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Facing the future: towards a green economy for New Zealand

the ROYAL SOCIETY of NEW ZEALAND TE APĀRANGI

Summary

This Emerging Issues paper presents evidence from local and global trends suggesting that New Zealand should carefully review its direction of development, and discusses the potential for New Zealand to move towards a green economy. The United Nations Environment Programme describes the core characteristics of a green economy as: low carbon, resource efficient and socially inclusive.

Global context

- International science-based reports have identified challenges facing the planet that arise from the effects of human activity on the environment. Many of these problems will impact on, or are already evident in, New Zealand (p2)
- Lowering greenhouse gas emissions will require changes in patterns of production and consumption, but need not reduce wellbeing (p2)
- Collaborative multi-stakeholder action is required as businesses, governments, and civil society alone do not have the tools and the authority to tackle systemic risks (p2)

New Zealand context

- New Zealand's government and parliamentary bodies have highlighted the potential impacts of these social and environmental challenges on New Zealand's industry, development and water quality, and the need for New Zealand to contribute to coordinated international action to reduce greenhouse gas emissions (p4-5)

New Zealand's potential for a green economy

- New Zealand would be advantaged by making a transition to a green economy, and is well positioned to start now to build on its existing strengths
- New Zealand has a strong competitive advantage in renewable energy systems, and has many opportunities for growing low –carbon technologies and services (p5)
- A number of New Zealand organisations are undertaking initiatives that increase the efficiency of resource use (p5)
- Initiatives that support social inclusiveness, as exemplified by the land and water forum, have shown resilient and sustainable solutions are more likely to be generated by collaborative processes that incorporate government, communities, businesses and individuals (p6)

Implementing change

- There is a need to engage the public and businesses in creating a vision for a resilient and prosperous future
- New Zealand should establish strong research collaborations to support green innovation, and foster ways to incentivise and grow the production of low-carbon goods and services, improve efficiency, and manage demand (p6)
- Long-term investments are needed in innovation, trialling new approaches, and supporting collaborations, in areas such as land use, energy supply and efficiency, transport and housing (p7-8)
- The path to a green economy requires a well-informed and stable policy environment, especially for issues at the interface between economic development and environmental protection (p6)

Introduction

Over the last century, the world entered a new era, the Anthropocene[1], in which human consumption patterns have become a significant influence on the global environment. Changes include biodiversity loss, reduced quality of freshwater, ocean acidification, and a changing climate. They are evident at both global and local scales and represent threats to long-term sustainability and wellbeing. These are complex problems which need innovative and strategic long-term thinking.

The purpose of this paper is to increase awareness of the changing global circumstances within which New Zealand must navigate its future. Drawing from policy reports of international and national organisations, and the peer-reviewed literature, this paper aims to encourage discussion amongst the policy, business, academic and wider communities to help shape a future that will safeguard New Zealand's social, economic and environmental wellbeing.

Global Context

The context for this paper is defined by three recent publications: the Sulston Report, "*People and the Planet*" (2012) by the Royal Society of London[2]; the report "*Global Risks 2014*" by the World Economic Forum[3]; and the first part of the IPCC Fifth Assessment Report[4], "*Climate Change 2013: The Physical Science Basis*". These reports identify a number of linked social and environmental challenges due to continuing growth in the global population, expansion of the middle-classes in developing countries, and increasing consumption of resources globally. Many of these challenges are evident in New Zealand.

The Sulston report examines the links between poverty, education, expanding populations and the growing demand for resources. It notes that the increasing rate of development of low and middle income countries is going to result in a rapid increase in the rate of consumption of the world's resources, including strategic materials and liquid fossil fuels. It concludes that unless consumption levels are reduced, and the global population stabilised, the global demand for resources will become unsustainable. The report argues that, to stabilise the global population, major improvements in resource use efficiency, and reducing the environmental impacts of economic activity, are needed to develop satisfying lifestyles for the 1.3 billion people living in extreme poverty. The Global Network of Science Academies[5] has endorsed the Sulston report and urged national and international policy makers to respond.

The *Global Risks 2014* report also analyses the interconnections between risks to global stability and prosperity. It argues that unless the complex, systemic interactions between them are better understood, no reliable mitigation strategies can be devised. In particular, it examines marked income disparity, structurally high unemployment and underemployment and fiscal crises in key economies, the failure of climate change mitigation and adaptation and associated risks of severe weather events and water crises. The report notes there are no necessary trade-offs between being economically competitive and being sustainable across nations[6]. A key message is that *"Collaborative multi-stakeholder action is required as businesses, governments, or civil society alone do not have both the tools and the authority to tackle systemic risks."*

Other reports agree that climate change represents a profound challenge to human wellbeing at a global scale[7]. The IPCC Fifth Assessment Report concludes, *inter alia*, that it is extremely likely human impacts are the dominant cause of observed global warming since the 1950s and that future surface temperatures will be largely determined by cumulative global greenhouse gas (GHG) emissions. Moreover, the present trajectory for GHG emissions is incompatible[8] with the Copenhagen Accord for stabilising long-term climate change[9] which set a maximum global average temperature target of 2°C above pre-industrial levels. Staying within this limit will require tight constraints on GHG emissions[10,11], as noted by the OECD[12]: "*Although there are a number of possible trajectories for reaching the 2°C target, they all imply a reduction to zero of the net global greenhouse gas emissions in the second half of this century*." These changes will require a significant transition in all aspects of energy supply and demand, including changes to investments and markets[13]. The International Energy Agency (IEA) considers that a significant fraction of existing fossil fuel reserves (particularly coal reserves) could not be consumed under the "450 scenario", but the economic burden arising from stranded assets would be limited[14].

Estimates by the IEA indicate that global costs involved in a low-carbon transition would be minimised by early action (i.e. before 2020), whereas the cost of the necessary investments could at least triple if action were delayed to later decades[15]. For these reasons the IEA considers that growth in global energy-related CO_2 emissions will need to halt and start to reverse in the current decade. However, securing reductions in GHG emissions will be difficult without a supportive policy environment, as acknowledged by the Secretary-General of the OECD[16]: "*Low-carbon technologies are facing an array of incumbent technologies that have a huge advantage based on vast investments over decades. Those investments are very profitable and easily attract new capital [and] the owners of these assets aren't going to take kindly to their value being impaired by policies designed to tackle climate change.*"

Lowering emissions will require changes in patterns of production and consumption, but need not result in reduced wellbeing. Different nations already exhibit a wide range of GHG emissions per capita. While many with low emissions per capita have low levels of life-satisfaction, others, such as Switzerland, Israel and Sweden, have relatively low emissions along with high life-satisfaction (Figure 1).

Most nations are actively working to reduce their GHG emissions, often as part of a wider package of activities to minimise exposure to the impacts of climate change and to increase resilience. The European Union

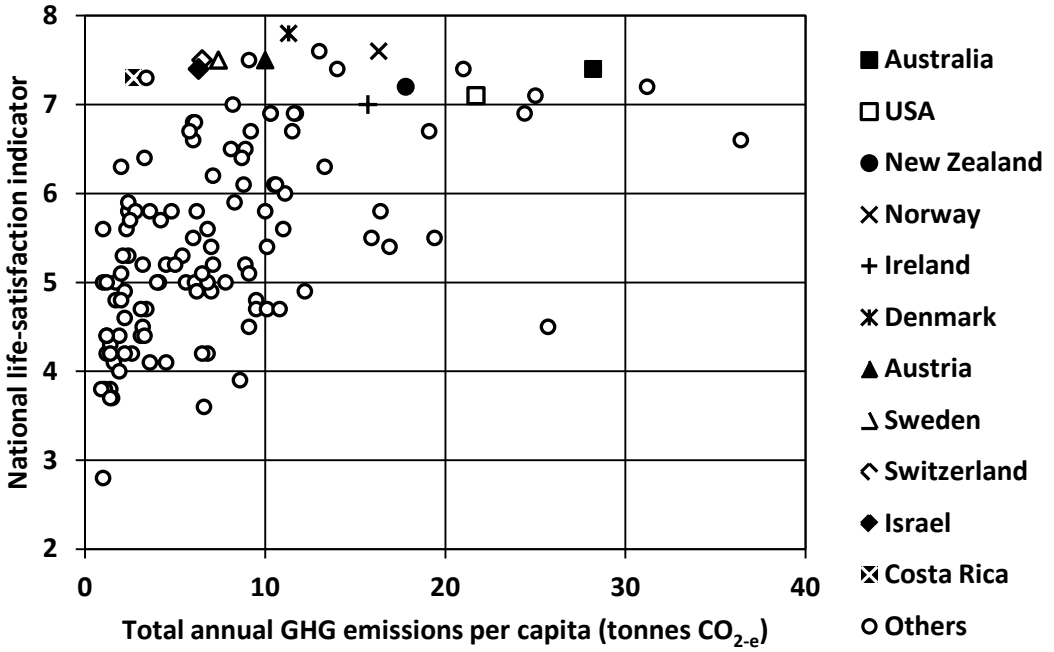

Figure 1: Total annual GHG emissions per capita for 123 nations and national life-satisfaction indicators[20].

Assessing Greenhouse Gas Emissions

The rules for assessing GHG emissions are important because they determine the responsibility for mitigating emissions. The data shown in Figure 1 were obtained using current rules for assigning total GHG emissions[17], with no allowance for land-use or forestry changes. Under this system each country is responsible for the emissions within its borders, but not for the emissions released in the production and delivery of goods that are imported. So New Zealand's gross GHG inventory includes all its agricultural emissions and the CO_2 released from the combustion of fossil fuels in New Zealand, both indigenous and imported.

This approach to GHG accounting is relatively straightforward to apply, but it can lead to perverse incentives[18]. For example, if a firm with high GHG emissions moves its operations from a country with strong emission policies to one with weak regulations, it can continue to supply products to its customers without penalty. Another example is in forestry, where carbon in the harvested timber is accounted for as if it were combusted at the time of harvest, although many wood products remain intact for decades. Consumption-based accounting[19] takes a different approach, and aims to resolve such problems by allocating the GHG emissions released in the production of goods to the consumers, not the producers. The GHG responsibilities of individual countries and the incentives for emitters would change if such rules were adopted. This could have significant implications for New Zealand because the agricultural production of goods for export generates nearly half its GHG emissions.

proposes to reduce its emissions to 40% below 1990 level by 2030[21] using domestic measures. In setting its own trajectory to a low carbon economy there are currently a number of choices that could be attractive to New Zealand.

For example the United Nations Environment Programme[22] envisions a 'green economy' that would: "*catalyse economic activity of at least a comparable size to business as usual, but with a reduced risk of the crises and shocks increasingly inherent in the existing model.*" The report notes that a green economy can generate such positive co-benefits as new employment opportunities, better health, and improved environmental outcomes. Under this approach, policies should be designed to link different sectors (e.g. health, transport, land-use, energy supply, energy efficiency), enable public procurement to stimulate demand for green goods and services, and achieve the lowest-cost and highest benefit solutions.

Another pathway to a 'green economy', suggested by Rifkin[23], focuses on bottom-up initiatives, such as community-supported business models. This approach emphasises the potential for emerging information and communications technologies to support growth in distributed renewable energy systems, as well as enabling the use of collaborative approaches to sustainability. Such a transformation would be driven by business, government and civil-society in partnership, with government providing supportive infrastructure, regulations, standards and taxation - processes the *Global Risks 2014* report[24] also supports.

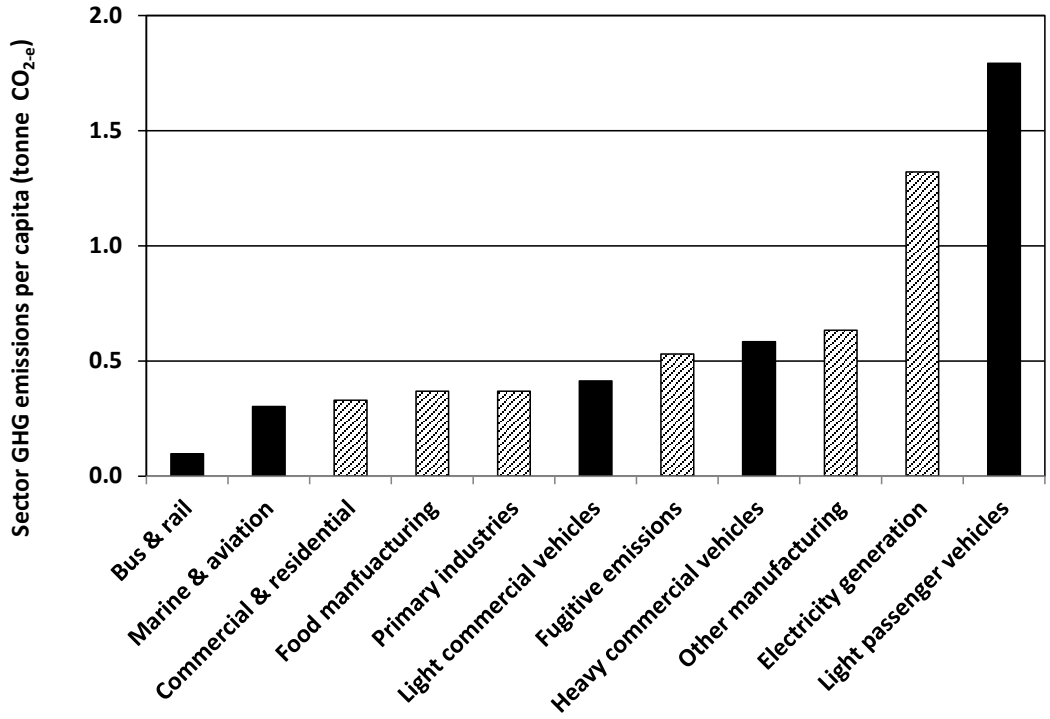

Figure 2: New Zealand's greenhouse gas emissions for 2011 due to energy use (grey shading) and transport (solid black)[25]

The New Zealand Context

Compared with other nations, New Zealand's gross GHG emissions per capita are relatively high (Figure 1). The main contributing sector is agriculture (47%), for which the emissions per capita are one of the highest in the world[26]. Other sectors include energy and transport (43%) and industrial processes (7%)[27]. The main GHGs are CO_2 (46%), CH_4 (37%) and N_2O (15%). Figure 2 shows the breakdown of energy-related emissions per capita.

Current GHG accounting rules make allowance for afforestation/deforestation and land use change when reporting emissions. As a result, New Zealand's net GHG emissions were 13.4 tonne CO_{2-e} per capita in 2011, rather less than its gross emissions of 16.4 tonne per capita[28]. However, as the plantation forest area is progressively harvested in the next decade, New Zealand's net GHG emissions will increase significantly[29].

The Prime Minister's Chief Science Advisor recently issued a report on how New Zealand is likely to be affected by climate change in coming decades, particularly the impacts on New Zealand industry and development[30]. The report notes that New Zealand is taking a leading role in global research to reduce agricultural GHG emissions through the New Zealand Agricultural Greenhouse Gas Research Centre[31] and the Global Research Alliance. Any reductions that may arise from this research are not yet known and are thus not included in official estimates of future emissions at present[32].

The Ministry for the Environment[33] acknowledges "*New Zealand must adapt to changes in climate and contribute to coordinated international action to reduce greenhouse gas emissions in the atmosphere*". The Government has set several targets for reducing national net GHG emissions compared with gross emissions in 1990[34], including an unconditional 5% reduction by 2020 and a 50% reduction by 2050. However, recent modelling by the Ministry for the Environment[35] indicates that by 2040 New Zealand's net GHG emissions are expected to be 51% higher than the 1990 baseline. This represents an average growth rate of 0.8% per annum. Although there is considerable uncertainty about the quantity of future agricultural emissions, projections for energy and transport emissions[36,37] show similar growth rates. Thus, under current policy settings, GHG emissions from these sources will continue to increase for several decades and emissions from the energy and transport sectors alone will exceed the 2050 target by 2030[38]. This suggests that New Zealand will need to review its development trajectory in order to reduce its GHG emissions in both the agricultural and energy-transport sectors, and/or increase its carbon sinks[39], if it is to meet its 2050 emissions target.

The need for New Zealand to review its development trajectory is also driven by emerging understanding of local environmental degradation. The impact of anthropogenic particulate emissions on health has been assessed in a comprehensive way in New Zealand only in the last decade[40]. In 2006 the estimated number of premature deaths of adults aged 30 years and over due to air pollution from human activities was approximately 1200[41]. The two largest contributing factors were emissions from domestic fires (approximately 650 deaths) and motor vehicles (approximately 250 deaths),

and the total social cost due to all anthropogenic particulate emissions was $4.3B. National Environmental Standards for Air Quality were introduced in 2004 and annual breaches of the standards are decreasing[42].

Understanding of water pollution is also growing. From the evidence compiled by the Parliamentary Commissioner for the Environment (PCE)[43], it is clear that New Zealand's freshwater has deteriorated significantly in recent years. The PCE concludes that "*It is almost inevitable that without significantly more intervention, we will continue to see an on-going deterioration in water quality in many catchments across the country, particularly in Canterbury and Southland*". Intensification of pastoral agriculture is a likely contributing factor to increasing concentrations of nutrients and loss of visual clarity[44] but other forms of land use and urban development have also contributed to the decrease in water quality.[45] Given the important recreational, health and cultural values associated with water, these changes impact on society as well as on the economy.

The Potential for a Green Economy

The global and local contexts outlined above provide evidence that New Zealand would be advantaged by making a transition to a green economy. New Zealand is well positioned to accelerate from current initiatives to a green economy, so that the benefits can occur in both the short and long terms, with enhanced societal well-being, improved environmental quality, and increased resilience of the economy.

The United Nations Environment Programme's core characteristics of a green economy are: low carbon, resource efficient and socially inclusive[46]. The paper examines each of these themes in relation to New Zealand.

Low carbon

New Zealand has a strong competitive advantage in low-carbon electricity generation, with many opportunities for further production[47] from sources including hydro, wind, geothermal, tidal, solar, biomass and wave energy. Some 77% of electricity generation[48] was from renewable sources in 2011 and the government target is to reach 90% by 2025[49]. Renewables make up 39% of New Zealand's total primary energy supply[50] and within the OECD only Iceland and Norway have comparable, or higher, contributions from renewables [51]. On the other hand, New Zealand's transport systems are currently almost completely reliant on oil. New Zealand presently produces enough oil to provide 31% of its supplies[52], but most of the oil consumed in New Zealand is imported at present and thus subject to exchange rate uncertainty and international risks. Similarly, where distance does matter, many of New Zealand's exports, and its tourism industry, rely on oil-based transport systems.

Looking to the future, there is already widespread interest and innovation in New Zealand in forms of development that reduce GHG emissions. In relation to the transport sector, many businesses, councils and community organisations are undertaking initiatives that contribute to a low-carbon transition[53]. The Government's Green Growth Advisory Group 2011[54] determined that New Zealand is well positioned for greener forms of economic development and called for a greening of strategies in every area of government activity and throughout the business sector. The aims of this recommendation were to drive long-term economic development; produce higher living standards; protect and enhance the natural environment; and improve business innovation, competitiveness and profitability. The New Zealand Green Growth Research Trust "*Pure Advantage*" report[55] identified similar opportunities for New Zealand and articulated the benefits of green growth to improve the wellbeing of New Zealanders. In his address to the Annual Congress of Plant and Food Research Ltd, Dr Garth Carnaby was equally positive and noted the role of the low-carbon service sector in New Zealand's development[56]: "*So here we are in New Zealand with a good starting position and lucky to find ourselves surrounded by favourable factors for strong comparative advantage. But we can add to that by using our brains.*" The Riddet Institute also identified opportunities for the agri-food sector, and recommended this sector focus on becoming a world leader in sustainability and product integrity[57].

Resource efficient

More efficient use of resources, including paying attention to the full life-cycle of goods and services, and recycling waste products, is an important feature of a green economy. Examples include:

- Energy: the lead Government agency is the Energy Efficiency and Conservation Authority (EECA) which works *"to make New Zealand a better place to live, economically, environmentally and socially, through the better use of energy"*[58]. It has a range of programmes that include providing financial assistance for retrofitting insulation; crown loans for energy efficiency in business; an information campaign for energy awareness; and energy efficiency labelling and standards.
- Environment: Resource efficiency involves maintaining, enhancing and, where necessary, rebuilding natural systems as critical economic assets and for their intrinsic importance. Using a resource in a way that degrades it for future generations creates future costs, as illustrated by the multi-party project to restore the degraded Te Arawa Lakes, Rotorua, which incurred

significant ongoing costs for restoration and mitigation[59].

- Infrastructure: Investment in roads, power-lines and other infrastructure is often designed for the highest use levels. However there is considerable untapped potential in improved efficiency of use, for example through better management of demand, as outlined by the National Infrastructure Unit[60]. Current examples of demand management in New Zealand include the AA Real Time Traffic Information Systems and the Transpower Demand Response programme.

Socially inclusive

Resilient, robust and sustainable solutions are more likely to be generated by collaborative processes which incorporate the relative strengths and advantages that come from government, communities, businesses and individuals[61]. As the Land and Water Forum has demonstrated[62], it is possible to get agreement on a way forward by bringing together people from different interest groups to work together on solutions, building on the vibrancy of multiple cultures and the innovations that come from different perspectives on a problem. Greater use of collaborative processes was a recommendation of the Green Growth Advisory Group: "*Central and local government should be encouraged to make, and/or support, greater use of collaborative processes for the management of natural capital and resolution of complex issues at the interface of economic development and environmental protection*."[63]

Collaborative stewardship of the environment requires genuine partnership across all sectors, including urban and rural, Māori and Pākehā, and it needs investment by central and local government in expertise and funding. Potential exists in providing opportunities for local stewardship of significant ecological zones – for example, the strong public interest in ecosanctuaries and marine reserves and the increase in customary management areas (*mataitai* and *taiāpure*). Collaborative solutions, however, are most likely to be achieved by communities that are socially inclusive and cohesive. The *Global Risks 2014* report ranks radical inequality in the distribution of wealth as the most urgent risk to economic and social prosperity, followed by climate change and water crises, findings that are echoed by New Zealand research.[64]

Implementing Change

The suggestions in this section are raised with the aim of promoting discussion rather than as specific recommendations. New Zealand's strengths include its economic vitality, its unique cultural values, its history of innovation and entrepreneurship, and the freedom for enterprise to develop. Being relatively unencumbered by trade agreements makes it easier for New Zealand to trial novel solutions without complex negotiations and trade-offs with other members of trading zones, for example. A powerful case has also been made that smaller scale production is often more carbon efficient and socially inclusive than industrial production on a large-scale[65].

Historically, increased economic wellbeing has come on the back of technological change. Technological change created economies of scale during industrialisation; technological changes in medicine led to (and will lead to) wider demographic transitions and changed population dynamics. Technological change will, no doubt, be the driver of sustainable increases in wellbeing both locally (in New Zealand) and globally. The key to greening New Zealand is through locally relevant technological change, 'pulling', through incentives and information sharing and public good science spill-overs, rather than 'pushing' New Zealanders to 'do and be good citizens', through second-best legislation. Businesses and consumers will ultimately establish what works in New Zealand, and what does not. However, work is needed to engage both the public and businesses in creating a vision for a resilient and prosperous future.

Moving down this pathway will involve investing in innovation, trialling new approaches, and supporting collaborations. In the short run there will be some losers in this process that may need support from the winners, and some (currently unsustainable) winners will need to adapt to stay ahead. In the long run all can benefit, but that will happen only if there is an acceptance that a range of better approaches will need to be implemented in the short term. Bottom-up initiatives by businesses and communities will be the spark, but positive policy support may need to provide tinder (e.g., education, subsidies, tax incentives, etc) in some cases. In particular, stable policies will be needed to provide business certainty, to support infrastructure transitions and to address issues at the interface of economic development and environmental protection.

To help implement the move to a green economy, further efforts are required to enhance knowledge and inform the pathway to change. New Zealand should establish a strong multi-disciplinary research collaboration that would support green innovation by fostering ways to incentivise and grow the production of low-carbon goods and services, improve efficiency and manage demand, while recognising economic, social and cultural drivers. This initiative is necessary for good intentions to be turned into practical solutions, whereby people embrace change because it benefits them directly within their own lifetime.

There are many sectors in New Zealand where research and innovation, new technologies, and innovative initiatives would be able to support a move to a green

economy. The following sub-sections discuss examples of these opportunities.

Land use

New Zealand is well placed to develop and trial locally-responsive agricultural and forestry regimes that are more resilient and result in improved environmental indicators and higher value products. Examples of these include:

- The Land and Water Forum, which has pioneered a collaborative approach to the vexed questions of water quality and allocation in New Zealand. There is much to learn from this model of working together to design a future that can generate prosperity within environmental limits.
- The new Forestry Stewardship Council standards for New Zealand, which followed a similar collaborative process[66]. This requires socially responsible management of plantations, the preservation of rare and endangered species, bush buffers along both sides of all permanent waterways, and 10% of the plantation area in native bush to be sustainably managed.[67] In many countries, the sustainable management of indigenous forests is fostered and some New Zealand native woods are highly valued as finishing timbers. .
- Steps being taken by Dairy New Zealand[68], and by many farmers, to reduce the social and environmental impacts of their operations, through upgraded effluent systems, better nutrient management, and smart water use. Many community groups are also actively engaged in the restoration of rivers, wetlands, coasts and other key ecological zones, in collaboration with farmers, such as the Integrated Catchment Management programme for the Motueka River[69].
- Businesses creating value from the environmental and social qualities of their products, such as Sustainable Winegrowers and Zespri, who verify these qualities through industry-initiated audit schemes[70].

It is vital that such collaborative approaches reach out to all sectors of the community, and that land-based industries work in ways that are socially positive, and within environmental limits for carbon and nutrient budgets. These limits should be based on reliable scientific evidence, and should be independently set and audited. This is needed to encourage locally-responsive innovation and to ensure that land-based industries are genuinely sustainable.

Energy Supply

The total primary energy supply in New Zealand per capita is slightly less than the average for the OECD[71] and the country is unusual for the abundance of its energy endowments, both renewable and non-renewable[72]. One emerging electricity generation source, tidal currents, presently under commercial trial in Kaipara harbour, has the potential to substantially increase New Zealand's power generation capacity[73]. There is also significant potential for other resources such as solar, wind, geothermal, bioenergy, and hydro[74]. New Zealand's reserves of non-renewables, such as coal, gas and oil, also include major deposits of methane hydrate, although there is no technology to exploit that resource at present. The government's goal is for New Zealand to make the most of all its energy resources[75].

A secure electricity supply that is essentially 100% renewable is technically achievable with the existing hydro capacity plus additional wind, geothermal, bioenergy and peak generation, although there is some uncertainty about how the system would operate in the existing electricity market[76]. These issues and others, such as demand side management, unscheduled and distributed generation, and new loads with potential storage, such as electric vehicles, should be addressed as part of the evolution of a 'smart-grid' in New Zealand[77]. The Government has recently announced the formation of the "*Smart Grid Forum*"[78] to advance the development of the network through dialogue among representatives from business, scientific circles, policy makers, regulators and consumers. This initiative is expected to build multi-stakeholder collaboration in the electricity sector[79,80].

New Zealand was an early leader for geothermal power when it first commissioned the 173 MW Wairakei power plant in 1958. Another innovative example of industrial level usage of geothermal energy is at Industrial Symbiosis Kawerau[81] combining industrial wood fibre processing with geothermal electricity, and low grade steam for pulp production, and drying lumber and paper products. This is the largest industrial user of geothermal steam in the world and is an example of community engagement to develop local sustainable opportunities. Kawerau is also the proposed site for development of an advanced biofuels processing plant to convert Radiata pine residues to bioethanol or "drop-in" biofuels[82]. A partnership has been established between pulp plant owners Norske Skog and the petroleum retailer Z-Energy, with some financial support from the government.

Housing and Domestic Energy Use

Houses consume 12% of all delivered energy in New Zealand[83] and residential energy use per capita is relatively low, just 57% of the OECD average[84]. Older houses in New Zealand are often poorly insulated and draughty, making them difficult to heat, and homes are frequently colder than the minimum temperatures recommended by the World Health Organization, and there is evidence that this has detrimental health outcomes[85]. Research on New Zealand household energy

cultures[86] showed that the 25% of households on lower incomes have the lowest energy use and very economical energy practices. Low-income home owners have few options for up-grading and tend to have cold damp houses with inefficient heating appliances. The *Warm Up New Zealand: Heat Smart* programme addresses their financial constraints in part, and has generated significant health benefits[87], estimated at $5 for every $1 spent.

One of the main success stories of the *Warm Up New Zealand: Heat Smart* programme is that it went beyond the usual approach of simply providing home-owners with incentives and information[88]. It focused explicitly on non-energy indicators of success such as the number of third-party funders contributing to the scheme, their financial input, numbers of doctor visits, the number of jobs created, and the quality of audits performed.

Despite this success, the growing number of rental properties means that more people are disadvantaged because they have little capacity to make changes for warmth and efficiency. This makes rental accommodation a priority for policy action[89] and a 'warrant of fitness' scheme, which sets rental housing standards, based in part on the Healthy Housing Index[90], is currently being trialled. The use of such home energy rating and certification schemes, and a wider range of Minimum Energy Performance Standards for energy appliances, has been previously recommended by the International Energy Agency[91]. Such measures may also help to improve the energy efficiency of another group, the 20% of households with the highest energy use. Although members of this group have the financial capacity to improve the efficiency of their dwellings, they tend not to do so[92].

Transport

Road transport is a significant source of GHG emissions in New Zealand, producing 45% of emissions from energy use, and is a significant source of particulate emissions[93]. The fuels are mainly petrol and diesel, with smaller quantities of LPG, bioethanol and biodiesel.

New Zealand's transport sector is unusual in a number of ways. The country has more vehicles per capita than most others[94] and energy use per capita for road transport is 20% above the OECD average[95]. In comparison with a group of 18 IEA countries in 2008, the share of passenger transport carried by cars, the percentage of freight carried by trucks, and the energy used per tonne-km of freight transport were all high[96].

Decarbonising the transport system will be a major socio-technical transition that will involve not only technological change, but people and their behaviours at all scales, including households, business sectors and government[97]. There are four aspects to consider[98]: changes in transport technologies; changes in the way technologies are used; shifting norms and aspirations; and broader changes such as infrastructure and policy settings. An analysis of 85 transport case-studies[99] indicates that many individuals, businesses and organisations are already making low-carbon transport a reality, but that they tend to work in isolation. This suggests that a multi-stakeholder *Transport Forum*, similar to the *Smart Grid Forum*, may be needed to advance the transport transition. Examples of some of the transport initiatives in New Zealand include:

- Electric Vehicles: Because of its renewable electricity sources, electric vehicles are well suited to New Zealand[100] and will reduce transport particulate emissions[101]. The power supply system is expected to cope well because demand will increase incrementally[102]. In addition the new demand is likely to be manageable, at around 25% of the present load[103]. Electric cars are now fully commercial on the basis of the last decade's research and development of batteries, electric motors and drivetrains[104]. The next few years will see these improvements amplified. Batteries are being developed with more capacity, longer life, which are lighter, and cost less to run. Current activity in New Zealand includes research, electric vehicle production and battery electric conversions[105]. New Zealand developments also include hands-free inductive charging of electric vehicles, extending to dynamic charging in motion[106] where vehicles are powered as they move above in-road induction coils, thereby helping eliminate range anxiety for electric vehicle users. This technology, originating at the University of Auckland[107], could provide the benefits of lower noise, higher efficiency and lower cost fuel.
- Fuel Saving: New Zealand transport and freight companies have been innovative with GPS technology, incentives, goal setting, and driver training to achieve large-scale behavioural changes to deliver fuel efficient eco-driving. New Zealand Post and Downer Transport are now driving more than 13 million km/year with major reductions in fuel use, vehicle emissions, and fewer accidents. Training sessions with especially trusted trainers showed immediate fuel reductions of 40% and continuing year on year reductions of 5%[108].
- Switching transport modes: Wellington Regional Council has implemented a transport programme every summer since 2010, called Active A2B[109] aiming to reduce congestion by increasing the choice of transport modes. It focuses on the non-energy related benefits of health and well-being from providing a significant amount of support to encourage non-motorised journeys. A reduction in car trips of 20% and an increase in

Alternatives to GDP

One barrier to a greener economy is the perception that it could lead to a lower GDP (gross domestic product), the measure most often used as an indicator of economic progress. However there is a growing understanding and awareness at the highest levels, both academically (Nobel Laureates in Economics, Sen and Stiglitz[110]) and politically (UK Prime Minister David Cameron[111]; former French President, Nicolas Sarkozy[112]) that there are now alternative, and often better, measures of economic development available to us than GDP.

GDP was developed during the 1930s as a measure of the state of the productive economy. At that time there was a need to measure the total amount of goods and services that were being produced in the market economy following the shock of the Great Depression. The subsequent demands of wartime economies to do likewise led to its popularity. However, life satisfaction and happiness levels have remained fairly stable in many developed countries, despite decades of rising GDP per capita. Evidently the quality of outcome of economic activity is at least as important as the quantity, and people derive benefits from many things that are not part of the market economy.

Recognising this, an increasing number of economists and elected leaders have come to see the present focus on GDP as too limiting. Consequently there has been growing pressure, both academically and politically, to consider alternative measures or complements to GDP that are 'better suited to the purpose' of capturing the quality, quantity and sustainability of economic wellbeing[113]. These alternative metrics include surveyed and composite measures of happiness and life satisfaction, such as the Human Development Index (HDI)[114]; the Ecological Footprint[115]; the OECD Better Living Index[116]; and the World Values Survey[117]. Their use is beginning to influence what some of the leading economies in the world are striving to achieve. GDP still has a role to play, but it is no longer regarded as the only metric that matters by forward thinkers in key developed economies.

There is also increased interest amongst commentators[118] and officials in New Zealand in examining broad measures of wellbeing. The NZ Treasury[119] has considered alternatives in its 'Higher Living Standards Framework'[120]. There is growing support from academic, political and policy communities for GDP to become just one of a number of indicators of what New Zealand might seek to measure and evaluate. As the country becomes more sophisticated socially, environmentally and ethically, the role of GDP as a singular goal for setting policy is likely to diminish.

cycling and walking have been consistently achieved since 2010.

While changes to transport technologies and infrastructure will be needed in the longer term to achieve reductions in emissions and fuel use, the last two examples show that programmes focussed on modal shift and behavioural change, finding human solutions to human problems of over-consumption and inefficiency, can show impressive results in the short term for small, up-front investments.

In Conclusion

Many natural systems (e.g. climate, water) are so affected by humans that they are starting to limit the quality of life, and if left unchecked will severely degrade human wellbeing. A wide range of indicators all point to the need for New Zealand to reduce its greenhouse gas emissions and to limit the deterioration of New Zealand's environment. New Zealand can deal with these challenges, and make a number of economic, social and environmental wins, by becoming a green economy.

New Zealand is well placed to make this transition, but in order to do so, policy and investment decisions need to consistently support this change. New Zealand's historic track record for developing innovative technological solutions is a strength that can help implement the transition, given appropriate support for research, development and demonstration, both in the public and private sectors.

Personal, social, cultural and behavioural changes will also be necessary for the transition. It will require strong leadership, incentives and regulations from government at all levels, as well as industry buy-in. It will also require a strong bottom-up culture of inclusive decision-making and society-wide embracing of a new vision for New Zealand. Businesses, large and small, will have a central role in the transition to a green economy, but few will achieve the change on their own and so will need government support, including strong drivers and tight regulations. Becoming greener can dramatically increase sustainable economic, social and business wellbeing. The challenge for New Zealand is to act nimbly and with foresight.

How the island became green – a 'Just So' scenario

One upon a time... there was a small country, an island nation, that survived mostly by selling food and fibre products on international commodity markets.

Every day... production would increase: more meat, more wool, more logs, more fish, more fruit, and more milk. Growing GDP was the most important goal for that country, even more important than the wellbeing of its people and the environment.

But one day... people started to realise that their rivers were becoming increasingly polluted, it was harder to catch fish and more native birds and animal species were threatened with extinction.

Then... the rest-of-the-world started to realise that the people of the island nation weren't that clever and happy after all, because they kept polluting their own nest.

At the same time ... serious storms and droughts started to impact on the world as a result of climate change. The rest-of-the-world also noticed that the people of this island nation were very high per capita producers of greenhouse gases, higher than almost all others in the world, and that it kept increasing. So the rest-of-the-world started to doubt that the island nation was truly 'clean and green' and they became less keen on visiting the country and buying its products.

Because of that... the people of the island nation were finally galvanised into action. They realised they had many advantages, like lots of renewable energy, many businesses that were already passionate about sustainability, farmers who knew how to maintain a healthy environment, and many innovators and entrepreneurs.

And then... they started to work together: businesses, councils, communities, politicians and researchers, realising that a move to a lower carbon footprint would be beneficial for the economy, society and the environment. They all agreed that a resilient, healthy environment and society needed to be the basis of the economy, and that GDP alone was not effective as a measure of success.

Also … they realised that it was actually not as hard as they thought to combine their nation's natural advantages and resources with cutting-edge innovation and come up with products and services that the rest-of-the-world really valued.

So finally... in much less time than they thought, they had 100% renewable electricity, low-carbon heating and transport systems, clean and healthy waterways and coasts, reduced biodiversity loss, and happier and healthier communities.

Ever since then... the island nation has once again been looked up to by the rest-of-the-world for its leadership in achieving a vibrant economy alongside a healthy environment. Smart people continue to return home to that country from around the world, attracted by the many jobs for skilled and knowledgeable people and its beautiful healthy environment.

The end.

Further information

This paper was authored by a Royal Society of New Zealand panel chaired by Professor Gerry Carrington FRSNZ. The Panel members were: Professor Geoff Austin FRSNZ, Dr Sea Rotmann, Professor Ralph Sims CRSNZ, Dr Janet Stephenson, Professor John Boys FRSNZ, Professor Les Oxley FRSNZ, and Professor Dame Anne Salmond CBE FRSNZ.

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