
4.0	21	Furskins, tanned or dressed, other than those of heading 848.31
4.0	22	Leather
3.5	23	Wood in chips or particles and wood waste
3.3	24	Live animals other than of division 03
3.0	25	Aluminium
3.0	26	Meat and edible meat offal, prepared or preserved, n.e.s
2.8	27	Floor coverings, etc.
2.6	28	Vegetables, fresh, chilled , frozen, simply preserved; roots
2.5	29	Crude vegetable materials, n.e.s
2.3	30	Sugar confectionery

Note: *n.e.s. stands for "not elsewhere specified"*

Source: *Vivid Economics*

Table 32. **Sectors with slight comparative advantage**

BI value	Rank	Commodity name
2.2	**31**	**Other cereal meals and flours**
2.1	32	Vegetables, roots and tubers, prepared or preserved, n.e.s
2.1	33	Sugars, molasses and honey
2.1	34	Agricultural machinery (excluding tractors) and parts thereof
2.0	35	Lead
2.0	36	Instruments and appliances, n.e.s, for medical and veterinary sciences
1.9	37	Fish, crustaceans, molluscs, aquatic invertebrates, prepared, n.e.s
1.8	38	Non-alcoholic beverages, n.e.s
1.8	39	Feeding stuff for animals (not including un-milled cereals)
1.7	40	Fruits, preserved, and fruit preparations (excluding fruit juices)

Note: *n.e.s. stands for "not elsewhere specified"*

Source: *Vivid Economics*

Table 33. **Remaining sectors with Balassa index values greater than unity**

BI value	Rank	Commodity name
1.3	51	Trailers, semi-trailers; other vehicles, not mechanically propelled
1.1	52	Paper and paperboard, cut to size or shape; articles of paper or paperboard
1.1	53	Paper and paperboard
1.1	54	Alcohols, Phenols, phenol-alcohols and their derivatives
1.1	55	Flat-rolled products of iron or non-alloy steel, clad, plated or coated
1.1	56	Waste, parings and scrap, of plastics
1.0	57	Wood manufactures, n.e.s
1.0	58	Food- processing machines (excluding domestic); parts thereof

Note: n.e.s. stands for 'not elsewhere specified'

Source: Vivid Economics

7.4 Identity of rivals and green indicators

New Zealand's export rivals in its specialised export markets

Table 34. **The identity of rivals and green impacts in key export markets**

Detailed industry classification	**Industry class. for greenness analysis**	**Rivals at detailed classification level: 8 main exporters or 75 per cent of global market**	**Main environmental impacts of industry**	**Indicators for main environmental impacts**
Milk and cream and milk products other than butter or cheese	Dairy	Germany, NZ, France, Netherlands, Belgium, USA, Australia, Poland	Greenhouse gas emissions, water use and water quality	Agricultural methane emissions per head of livestock; agricultural nitrous oxide emissions per $ of agricultural GVA; composite water quality; annual freshwater withdrawals for agriculture per $ of GVA; gas/diesel oil consumed in agriculture per agricultural GVA; consumption of fertilizer per $ of agricultural GVA
Butter and other fats and oils derived from milk	Dairy	NZ, Netherlands, Belgium, Ireland, Germany, France		
Cheese and curd	Dairy	Germany, France, Netherlands, Italy, Denmark, NZ, Belgium, Ireland		
Other meat, meat offal, fresh, chilled, frozen (for human)	Meat	USA, Brazil, Germany, Netherlands, Denmark, Belgium, Spain, France *Additional rivals in main export market:* Ireland		As for Dairy analysis
Meat of bovine animals, fresh, chilled or frozen	Meat	Australia, Brazil, Netherlands, USA, Germany, Ireland, Argentina, France *Additional rivals*		

Detailed industry classification	Industry class. for greenness analysis	Rivals at detailed classification level: 8 main exporters or 75 per cent of global market	Main environmental impacts of industry	Indicators for main environmental impacts
		in main export market: Canada		
Fruit and nuts (not including oil nuts), fresh or dried	Fruit and nuts	USA, Spain, Netherlands, Chile, Italy, Belgium, Turkey, China *Additional rivals in main export market:* Philippines		Greenhouse gas emissions and pollution from fertilizer use, water stress
Wood in the rough or roughly squared	Forestry	Russian Federation, USA, NZ, Malaysia, Gabon, Germany, France, Canada *Additional rivals in main export market:* Thailand, Papua New Guinea, Australia		Harvest of forest resources
Wood, simply worked, and railway sleepers of wood	Forestry	Canada, Sweden, Russian Federation, Germany, USA, Austria, Finland, China *Additional rivals in main export market:* Indonesia, Malaysia		
Fish, fresh (live or dead), chilled or frozen	Fish	Norway, China, USA, Chile, Vietnam, Sweden, Spain, Russian Federation, *Additional rivals in main export*		Overfishing, impacts on overall marine environment

Detailed industry classification	Industry class. for greenness analysis	Rivals at detailed classification level: 8 main exporters or 75 per cent of global market	Main environmental impacts of industry	Indicators for main environmental impacts
		market: South Africa, Indonesia, Thailand		

Source: Vivid Economics, UN COMTRADE database

7.5 Sources of green impact data

Table 35. **Green impact data sources**

Metric	Source	Units	Time series
Dairy and meat			
agricultural N_2O emissions	World Bank	thousand metric tons of CO_2 equivalent	quinquennial from 1990 to 2005
agricultural gross value added	World Bank	constant 2000 US$	annual from 1990 to 2009 (Germany 1995-2009, Australia 1990–2008; data for Belgium unavailable)
composite index of water quality	Environmental Protection Index	proximity to United Nations Environment Programme targets; a score of 100 indicates all testing stations met all targets	2008, 2010
annual freshwater withdrawals for agriculture	FAO AquaStat (OECD for New Zealand)	billion cubic metres per year	data availability and frequency vary by country; latest available years – 2007: Belgium, Denmark, France, Germany, Poland, Netherlands, Spain; 2006: New Zealand, Brazil; 2005: USA; 2000: Argentina, Australia, Ireland, Italy
livestock numbers (dairy and non-dairy cattle and sheep)	FAO GLiPHA (The Global Livestock Production and Health Atlas)	heads	annual from 1997 to 2007
gas/diesel oil consumed in agriculture	United Nations Statistics Division	thousand metric tons	annual from 1990 to 2008 (Germany 1991 to 1998)
CH_4 emissions from dairy and non-dairy cattle	enteric fermentation from dairy and non-dairy cattle Annex I countries: UNFCCC Brazil: enteric fermentation from cattle calculated from applying published shares of enteric fermentation emissions from cattle as a proportion of total agricultural methane	tons CO_2 equivalent per dairy (and non-dairy) cattle	annual from 1990 to 2009; Netherlands data unavailable; Brazil: quinquennial from 1990 to 2005; Argentina: 1990, 1994, 1997, 2000, 2005

Metric	Source	Units	Time series
	emissions. Total agricultural methane emissions from the World Bank. Shares of enteric fermentation from cattle as a proportion of agricultural methane emissions in 1994 from the Brazilian Agricultural Research Corporation (2006) Argentina: enteric fermentation from cattle calculated from published statistics of emissions from enteric fermentation from all enteric ruminants (Marin et al. 2009). Shares of enteric fermentation from cattle as a proportion of total enteric fermentation emissions in 2000 from Ministry of the Environment (2011)		
CH_4 emissions from sheep	as per CH_4 emissions from cattle	tons CO_2 equivalent per sheep	as per CH_4 emissions from cattle
Fertilizer use	World Bank	total consumption in kilograms obtained from kilograms of fertilizer per hectare of arable land, multiplied by arable land (hectares)	annual from 2002 to 2008 (data for Belgium unavailable)
Fruit and nuts			
agricultural N_2O emissions	World Bank	thousand metric tons of CO_2 equivalent	quinquennial from 1990 to 2005
agricultural gross value added	World Bank	constant 2000 US$	annual from 1990 to 2009 (Germany 1995-2009, Australia 1990–2008; data for Belgium unavailable)
composite index of water quality	Environmental Protection Index	proximity to United Nations Environment Programme targets; a score of 100 indicates all testing stations met all targets	2008, 2010
annual freshwater withdrawals for agriculture	FAO AquaStat (OECD for New Zealand and Turkey)	billion cubic metres per year	data availability and frequency vary by country; latest available years by country – 2007: Belgium, Denmark, France, Germany, Poland, Netherlands, Spain; 2006: New Zealand, Brazil; 2005: USA; 2000: Argentina, Australia, Ireland, Italy; Turkey : 2000-2 average
gas/diesel oil consumed in agriculture	United Nations Statistics Division	thousand metric tons	annual from 1990 to 2008 (Germany 1991-1998)

Metric	Source	Units	Time series
fertilizer consumption	World Bank	kilograms	annual from 2002 to 2008 (data for Belgium unavailable)
Forestry			
Greenhouse gas emissions from Land Use, Land-Use Change and Forestry	UNFCCC	tons CO_2 equivalent per capita	annual 1990 – 2009 (data for Malaysia, Gabon, China, Indonesia, Thailand, Papua New Guinea unavailable)
change in extent of forest area	FAO ForestStat	per cent change in ha of forest	averages 1990-2000, 2000-2005,2005-2010
Fish			
exclusive economic zone trawled	Environmental Protection Index	the proportion of the exclusive economic zone trawled is subtracted from 100, so that a higher score indicates better performance	2008, 2010 (data for the US unavailable)

Source: Vivid Economics

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