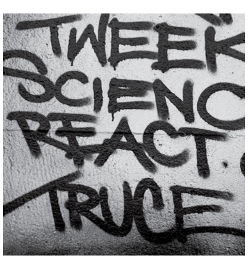
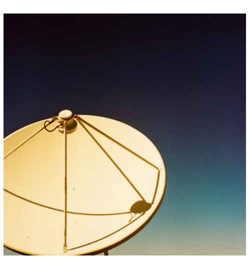
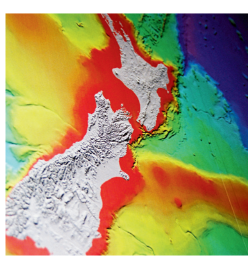
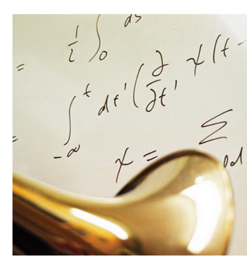
# 2020: Energy Opportunities

## Report of the Energy Panel of The Royal Society of New Zealand

## Book I Overview


the ROYAL SOCIETY of NEW ZEALAND

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# 2020: Energy Opportunities
# Report of the Energy Panel of The Royal Society of New Zealand
# Book I Overview
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# STATEMENT OF PURPOSE

The Royal Society of New Zealand recognises that securing a long term, sustainable, and affordable supply of energy is one of the greatest challenges facing New Zealand today. How we address our energy future presents perhaps the greatest single opportunity before us for radically transforming New Zealand's economy.

Our national energy security is at growing risk from our total dependence on overseas supplies of petroleum products for transport fuels. Our economy is affected by their rising price and impact on our current account deficit. Our indigenous oil and gas resources are finite while our coal resources are substantial. The continued use of fossil fuels accelerating climate change is leading to global concern and a potential new layer of costs for carbon emissions in seeking to respond.

As the world faces these energy challenges, new and transformational industries are emerging based around the development of sustainable sources of energy and energy conserving technologies. Whether New Zealand can be a leader in the development of any of these new energy industries depends on the choices we make.

Energy plays such a fundamental role in New Zealand's agricultural production, transport, economic development and social well-being that a strategic plan must recognise both the issues arising from uncertain supply and the opportunities to derive substantial benefits from successfully addressing the supply and sustainability problems.

We note the extensive previous work done in this area which has informed our discussions. This includes work by the Parliamentary Commissioner for the Environment, the Ministry for Economic Development, EECA, the International Energy Agency, the Institution of Professional Engineers NZ, the Institute of Policy Studies at Victoria University of Wellington, Solid Energy, CRL Energy Ltd, the Energy Federation of New Zealand, NIWA, New Zealand Business Council for Sustainable Development, the Centre for Energy Research at Massey University, Power Projects Ltd, Frazer Lindstrom, and BRANZ. We do not wish to duplicate this work.

We offer six recommendations towards a national energy strategy based on what may be necessary, not on what is currently seen as politically feasible. The former we cannot change; the latter we must.

J.D. Watson

Chairman

## SIX RECOMMENDATIONS

The Energy Panel of the Royal Society makes the following recommendations towards the development of a national energy strategy:

I. That Government set aggressive but achievable targets for renewable transport fuels, phase out the use of fossil fuels unless carbon emissions can be securely sequestered and put in place the regulatory and investment policies to ensure reduced carbon emission fossil fuel free targets are met by 2020.

II. That biofuels be introduced as soon as possible, to provide greater security of transport fuels, with an emphasis on developing local industries for their production.

III. That the transport fleet composition be modified over time to enable the more widespread uptake of renewable fuel use and that transport systems be modified to become sustainable.

IV. That our electricity sector should make the transition to renewable supply by 2020. Further fossil fuel development must incorporate a commitment to zero carbon emissions. Electricity markets and systems must deliver a balance between supply and demand investments.

V. That New Zealand continues to adhere to carbon emission agreements involving the wider international community. A shift to lower carbon emission systems will enable New Zealand to become an exporter of carbon emission reduction credits.

VI. That New Zealand must undertake a sustained effort to drive indigenous innovation to address systemic energy and environmental issues. Substantial collaborative research and development is required and must involve the spectrum of industry, community, government and research.

## PANEL MEMBERS

| | |
|---|---|
| Dr Jim Watson, CNZM, FRSNZ | Chairman of the Energy Panel,<br>President of the Royal Society of New Zealand (2003 – 2006) |
| Sir Ian Axford, FRS, Hon.FRSNZ | |
| Professor Tom Barnes, FRSNZ | Deputy Vice Chancellor (Research), University of Auckland |
| Professor John Buckeridge, | Head of the School of Civil, Environmental,<br>and Chemical Engineering, RMIT University, Melbourne |
| Professor Gerry Carrington, FRSNZ, FIPENZ | Head, Department of Physics, University of Otago |
| Dr Richard Forster, Chief Executive | Lanzatech New Zealand Ltd |
| Dr John Huckerby | Power Projects Limited, Wellington |
| Associate-Professor Hicham Idriss | Chemistry Department, University of Auckland |
| George Jones, CRSNZ | Krypton Technology Ltd, Wellington |
| Dr Susan Krumdieck | Advanced Energy and Material Systems Laboratory, Department of Mechanical Engineering, University of Canterbury |
| Dr Ian Maxwell | General Manager Special Projects, Auckland Uniservices Ltd |
| Dr Mike Packer | Cawthron Institute, MacDiarmid Institute for Advanced Materials and Nanotechnology |
| Dr Jim Salinger, CRSNZ | National Institute of Water and Atmospheric Research |
| Professor Caroline Saunders | Director of the Agribusiness and Economics Research Unit, Commerce Division, Lincoln University |
| Professor Ralph Sims, CRSNZ | Director, Centre for Energy Research, Massey University |
| Paul White | GNS Sciences, Wairakei Research Centre,Taupo |

**Secretariat**

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| Dr Jez Weston | Royal Society of New Zealand |

## DECLARATION OF INTERESTS

Members of the panel would like to declare various energy-related interests:

Dr Jim Watson is leading the development of an energy company from Genesis Research and Development Corporation Limited focused on total biomass refining including ethanol production.

Professor Tom Barnes is the Deputy Vice Chancellor Research at Auckland University which has established an Energy Institute.

Professor Gerry Carrington is proposing a National Energy Research Institute. His energy research has been supported by many years of government grants.

Dr Richard Forster is the Chief Executive of Lanzatech New Zealand Limited, which is developing technology for ethanol production from industrial waste products.

Dr John Huckerby is an independent energy industry consultant for Power Projects Limited and heads the Aotearoa Wave and Tidal Energy Association.

Associate-Professor Hicham Idriss at the University of Auckland works on catalysts for ethanol to hydrogen conversion.

George Jones is an independent consultant for Krypton Technology Limited and is developing waste rubber to fuel technologies.

Dr Susan Krumdieck has consulted for several energy companies and public agencies in her role as Director of the Advanced Energy and Material Systems Laboratory, University of Canterbury.

Dr Ian Maxwell of Auckland Uniservices has worked for Shell International for 20 years.

Dr Mike Packer works at the Cawthron Institute on biofuels production using microalgae.

Dr Jim Salinger has provided climate advice to energy companies in his role at the National Institute of Water & Atmospheric Research (NIWA).

Professor Ralph Sims has received many years of government funding as Director of the Centre for Energy Research, Massey University and is presently seconded to the International Energy Agency in Paris.

Paul White has acted as a consultant for hydro and geothermal energy companies in his role at GNS Science Limited.

# REALITY CHECK

The energy problems facing New Zealand involve interconnected aspects of New Zealand's economy, energy security and environmental well-being, and many indigenous energy resources including substantial coal resources, all of which need to be considered together.

**Energy Security Reality**

1) Currently known local sources of gas and oil are nearly exhausted. Even if major new discoveries are made, they are only likely to meet a small proportion of New Zealand's total needs, and our fuel supply could become increasingly dependent upon imported resources. A peak in cheap, easily available oil will occur, although it is not known when.
2) Large-scale use of New Zealand substantial coal resources without secure and efficient carbon capture and storage (CCS) technology in place will only increase international carbon emissions liability.
3) New Zealand has substantial sustainable resources, e.g. hydro, geothermal, wind, solar, marine and biomass, which could all be developed further.
4) New Zealand could begin to develop a home-grown biofuel industry immediately if regulatory changes are made with legislation introduced to reduce current barriers and enable the fledgling industry to grow.

**Economic Reality**

5) New Zealand has a current account deficit of about 8.9% of GDP ($13.7 billion). Our total international liabilities (mostly private) are $136.5 billion (89% of GDP), requiring annual servicing payments of $10.3 billion[1]. The cost of imported fossil fuels is $4.5 billion per year and making up a substantial part of our current account deficit. This will increase as the cost of imported oil and gas continues to rise, more so if the New Zealand dollar weakens further.
6) Our current limited attempts to meet our Kyoto emission reduction requirements by 2012 are having little effect on our emissions. The expected cost is $582 million[3].
7) Economic growth, population growth and immigration will continue to increase energy demands. Pressure for immigration will only increase as climate change bites, particularly if the sustainable food production capabilities of New Zealand's Pacific Island neighbours are reduced[4].

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[1]Statistics NZ, "Annual Current Account Deficit Widens Further", Balance of Payments and International Investment Position (December 2005 quarter)

[2]Oil imports were a provisional $4.5 billion for 2005. Statistics NZ, "New Zealand External Trade Statistics", December 2005, Table 3.02

[3]NZ Climate Change Office, "The Kyoto Liability/Provision", using February 2006 values http://www.climatechange.govt.nz/about/kyoto-provision.html

[4]DuPont, A., Pearman, G., "Heating up the planet – Climate change and security", Lowy Institute, Paper Number 12, 2006

Internationally, in 2001 there were already 25 million environmental refugees International Red Cross and Red Crescent Societies, "World Disasters Report 2001 http://www.ifrc.org/publicat/wdr2001/

**Environmental Reality**

8) The planet is warming mainly as a result of the introduction of heat-trapping greenhouse gases associated mainly with fossil fuel burning (carbon dioxide is responsible for 60% of radiative forcing), land use changes in wetlands, rain forests, rice paddies and use of animals, etc. (methane: 20%), the existing chlorofluorocarbons (CFCs: 15%), and with agricultural wastes and fertilizers (nitrogen oxides: 5%)[5]. Recent extensive science has served to confirm this[6].

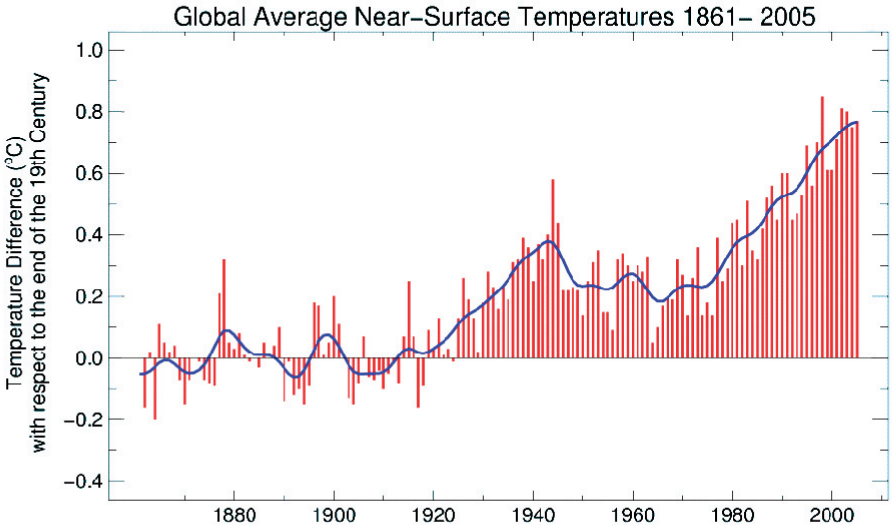


**Figure.1** – Mean temperature rise since the Industrial Revolution[7]

9) Fossil fuel use is the main cause of historically unprecedented global warming. Carbon dioxide levels in the atmosphere at 379 ppm are the highest that they have been for at least 650,000 years[8] and possibly for 20 million years[9]. They may reach 450 ppm by 2035[10]. At that level and rate of increase, the net global effects on continued climate change and the environment are expected to be negative.[11]

[5]IPCC, "Third Assessment Report", 2001, Climate Change 2001: Working Group I: The Scientific Basis: Summary for Policy Makers http://www.grida.no/climate/ipcc_tar/wg1/006.htm

[6] "Avoiding Dangerous Climate Change – International Symposium on the Stabilisation of greenhouse gas concentrations", Hadley Centre, Met Office, Exeter, UK, 1–3 February 2005 http://www.defra.gov.uk/environment/climatechange/internat/dangerous-cc.htm

[7]Steffen, Will, "Stronger Evidence but New Challenges: Climate Change Science 2001–2005, Australian Greenhouse Office, Department of the Environment and Heritage http://www.greenhouse.gov.au/science/publications/pubs/science2001–05.pdf

[8]Siegenthaler, et al, "Stable Carbon Cycle–Climate Relationship During the Late Pleistocene", Science 25 November 2005, Vol. 310. no. 5752, pp. 1313 – 1317

[9]Pearson, P.N., Palmer, M.R., "Atmospheric carbon dioxide concentrations over the past 60 million years", Nature, 2000, Vol 406, pp. 695–699

[10]The current annual rate of increase for the last ten years has been 1.9 ppm. At that rate, 450 ppm will be reached by 2043. NOAA Global Monitoring Division, "Trends in Atmospheric Carbon Dioxide", http://www.cmdl.noaa.gov/ccgg/trends/
However, the rate of increase is itself increasing and by 2030, fossil fuel emissions may be 60% higher than at present, if nothing is done to constrain them. At that rate, 450 ppm will be reached by 2033. Emissions path from IEA, "World Energy Outlook", 2004

[11] "Avoiding Dangerous Climate Change – International Symposium on the Stabilisation of greenhouse gas concentrations", Hadley Centre, Met Office, Exeter, UK, 1–3 February 2005 http://www.defra.gov.uk/environment/climatechange/internat/dangerous-cc.htm

10) Climate change is likely to put current agricultural practices at risk. In New Zealand, climate change is predicted to be accompanied by increased drought in eastern regions and increased rainfall in the western regions. Our water supplies for agricultural purposes are likely to be seriously affected; our water supplies for power generation will be changed in ways that we cannot control.

11) Climate change will put some coastal communities at risk from increased storminess and rising sea levels.

12) It is not certain as to when the adverse impacts of climate change will become critical. This depends on the rate of emission of carbon dioxide into the atmosphere (contingent upon the rate of economic development of countries such as India and China, which have little crude oil or gas reserves but a great deal of coal); the contribution from other greenhouse gases, especially methane; and the effects of destabilising feedbacks in the climate system, which might be abrupt, and lead to an irreversible greenhouse effect[12].

13) Some analyses suggest that we must stabilise carbon dioxide levels at 450 ppm to provide a chance of keeping global warming below 2°C above pre-industrial levels, or a further 1°C warming from current levels[13]. Stabilisation at this level is looking increasingly unlikely to occur unless the use of fossil fuels without CCS is eliminated by 2020 and the effects of methane and other gases are brought under control in the same time-frame.

14) If secure CCS technology were successfully developed this could allow the world's coal and remaining oil and gas resources to be exploited at increased cost but with much less increase in carbon dioxide emissions.

[12]For example, a warming of 1.5°C above current temperatures may trigger complete melting of the Greenland ice sheet and a corresponding 7 metre global sea level rise.
DEFRA, "Avoiding dangerous climate change – Executive Summary", 2006
http://www.defra.gov.uk/environment/climatechange/internat/dangerous-cc.htm

[13]DEFRA, "Avoiding dangerous climate change", 2006
http://www.defra.gov.uk/environment/climatechange/internat/dangerous-cc.htm

# RECOMMENDATION I
# OPPORTUNITIES, TARGETS AND STRATEGIES

That Government set aggressive but achievable targets for renewable transport fuels, phase out the use of fossil fuels unless carbon emissions can be securely sequestered and put in place the regulatory and investment policies necessary to ensure fossil fuel free targets are met by 2020.

*"The whole world is now dreading the problems brought about by dependence on oil… The aim is to break dependence on fossil fuels by 2020." – Mona Sahlin, Swedish Minister for Sustainable Development*[14]

I. 1. New Zealand's energy use continues to increase. Our present way of life has been substantially built on energy from fossil fuel, our energy efficiency is not improving, and our dependence upon fossil fuels is increasing. Evidence about the risks and costs of climate change continues to accumulate and the physical evidence that human activities are increasing the rate of climate change is certain. The costs of doing nothing will be immense, whereas the costs of mitigation and adaptation will be much less in comparison.

I. 2. Inexpensive and secure energy has been a major source of competitive advantage for our economy. New Zealand has benefited from a hundred years of inexpensive, reliable hydroelectricity and from twenty-five years of inexpensive, reliable Maui gas.

I. 3. We have sufficient cost-effective indigenous resources to return to a renewable energy basis for our economy. We can use our renewable energy sources to achieve certainty of supply for long term energy and business investments, freeing us from the economic insecurity borne of our dependence on fossil fuels, meeting our climate change obligations and helping New Zealand to be among the economic leaders of the twenty-first century.

I. 4. New Zealand has sufficient marginal land and water to grow energy crops and become more than self sufficient in biofuels.

I. 5. We need more renewable generation, new ideas, innovations in markets and new technologies that will allow our twenty-first century electricity and transportation systems to grow and function within economic and environmental constraints.

I. 6. Above all, what New Zealand urgently needs is an energy strategy[15] that provides certainty of supply and builds on our natural advantages in the global carbon market, namely our relatively benign climate and capabilities in agriculture. Furthermore, we need programmes that will allow us to grow new energy-based industries. With increasing global demand for energy security and a cleaner and greener environment, future industries will emerge in this century based around energy and the environment. New Zealand has the opportunity to use an energy strategy to effect economic transformation but must have the resolve to act.

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[14]Sahlin, Mona, "Sweden first to break dependence on oil!" in Dagens Nyheter, 01 October 2005 http://www.sweden.gov.se/sb/d/3212/a/51058

[15]As recognised in the recent IEA review "Energy Policies of IEA Countries – New Zealand", 2006

# RECOMMENDATION II
# RENEWABLE TRANSPORT FUELS BY 2020

That biofuels be introduced as soon as possible, to provide greater security of transport fuels, with an emphasis on developing local industries for their production.

*"Oil… its volatile price erodes prosperity; its vulnerabilities undermine security; its emissions destabilize climate"*[16]

II. 1. Some 6.3 billion litres of transport fuel are currently consumed annually in New Zealand. This is 3.4 billion litres of petrol and 2.9 billion litres of diesel[17] and represents approximately one third of our annual current account deficit.

II. 2. New Zealand agriculture produces sufficient tallow to produce around 200 million litres of biodiesel annually, equivalent to less than 5% of our diesel fuel consumption[18]. While biofuel production can begin from this source, it cannot make more than a minor contribution to our transport fuel supply.

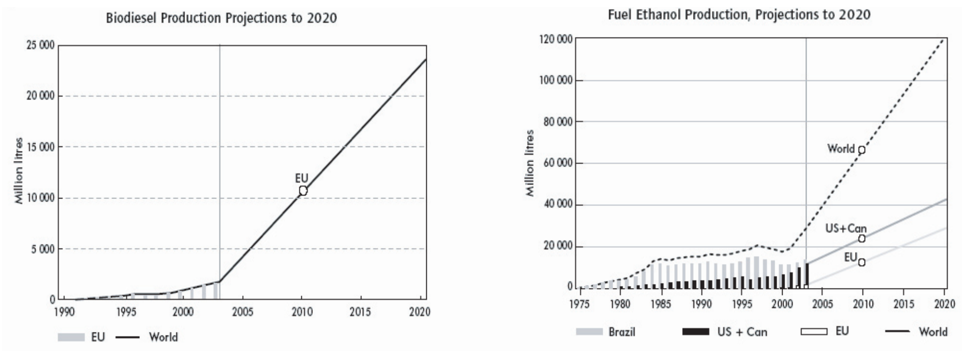


**Figure 2** IEA projection of biodiesel and bioethanol production to 2020[19].

II. 3. The impact of Kyoto protocol obligations and escalating oil commodity prices have created a worldwide resurgence of interest in both biodiesel and bioethanol production. The International Energy Agency (IEA) projects that biodiesel and bioethanol production is set to rise to 23 billion litres and 120 billion litres respectively by 2020.

[16]Rocky Mountain Institute, "Winning the Oil Endgame", 2006, 8th June http://www.oilendgame.com

[17]New Zealand Energy in Brief, http://www.med.govt.nz/energy/eib

[18]http://www.eeca.govt.nz/eeca-library/renewable-energy/biofuels/fact-sheet/biofuel-fact-sheet–05.pdf

[19]International Energy Agency/OECD, "Biofuels for transport: an international perspective", 2004, p 167 and 169

II. 4. The focus of renewable fuel programmes in the United States, Brazil, Japan, Canada, Southern Asia, and China is largely on bioethanol[20]. International demand for biofuels today exceeds current global production capacity and so the price of ethanol has risen as many countries seek to replace petrol with bioethanol.[21]

II. 5. Even if IEA projections were accurate then there would be sufficient ethanol available for only an E6 blend of ethanol with petrol in the world transport fuel supply. This must mean that there will be long term limitations on the supply of ethanol through the export ethanol market as producers seek to satisfy domestic needs first.

II. 6. New Zealand's expertise in agriculture and forestry, good growing conditions and small population imply that we could be one of the few countries in the world that can meet its own biofuels requirements.

II. 7. New Zealand has the potential to produce much greater volumes of bioethanol than biodiesel as more extensive feed-stock resources are available.

II. 8. Available technologies for ethanol production are biorefining plant biomass or gas fermentation.

II. 9. Adoption of policies that encourage plant conversion to ethanol and co-products, and total biomass refining will create a value chain from biomass production to processing, distribution and market use.

II. 10. Feedstocks that could make significant contribution to the production of transport ethanol in New Zealand include maize, grasses such as *Miscanthus*, ligno-cellulosic (woody) feedstocks such as pine, forestry residues, wood processing waste, and coppicable woody crops[22].

II. 11. While pine resources are currently large, long term coppicable hardwood feed-stocks offer greater potential, as energy balance, harvesting and biorefining costs are more favourable, and offer a greater range of high value multiple valuable product streams in addition to ethanol.

II. 12. While ethanol is one of these products, ethanol may or may not be the economic driver. The by-product natural lignin has properties that will allow it to compete with other petrochemical feedstocks in plastics, resins, paints and adhesives.

II. 13. One million hectares would be sufficient to produce 3-4 billion litres of bio-ethanol per year and large quantities of other valuable by-products. In the North Island alone there are more than one million hectares of marginal lands suitable for energy farming[23]. In the South Island, there are more than two million hectares. New Zealand has enough land to be more than self-sufficient in biofuels.

[20]International Energy Agency/OECD, Biofuels for transport: an international perspective", 2004, p 167 and 169

[21]FO Licht et al., Ethanol production and costs, a worldwide survey, Agra Informa Ltd, Kent, UK, 2004 (www.agra-net.com) and information made available through the Chicago Board of Trade ethanol futures market http://www.cbot.com/cbot/docs/69587.pdf

[22]International Energy Agency/OECD,"Biofuels for transport: an international perspective", 2004

[23]Includes only land that is currently known to return less than $350 per hectare per year, and excludes dairy and horticulture, native reserves and Department of Conservation land.

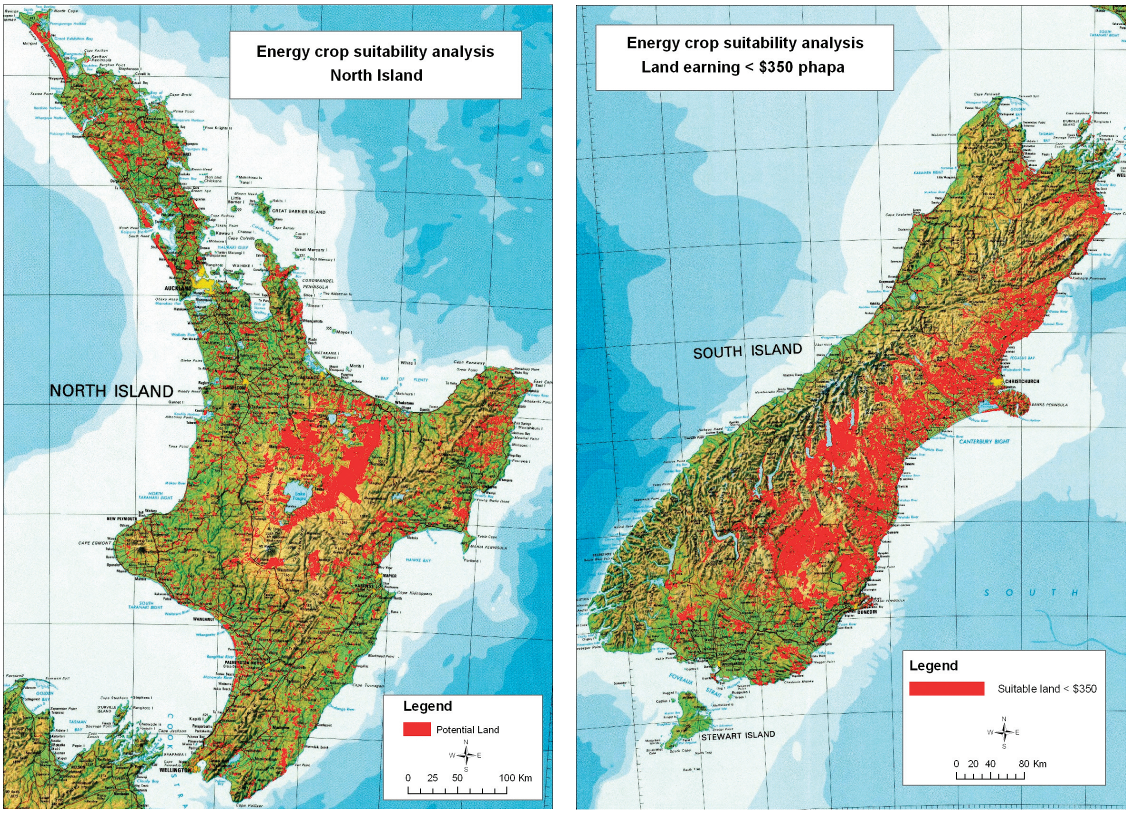


**Figure 3** Land potentially suitable for energy farming in New Zealand[23].

II. 14. However, unless new technology is developed to produce or replace diesel, then it will be difficult to produce sufficient biodiesel[24].

II. 15. Gas fermentation technologies could utilise existing pine forestry wastes as feedstock in the gasification process.

II. 16. New Zealand's large potential supplies of renewable electricity could enable the widespread use of hydrogen as an energy carrier. We should to follow international developments in hydrogen technology although its adaptation for widespread use is some time away.

[24]Mittelbach, M., "Biodiesel – The Comprehensive Handbook", Graz, 2004

# RECOMMENDATION III
# SUSTAINABLE TRANSPORT SYSTEMS

That the transport fleet vehicle composition be modified over time to enable the more widespread uptake of renewable fuel use and that transport systems be modified to become sustainable.

III. 1. A transition to a renewable fuel future will require measures to increase the efficiency and flexibility of our transport system. The high price of oil[25] is already raising demand for smaller, more fuel efficient vehicles[26] and for public transport[27]. These high prices are set to continue to increase and to worsen as the full costs of climate change become clearer. With constrained supplies of fuel, whether from oil or biofuels, efficiency will be the key to providing greater levels of productivity and minimising the risk from price and supply shocks.

III. 2. To improve fuel efficiency and flexibility New Zealand needs to introduce acceptable and effective long term strategies taking into account existing vehicle fleets, urban design, transition to biofuels, the long replacement cycle of the transport system and the possibility of sudden fossil fuel supply constraints.

III. 3. Numerous policy tools have been tested internationally for raising the fuel efficiency of vehicles and transport systems. These include vehicle fuel efficiency labeling, emissions testing, insurance-per-mile initiatives, and fiscal or tax incentives for vehicle ownership and fleet standards. Substantial operational research is needed to understand which of these tools will work effectively in New Zealand.

III. 4. Biofuel use is currently severely constrained because the majority of vehicle imports are not warranted for more than 3% biofuel. It would cost relatively little to require all new vehicles to be compatible with higher percentage of biofuels and little more, potentially only a few hundred dollars per vehicle, to convert imported second-hand vehicles to handle higher percentage bioethanol blends.

III. 5. Hybrid vehicles are expensive and are mainly beneficial in urban driving, where other transport modes may be more relevant. The financial costs of supporting these vehicles may be better put towards supporting more accessible transportation modes. Plug-in hybrids are even more expensive and may never compete, financially or environmentally, with biofuel-powered vehicles. Hybrids have a clear advantage in purely urban uses, such as buses, taxis or light rail.

III. 6. The twenty-first century may see an adaptation to a new type of transportation system. Rather than providing on-demand mobility based on unconstrained fuel and emissions, future systems could be based on organising better planned access to services and markets. Advances in information systems, urban design, freight organisation and integration, and economic instruments will be the key elements of adaptation to a renewable energy transportation system.

[25]MED, "Oil Price Assumptions for Energy Outlook", 2005. This report predicted $60/bbl in November 2005. Since then the NYMEX prices have been consistently above that level, peaking at $75/bbl in May 2006 with futures markets predicting little decrease. http://www.med.govt.nz/templates/Page____10612.aspx

[26]Dominion Post, "Car sales slump as fuel price soars", 04 May 2006 http://www.stuff.co.nz/stuff/0,2106,3656619a30,00.html

[27]Dominion Post, "Rising petrol costs boost bike sales", 01 May 2006 http://www.stuff.co.nz/stuff/0,2106,3653334a11,00.html

III. 7. International constraints on oil production pose high near-term risks in the form of local and national fuel shortages and fuel price increases that exceed many customers' ability to pay. Shortages could cause price shocks, inflation, loss of transport services with consequential commercial, economic and social effects.

III. 8. Current mitigation strategies only deal with up to 7% supply shortfall[28], but the probability of shortages far above this level occurring within a 10–15 year time frame is high. Strategies for dealing with larger shortages should be a high priority for multidisciplinary research.

III. 9. Managing the transition to renewable energy transportation will require a visionary and multidisciplinary approach to policies, science, engineering, and planning.

[28]MED, "Oil Demand Restraint Options for New Zealand: Planning for Emergencies", 2005 http://www.med.govt.nz/templates/ContentTopicSummary____15103.aspx

# RECOMMENDATION IV
# A ZERO-CARBON ELECTRICITY SYSTEM

That our electricity sector should make the transition to renewable supply by 2020. Further fossil fuel development must incorporate a commitment to zero carbon emissions. Electricity markets and systems must deliver a balance between supply and demand investments.

IV. 1. New Zealand is an energy-rich country underpinned by large-scale hydro generation, in transition to a more diverse supply portfolio, which will continue to involve fossil fuels for the short term. However our proportionate use of renewable electricity has fallen from 81% in 1990 to 75% in 2004[29]. We need to focus our efforts on growing non- or low-carbon-emitting electricity generation and to make serious efforts to contain emissions from electricity production.

IV. 2. Renewable electricity costs are not directly tied to volatile oil and gas prices and generate energy with zero net carbon emissions. Indeed, the cost of renewable electricity continues to decrease, with the cost of producing electricity from wind energy falling by over 80% over the last twenty years[30]. Fossil fuel prices are tied to oil prices which are increasingly volatile[31]. For biomass-based fuels, we will have much greater control over the feedstock cost and therefore be less subject to the fluctuations of oil and gas on world markets.

IV. 3. At present, wind and geothermal generation are growing rapidly but not as fast as oil and gas[32]. Wind, geothermal and hydro have great potential but are currently limited by resource consent application difficulties. Regulatory barriers apply to these sources where, under the current RMA, passing the control of such national assets down to local authorities has constrained their optimal development. These barriers should be addressed by supportive amendments to the Resource Management Act. However, any increase in electricity generation will have environmental costs, locally for renewables and globally for non-renewables. At present, our demand growth requires an extra 100 MW of thermal generation or 220 MW of intermittent renewable generation per year. Efficiency and demand side approaches should be the first step.

IV. 4. Currently, 600 MW of new generation from renewables should be in operation by 2008. Wind power is cost-competitive and growing rapidly. In the long term, wind generation may be limited to 35% of peak power by the difficulty of integrating a fluctuating supply with the grid[33]. However, by 2020 wind could provide another 2,000 MW[34].

[29]MED "New Zealand Energy in Brief", 2006, March
http://www.med.govt.nz/upload/32800/2006.pdf

[30]NREL Energy Analysis Office, "Renewable Energy Cost Trends", 2002
http://www.nrel.govt/analysis/docs/cost_curves_2002.ppt
Electric Power Research Institute, "Economic Assessment Methodology for Offshore Wave Power Plants", report E21 EPRI WP – US – OO2, November 2004
http://www.epri.com/attachments/297213_002_Rev_4_Econ_Methodology_RB_12–18–04.pdf

[31]Coal retail prices have doubled since 1985. IEA, "Energy prices and taxes", 2006, New Zealand, Table 4

[32]IEA " Energy Policies of IEA Countries – New Zealand", 2006, p159

[33]MED, "Wind Energy Integration in New Zealand – Final Report", 2005
http://www.med.govt.nz/templates/MultipageDocumentTOC____4317.aspx

[34]Electricity Commission, "Scenarios for the Wind Generation Investigation Project: December 2005

IV. 5. Geothermal generation provides renewable power without intermittency or weather-dependence. It provides base-load power operating with over 90% load factor. In the long term, it could provide more than 600 MW[35], possibly 1,300 MW[36]. Geothermal generation costs are competitive with coal and gas and currently less than either. Geothermal costs are even lower when compared with international fossil fuel prices such as for imported coal. Reinjection of working fluid reduces subsidence and heavy metal discharge and should be included in all developments.

IV. 6. If New Zealand exploited its enormous potential in lower temperature geothermal resources, then a significantly greater proportion of New Zealand's electricity needs could be met from renewables. It has been estimated that the potential extractable energy at lower temperatures could greatly increase geothermal energy supply[37].

IV. 7. There is the potential for further increases in hydro-generation on a range of scales, from small to large[38].

IV. 8. Marine generation is becoming commercially available. Many different marine generation technologies are being trialled on a commercial basis. Costs are dropping just as they did for wind generation, through design optimisation and economies of scale. For example, the UK is investing NZ$150 million in a Marine Renewables Deployment Fund[39]. This support should rapidly reduce the cost of marine generation and is expected to provide a net saving overall[40]. The long term price of marine-generated electricity may be equivalent to or lower than the cost of wind-generated electricity[41].

IV. 9. Marine generation in Scotland may provide 1300 MW by 2020[42]. New Zealand's potential supply of wave and tidal stream resources are reportedly 'tremendous'[43] and probably better than Scotland's but the resources are not well characterised yet. New Zealand's resources should work well with other renewables, providing more energy in winter, and we have large resources close to major users.

IV. 10. Direct generation of electricity from photovoltaic cells (solar panels) remains too expensive for bulk applications and we expect this to still be the case by 2020. However, costs continue to fall and this will enable photovoltaic cells to be used in increasing numbers of niche markets. The direct use of heat from the sun, through solar water heating and passive space heating, is competitive and should be encouraged as a means to reduce electricity use for heating.

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[35] Geothermal Association, "Geothermal Energy: New Zealand's most reliable sustainable energy resource", February 2006

[36] MED, "Existing and Potential Geothermal Resource for Electricity Generation", December 2004

[38] Thain, I., Reyes, A.G., Hunt, T.," A Practical Guide to Exploiting Low Temperature Geothermal Resources", GNS Science Report No. 2006/09 http://www.gns.cri.nz/research/geothermal/2006_09_Lw_tmprtr_gthrml_rsrcs.pdf

[38] East Harbour Management Services, "Identification of Potential Hydroelectric Resources", July 2004

[39] http://www.dti.gov.uk/energy/sources/renewables/business-investment/funding/marine/page19419.html

[40] The Carbon Trust, "Future Marine Energy: Results of the Marine Energy Challenge: Cost competitiveness and growth of wave and tidal stream energy", 2006 http://www.carbontrust.co.uk/technology/technologyaccelerator/marine_energy.htm

[41] Electric Power Research Institute, "Economic Assessment Methodology for Offshore Wave Power Plants", report E21 EPRI WP – US – OO2, November 2004 http://www.epri.com/attachments/297213_002_Rev_4_Econ_Methodology_RB_12–18–04.pdf

[42] Marine Energy Group, "Harnessing Scotland's Marine Energy Potential", 2004

http://www.scotland.gov.uk/Publications/2004/08/19742/41047

[43] NIWA, "Ocean bounty: energy from waves and tides", in Water & Atmosphere, 2005, volume 13, number 4, pp16–17.

IV. 11. Given our abundant renewable resources, the high costs of nuclear power, the large size of nuclear generating plants, our lack of experience with the technology and the risks associated with nuclear waste, nuclear power is not a viable option for New Zealand.

IV. 12. Our cost-effective renewable resources are capable of meeting our electricity needs for the future.

IV. 13. Distributed generation is low risk, provides resilience, especially for rural communities, allows for incremental investment and reduces grid dependence and load. Combined use of heat and power can reduce overall emissions[44] and raise overall efficiency. Microgeneration should be encouraged if grid expansion is limited. However, a push for microgeneration now without consideration of carbon costs would result in increased use of diesel generator sets and other fossil-fuel generation. This growth may occur anyway for peak shaving and to avoid blackout risk. From an environmental viewpoint, this would increase carbon emissions and localised pollution.

IV. 14. Energy efficiency has been described as the cheapest and safest way to meet new energy goals[45]. However, our electricity market is relatively poor at delivering energy efficiency. There is clear evidence of the benefits of targeted interventions. The recent Ecobulbs promotion reduced energy demand at a cost of less than 1.5 c/kWh, as opposed to 6–8 c/kWh for new generation[46]. The current strategy for energy efficiency, the National Energy Efficiency and Conservation Strategy (NEECS), lacks mechanisms and forces for change. In essence it lacks the teeth it needs to be effective. We are not on track to meet the NEECS energy efficiency target for 2012[47].

IV. 15. An effective, liquid and transparent market in energy securities could put a price on the right to be supplied a specific quantity of energy at a specific time. This would allow a better balance between supply and demand investments, helping investors on either side of the meter to make economically efficient decisions.

IV. 16. For the level of energy efficiency to increase, investment must shift across the meter to the demand-side. Effective policies already exist for improving home insulation, and the tightened building standards have been effective[48]. Minimum energy efficiency standards are welcome but should be expanded and tightened. There is a role for market based solutions as well as mandated improvement.

IV. 17. Energy efficiency improvement targets of 2% per year are achievable, but research is needed to understand the effective drivers for energy efficiency decisions and to minimise unintended consequences from efficiency interventions.

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[44] E.ON UK plc "Performance of Whispergen micro CHP unit in Carbon Trust field trials", May 2006

[45] DTI Energy White Paper, "Our energy future – creating a low carbon economy", 2003 http://www.dti.gov.uk/energy/energy-policy/energy-white-paper/page21223.html

[46] Electricity Commission, "Residential Compact Fluorescent Programmes – Request for proposals", May 2006

[47] IEA, "Energy Policies of IEA Countries – New Zealand", 2006, p72

[48] IEA, "Energy Policies of IEA Countries – New Zealand", 2006, p74

IV. 18. Coal is not a sustainable option for the long term, unless breakthroughs are made in capturing, separating and sequestering the carbon dioxide emitted when coal is burnt in a safe and secure way, at an acceptable cost. In principle, it will be very difficult to guarantee that storage of carbon dioxide over hundreds of years will be secure[49].

IV. 19. There are three main methods of sequestration: (1) scrubbing emissions followed by deep ocean disposal; (2) disposal by pumping the gas into deep oil wells or saline aquifers; (3) capture in solid material as inert carbonates which can be dropped safely in the ocean. Given concerns over acidification and the possible instability of the material deposited, (1) appears to be unacceptable. The level of tectonic activity in New Zealand suggests that both (1) and (2) could have additional risks in the long-term[50]. The safest procedure for New Zealand is (3), but present predictions of costs are higher than for other options. Use of char from partially-burnt biomass as a soil conditioner is another potential method to sequester carbon that is worthy of further investigation.

IV. 20. If carbon capture and sequestration technologies can be developed and deployed at an acceptable cost, then New Zealand's vast reserves of coal can be used in an environmentally acceptable manner. However, the expected cost of capturing carbon dioxide from the exhaust of a coal-fired generator may raise the cost of the generated electricity by 30–90%[51]. Hence other ways to use our domestic coal resources may be more fruitful than simply burning the coal. Collection of coal seam methane or in-situ reformation are potential options.

IV. 21. Cost increases and the technical and geological risks of sequestration mean that New Zealand's energy supply will be dominated by renewables as far as electricity and transport are concerned. Oil/gas/coal generation will definitely be required in the short term as the lead times to develop and install the renewable sources of energy that will make a difference will be long, hence the sense of urgency that needs to be created in terms of energy strategy and focused research.

[49]A recent, in-depth summary of carbon dioxide capture and storage (CCS) has been published by the IPCC as a special report. Substantial research investment is being made globally into CCS, hence its costs and viability may change. http://www.ipcc.ch/activity/srccs/index.htm

[50]IPCC, "IPCC Special Report on Carbon dioxide capture and storage", 2005, Chapter 5, p213, "Basins located in tectonically active areas, such as those around the Pacific Ocean …, may be less suitable for $CO_2$ storage and sites in these regions must be selected carefully because of the potential for $CO_2$ leakage" http://www.ipcc.ch/activity/srccs/index.htm

[51]IPCC, "IPCC Special Report on Carbon dioxide capture and storage", 2005, Table TS 10. http://www.ipcc.ch/activity/srccs/index.htm

# RECOMMENDATION V INTERNATIONAL AGREEMENTS AND A PRICE ON CARBON

> That New Zealand continue to adhere to carbon emission agreements involving the wider international community. A shift to lower carbon emission systems will enable New Zealand to become an exporter of carbon emission reduction credits.

V. 1. Investment attention is focused on the expectation that a price will be put on carbon emissions and that biofuels will be a massive new industry. For European nations to meet even a 5% biofuels target will require major imports.

V. 2. The Kyoto agreement already includes mechanisms for trading emission rights and mitigation technologies through the Clean Development Mechanism and the Joint Implementation agreements. We should not ignore these.

V. 3. There will be no silver bullet to solve the problem of climate change. Indeed, one study suggested that no fewer than fifteen technological bullets will be necessary, of which at least seven would be needed in the next fifty years. However, these technologies are already available to us[52].

V. 4. The follow-on International agreement to the Kyoto protocol must include all nations. Kyoto has the potential to work because it set clear goals and costs for not meeting them. The next agreement must do the same. This is a worrying prospect for New Zealand, when we are failing to meet our Kyoto obligations by an expected 64 million tons $CO_2$ equivalent[53] per annum, a factor of 21% above our targets[54]. We can hardly influence these negotiations if we are not seen to be pulling our weight, let alone lead them[55]. At present, we are not pulling our weight and this leaves us at risk when our export markets demand stronger action to address climate change. For example, the growing popular awareness in Europe of ideas such as 'food-miles' puts our food exports at substantial risk. The response to this risk should be for New Zealand to put some substance behind its clean, green image.

V. 5. Twenty years ago, the idea of putting a price on carbon emissions seemed a purely academic idea. Now, trading systems have begun that many countries and regions use to set that price. New Zealand has chosen to avoid a direct tax but we are obliged to pay a high price for our emissions in the present Kyoto commitment period. Within ten years time, we expect that no nation will be able to avoid paying a price for carbon. New Zealand will have to pay the price of the carbon we emit and we will be financially rewarded if our emissions fall.

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[52]Pacala, S., and Socolow, R. "Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies", Science, 13th August 2004, Vol. 305. no. 5686, pp. 968 – 972 http://fire.pppl.gov/energy_socolow_081304.pdf.

[53]IEA" Energy Policies of IEA Countries – New Zealand", 2006

[54]IEA" Energy Policies of IEA Countries – New Zealand", 2006

[55]Chapman, R., "A way forward on climate policy for New Zealand", Victoria University of Wellington, 2006

V. 6. Current carbon markets are not a clear guide to future carbon prices. The price of carbon is limited by the uncertainty of the future costs of climate change. This uncertainty will decrease as the climate change costs rise.

V. 7. It is not yet clear what will set a limit on the price rise hence we may be facing extreme price increases.

V. 8. There is starting to be some evidence that in the very long term, there may be no safe level of carbon emissions, i.e. that our net global emissions must drop to zero[56]. A price mechanism without an emissions cap may be an insufficient tool for this, making regulatory measures necessary.

V. 9. Assuming that an established level of greenhouse gas emissions is enough to stabilise the climate, the future will hold ever-harsher constraints on the emission of green house gases. The price of carbon will increase – thus reducing carbon emissions will benefit us domestically, by diminishing the risks to our domestic economy, and internationally, by creating competitive advantage over other nations in the global export market.

[56]Allen, M, "Climate change modeling and projections", at "Climate change and governance" conference, Victoria University of Wellington, 28–29 March 2006

# RECOMMENDATION VI ENERGY RESEARCH

That New Zealand must undertake a sustained effort to drive indigenous innovation to address systemic energy and environmental issues. Substantial collaborative research and development is required and must involve the spectrum of industry, community, government and research.

VI. 1. New Zealand's energy problems must be solved for New Zealanders by New Zealanders.

VI. 2. Demand side management for electricity and transport, energy efficiency uptake, carbon capture and secure sequestration technology, biomass refining technology, coal and biomass gasification technology and hydrogen technology all stand out as research areas pivotal to New Zealand's energy future.

VI. 3. We have the skills and capabilities to import many existing energy technologies, including biorefining and gasification technologies, to adapt them and then to export these adaptations to others.

VI. 4. We have scientific, technological and engineering skills but to solve many of our energy problems we will need to unite scientific and commercial endeavours. In particular, New Zealand scientists and engineers have proven expertise and international leadership in geothermal generation development, and recognize specific areas for ongoing research and development.

VI. 5. We need to grow New Zealand's energy science, technology and engineering capabilities through focusing on the tertiary education sector as energy solutions will be a long term quest. New Zealand needs an expanding capability in energy research, development and deployment.

VI. 6. The research and development thrust in constrained system engineering, management, social adaptation, market development and transformation, and economics represents an opportunity for growth based on innovation.

VI. 7. Research on options for New Zealand's future transportation systems should be integrated with other energy research. The primary needs include: alternatives to on-demand mobility; systems for better planned access to services and markets; advances in information systems; urban design; freight organization; adaptation to a renewable energy transportation system; land use implications of large scale biofuel production systems.

VI. 8. Turning our creative efforts toward responding to the constraints of the twenty-first century will help New Zealand to provide services far into the future. Key operational research themes include: behavioural and cultural influences on energy demand; factors influencing the deployment of more energy efficient systems; land use and large scale renewable energy activities; health issues linked with energy use and energy related emissions; tradeoffs involved in developing new forms of energy; economic, structural and legal aspects of energy use and energy management; distributed energy systems, including energy provision for isolated communities and for the disadvantaged. Advances and discoveries made will have ready markets overseas as both developed and developing countries will have to deal with their own energy supply security and carbon emissions targets.

VI. 9. We need to build New Zealand's adaptive capability through a focus on research and innovation in new technologies, smart systems, modelling and economic instruments which can be deployed to manage regimes of constrained energy supply and/or capped greenhouse gas emissions.

VI. 10. New Zealand must have top-quality and transparent research-based foresight capability to inform long-term energy and environmental policy development, strategic planning, long-term infrastructure investment, and the transition to renewable energy transportation and electricity systems. For these purposes New Zealand needs to build its capacity for energy systems modelling and scenario-building to anticipate its future on a 50 year time scale in an ongoing way. This capacity should be supported by research in relevant engineering, scientific, resource, economic, health and social disciplines.

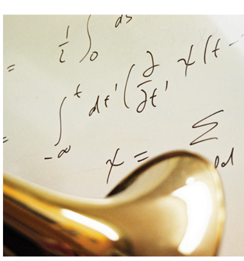
VI. 11. Energy research and development now receives public-good funding of approximately $17 million per annum. Research on petroleum and coal resources had received by far the greatest share of energy funding. Such an important area as energy, and renewable technologies, should receive more than a small fraction of the public-good research funding and this year's budget increases are but a tiny step in the right direction[57].

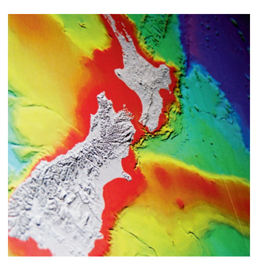
VI. 12. Revenue from future carbon charges and windfall profits from high oil prices should be put towards funding energy education, research and development.

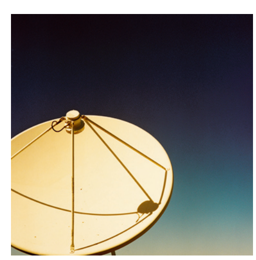
VI. 13. Given the scale of the problem of developing renewable energy resources, a significant funding investment is essential with an entirely different set of processes to mobilise multidisciplinary teams across scientific institutions.

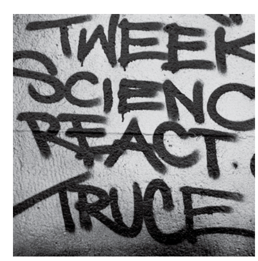
VI. 14. To ensure renewable energy and economic security progress we recommend that an Energy Taskforce be set up, with a budget to drive the development and implementation of efficient and renewable energy technologies. The Taskforce must ensure our capacity in energy research, development and deployment. Universities need support to seed that capability; CRIs need support to develop and apply that capability. The Taskforce will also drive the analysis of the behavioural changes that face society and the analysis of what sustainable energy sources imply for society, issues often ignored in developing and implementing significant technological change.

[57]IEA" Energy Policies of IEA Countries – New Zealand", 2006





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