new zealand energy
revolution

HOW TO PREVENT CLIMATE CHAOS

report new zealand national energy scenario

new zealand energy revolution

Greenpeace Aotearoa/New Zealand, Greenpeace International, European Renewable Energy Council (EREC)

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for further information about the global, regional and national scenarios please visit the energy [r]evolution website: **www.energyblueprint.info/**

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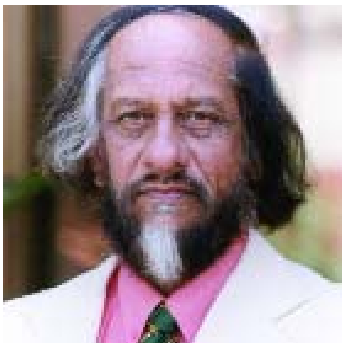
image VERTICAL VIEW OF A WIND POWER GENERATOR ON A WIND FARM IN AUSTRALIA.

foreword

There is now growing awareness on the imperatives for a global energy future which marks a distinct departure from past trends and patterns of energy production and use. These imperatives emerge as much from the need to ensure energy security, as they do from the urgency of controlling local pollution from combustion of different fuels and, of course, the growing challenge of climate change, which requires reduction in emissions of greenhouse gases (GHSs), particularly carbon dioxide.

This publication provides stimulating analysis on future scenarios of energy use, which focus on a range of technologies that are expected to emerge in the coming years and decades. There is now universal recognition of the fact that new technologies and much greater use of some that already exist provide the most hopeful prospects for mitigation of emissions of GHGs. It is for this reason that the International Energy Agency, which in the past pursued an approach based on a single time path of energy demand and supply, has now developed alternative scenarios that incorporate future technological changes. In the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) as well, technology is included as a crosscutting theme in recognition of the fact that an assessment of technological options would be important both for mitigation as well as adaptation measures for tackling climate change.

The scientific evidence on the need for urgent action on the problem of climate change has now become stronger and convincing. Future solutions would lie in the use of existing renewable energy technologies, greater efforts at energy efficiency and the dissemination of decentralized energy technologies and options. This particular publication provides much analysis and well-researched material to stimulate thinking on options that could be adopted in these areas. It is expected that readers who are knowledgeable in the field as well as those who are seeking an understanding of the subjects covered in the ensuing pages would greatly benefit from reading this publication.



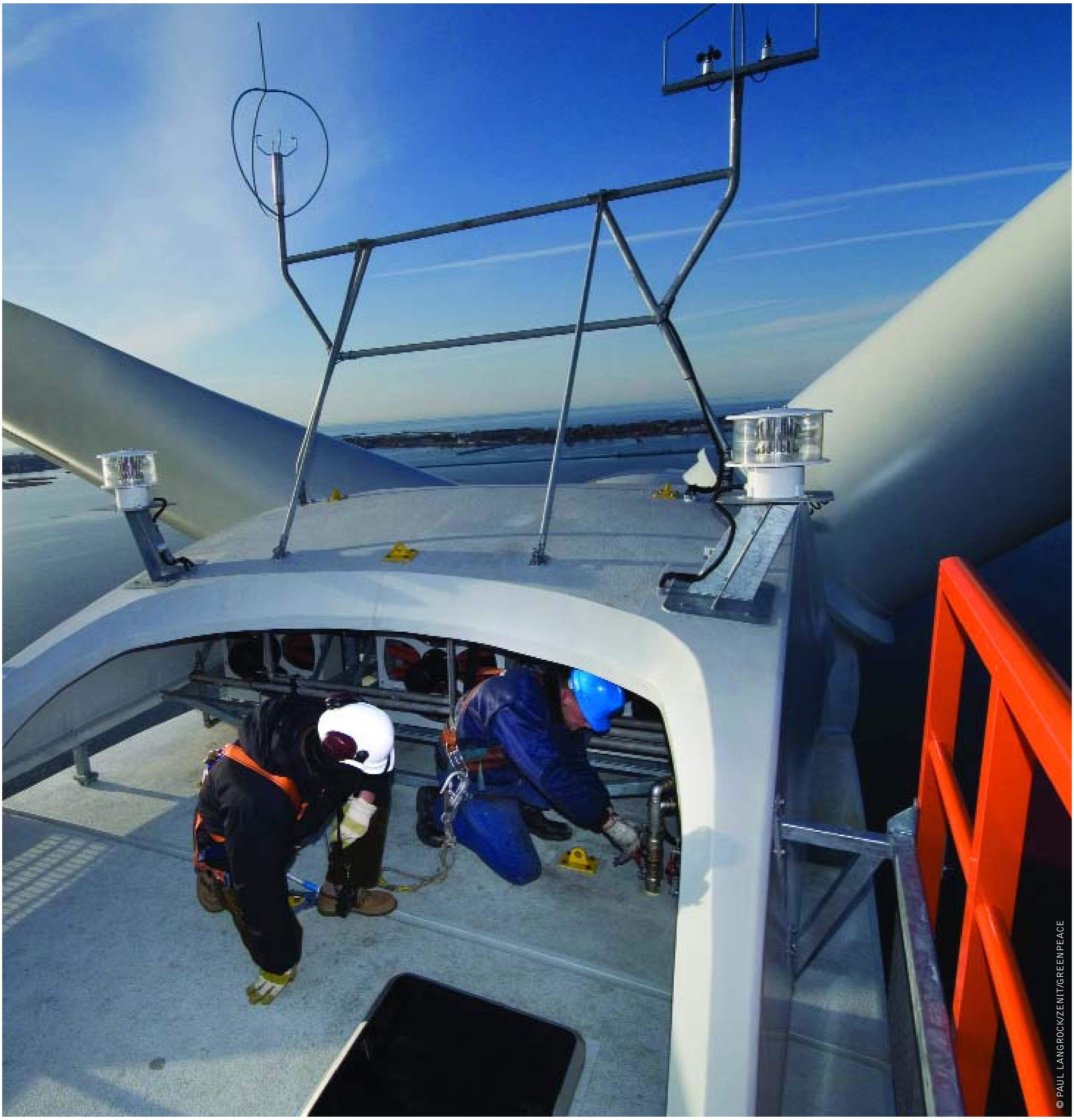
Dr. R. K. Pachauri

CHAIRMAN INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

JANUARY 2007

introduction

"IT HAS BEEN SAID THAT THE ENTIRE HISTORY OF THE ENVIRONMENTAL MOVEMENT HAS BEEN A DRESS REHEARSAL FOR THE FIGHT AGAINST CLIMATE CHANGE, AND IT'S A FIGHT THAT WE MUST WIN, BECAUSE OUR OWN CIVILISATION IS AT STAKE."



© PAUL LANGROCK/ZENIT/GREENPEACE

image TEST WINDMILL N90 2500, BUILT BY THE GERMAN COMPANY NORDEX, IN THE HARBOUR OF ROSTOCK. THIS WINDMILL PRODUCES 2,5 MEGA WATT AND IS TESTED UNDER OFFSHORE CONDITIONS. AT LEAST 10 FACILITIES OF THIS TYPE WILL BE ERECTED 20 KM OFF THE ISLAND DARSS IN THE BALTIC SEA BY 2007. TWO TECHNICIANS WORKING INSIDE THE TURBINE.

image GEOTHERMAL POWER STATION, NORTH ISLAND, NEW ZEALAND.

We stand in the face of the most important decision of our time.

It has been said that the entire history of the environmental movement has been a dress rehearsal for the fight against climate change, and it's a fight that we must win, because our own civilisation is at stake.

But have we got the courage to do what we must?

Last October, former World Bank economist Sir Nicholas Stern warned that the economic costs of the changing climate would be similar to those of the Great Depression and the two World Wars, and would leaving some 200 million people homeless.

This month, the Intergovernmental Panel on Climate Change – an inherently conservative body of 2500 scientists from every country in the world – said that it is now 90 per cent sure that human activity is the major contributor to climate change. The IPCC revised its prediction about climate warming upwards, from a maximum of 5°C to 6.4°C. While these temperature rises sound small, they could have a huge impact on the planet – the last ice age was just 5°C lower than today's average global temperature.

Warnings about climate change have grown steadily louder over the past 20 years, but we have ignored them. New Zealand's carbon emissions have actually increased since signing up to the Kyoto agreement in 2002, and if we continue on our current path, will more than double by 2050.

The Stern report said that if we act now "internationally, strongly and urgently", we can curb the impact of climate change at a cost of around only one per cent of GDP.

We in New Zealand are not exempt from the problem - or the solution. Our agricultural economy and reliance on fossil fuel-driven cars and trucks for transport, along with our First-World lifestyle, mean that we are heavy producers of the greenhouse gases.

This report is Greenpeace's contribution to the solution. Developed as part of an international effort, and drawing on the services of top analysts, this is the first serious analysis of how New Zealand can reduce greenhouse pollution on a scale necessary to avoid the worst climate impacts.

It's not pretty reading. Twenty years ago our electricity supply was from 80 per cent renewable resources; today we rely on fossil fuels for 43 per cent of our electricity. We are driving more cars and more trucks, we're clearing forests, we're importing coal and a Government-owned agency is fighting to build a new coal-fired power station. The result – our carbon dioxide emissions have jumped 38 per cent since 1990.

But there is hope. In this report, Greenpeace presents an alternative scenario, the Energy Revolution, in which we move in a managed way towards cutting greenhouse gas emissions from the energy sector by 72 per cent by 2050. The report shows that this can be done largely through energy efficiency and renewable energy sources, and at relatively low cost. In fact, there will be long-term economic benefits; not only will New Zealand avoid the enormous costs of unchecked climate change, but will benefit from the development of alternative technologies and a more reliable energy supply.

Of course, energy is just one part of the story; dealing with the climate-changing impacts of agriculture will be an even greater challenge for New Zealand, but we must face these challenges. As the Stern report said, delay of even a few years will inexorably increase the cost and impact of decisions that are ultimately inevitable.

The New Zealand Government is right now considering the measures it will take in response to climate change. It is up to all of us – policy makers, industry leaders and the people, to make sure that they are the right decisions.

Join us in the Energy Revolution; our children and the planet are at stake.

Bunny McDiarmid

Bunny McDiarmid
EXECUTIVE DIRECTOR
GREENPEACE AOTEAROA / NEW ZEALAND
FEBRUARY 2007

executive summary

"... NEW ZEALAND HAS VERY LITTLE TIME LEFT TO KICK-START THE SHIFT TO CLEAN ENERGY."

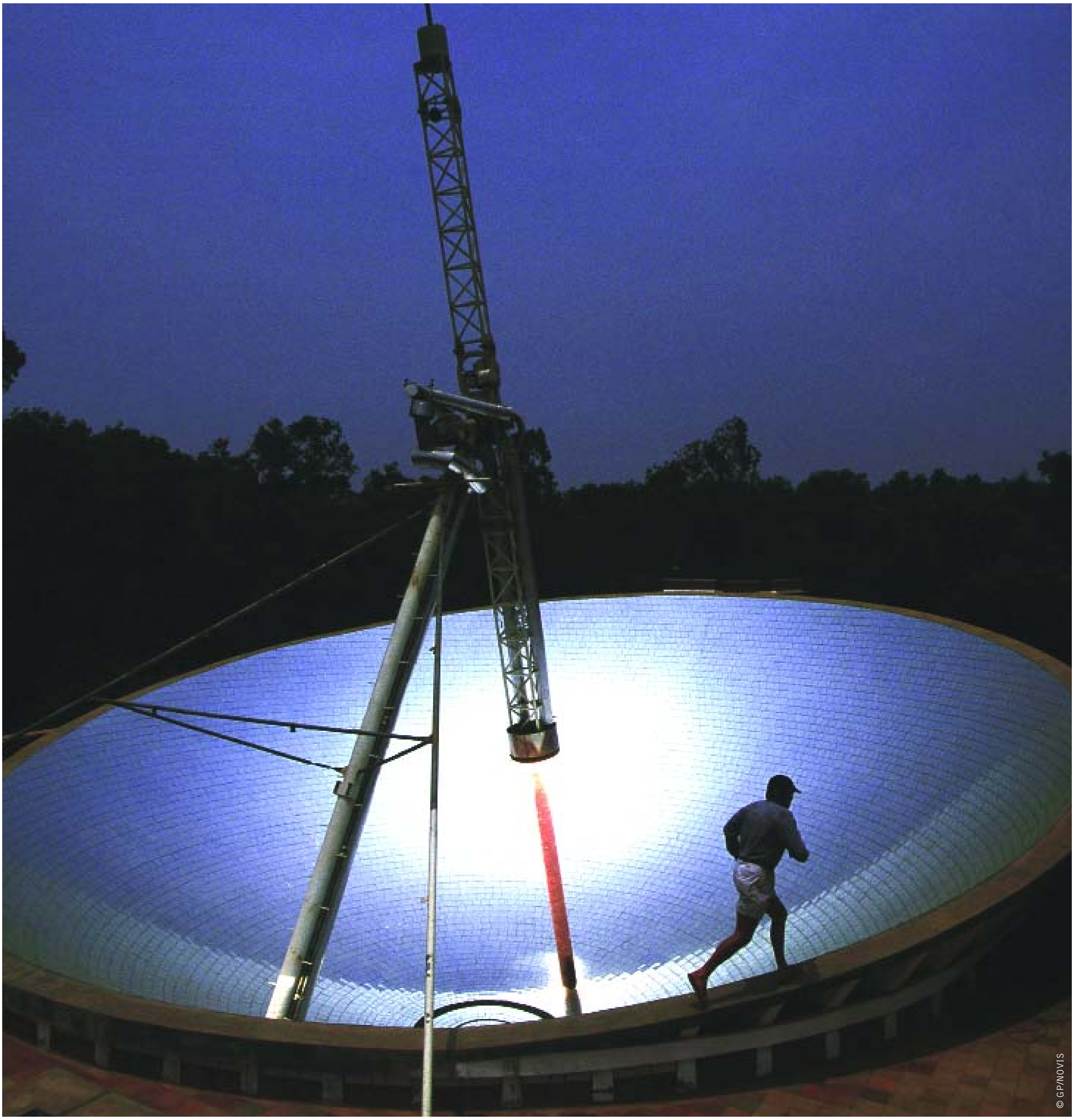


image MAN RUNNING ON THE RIM OF A SOLAR DISH WHICH IS ON TOP OF THE SOLAR KITCHEN AT AUROVILLE, TAMIL NADU, INDIA. THE SOLAR DISH CAPTURES ENOUGH SOLAR ENERGY TO GENERATE HEAT TO COOK FOR 2,000 PEOPLE PER DAY.

image GEOTHERMAL VENTS, ROTORUA, NEW ZEALAND.

© DREAMSTIME

climate change – the imperative to act

Climate change is real and it is happening now. Humans have already warmed the planet by 0.6°C, and have experienced a range of serious impacts as a result. If we allow temperatures to rise more than 2°C we will cross a "dangerous" threshold - with dramatic and unmanageable consequences for our environment, society and economy. The latest update, in February 2007, from the world's leading climate scientists at the Intergovernmental Panel on Climate Change (IPCC),warns that we may see up to 6.4°C warming this century if we do not dramatically reduce greenhouse pollution.

Our entire existence depends on a stable climate. If we don't reduce our greenhouse pollution, climate change will lead to falls in global production of food staples (resulting in famine and food shortages), cause ecosystems to collapse (the Amazon could convert to grassland), increase extreme weather events (such as Hurricane Katrina in the United States and droughts and floods in New Zealand and Australia), and the loss of glaciers and the melting of the Arctic and Antarctic regions which could raise sea levels by metres. The Gulf Stream, which keeps most of Europe warm by bringing warmer surface waters from the south up along its coast, could shut down as melting Arctic waters stop the "pumps" which drive this deep ocean current. This would plunge Europe into a mini ice age.

The IPCC warns that the climate is much more sensitive to increases in greenhouse pollution than previously thought. This means, for every tonne of greenhouse pollution released, we will see greater and more rapid warming than expected. As these scientists learn more about the climate system it is now clear that when the climate changes, it often changes very rapidly. It is more like flipping a switch than turning a dial.

We can avoid climate disaster, but only through concerted and urgent action to reduce greenhouse pollution. We must shift to a clean, safe and secure energy system.

new zealand - a lead role in the clean energy revolution:

There is a strong case for New Zealand to lead the world in clean energy and climate protection:

- We have vast renewable energy resources - including wind, hydro, biomass, geothermal, solar, wave and tidal energy, and we have experience in tapping them.
- We have huge potential energy savings and efficiency. Discovering that potential will reduce our energy expenditure, and result in a more productive economy.
- Clean energy will give New Zealand energy independence and security, by reducing our reliance on energy imports, and our susceptibility to rising oil and gas prices.[1]
- We have a responsibility to act. We are heavy greenhouse polluters, and since 1990 have allowed our levels of greenhouse pollution to increase by more than 21 per cent, and our carbon dioxide emissions by 38 per cent.

how do we get there? the path to a clean energy future

Greenpeace commissioned this report from the Institute of Technical Thermodynamics Department of Systems Analysis and Technology Assessment of the German Aerospace Centre together with Dialogue Consultants, Wellington. The result is a pathway for a secure and environmentally sustainable New Zealand energy system. The Greenpeace Energy Revolution Scenario shows that we can achieve:

- 100 per cent renewable electricity by 2025.
- 72 per cent reductions in CO_2 emissions by 2050 through domestic action alone.

There will also be significant economic, environmental and social benefits through the use of clean, renewable energy sources such as solar and wind power, and a high level of energy efficiency.

This report is a subset of global modelling presented in Greenpeace and the European Renewable Energy Council's report, Energy [R]evolution: A sustainable World Energy Outlook. That report demonstrated how global carbon dioxide emissions could be cut by almost 50% by 2050 whilst providing a secure and affordable energy supply and maintaining steady worldwide economic development. It can be downloaded at: www.greenpeace.org/new-zealand/press/reports/global-energy-report

reduced reliance on fossil fuel imports

The scenario achieves a phase-out of fossil fuels in the electricity sector by 2025, comes close to a fossil fuels phase-out in heating by 2050, and achieves significant reductions in the transport sector. We can achieve this in a relatively short time-frame without relying on any major future technology breakthroughs. (Any such breakthrough, such as nanosolar technology, will be a bonus.)

renewable energy will be cheaper in the long run

The Greenpeace Energy Revolution Scenario shows that in the long run, renewable energy will be cheaper than conventional energy sources and reduce New Zealand's dependence on imported fossil fuels.

reference

1 DURING THE 2005/06 FINANCIAL YEAR, NEW ZEALAND SPENT $4.94 BILLION ON PETROLEUM IMPORTS. EXPENDITURE ON PETROLEUM IMPORTS INCREASED 148% (FROM $1.99 BILLION) IN JUST 6 YEARS. SOURCE: STATISTICS NEW ZEALAND, INFOS DATABASE. TOTAL FIGURE REPRESENTS THE SUM OF MERCHANDISE CATEGORIES 2709 TO 2715.

two bad options – nuclear energy and carbon capture and storage

Employing nuclear energy and carbon-capture and storage technology would divert attention and effort away from the real solutions to climate change – renewable energy, energy efficiency and conservation.

nuclear energy is often cited as a solution to climate change, but employing it would be simply swapping one environmental nightmare for another. Nuclear power is never safe. Not only is there no safe way of disposing of nuclear waste, but the nuclear power industry requires enormous government subsidies. Nuclear energy cannot compete on an open market; it costs at least 20 per cent more (and up to 10 times more per kilowatt hour) than renewable energy or energy efficiency.

Further, New Zealand does not have the infrastructure or expertise to deal with nuclear energy, and even the smallest commercially viable nuclear reactor would be too big to fit into New Zealand's electricity system.

carbon capture and storage (burying greenhouse pollution in the ground) is not viable either. It is very expensive, more expensive than a typical wind farm and the technology is unproven and therefore risky.

The Intergovernmental Panel on Climate Change says that there are still far too many questions about environmental risk, safety and costs for CCS to be deployed on a scale that would make it economically viable until at least the second half of the century, but we need to cut greenhouse gas emission by 50 per cent by 2050 and must take significant action in the next 10 years. Carbon capture and storage will not be ready in time to help us avoid catastrophic climate change.

New Zealand is geologically unstable and there is real risk of dangerous leakage and pollution from stored carbon gas. Monitoring the stored gas would be expensive and on-going, and there are questions about who would be responsible for this work and liable for any leakage.

no time to waste!

The Greenpeace Energy Revolution Scenario proves that renewable energy sources, combined with energy efficiency and savings, can make the necessary cuts to our greenhouse emissions. The Scenario also shows that New Zealand has very little time left to kick-start the shift to clean energy. Delaying even a few years will make it impossible to achieve a smooth transition.

Globally, total emissions need to peak no later than 2020, with at least 50 per cent reductions in 2050. Wealthy countries like New Zealand and the United Kingdom (Annex 1, countries under the Kyoto Protocol) which collectively have been the main cause of the current levels of greenhouse pollution have a responsibility to act first. They need to aim for 20-30 per cent reductions on 1990 levels of emission by 2020, and 80 to 90 per cent reductions by 2050 if the planet is to have a good chance of avoiding very dangerous levels of climate change.

This report shows that New Zealand will struggle to meet these emission reductions in the energy sector, and will lag 10 years behind the target. By 2020, when we should have achieved 20-30 per cent reductions, we will be only stabilising emissions. We will reach 23 per cent reductions, but not until 2030. By 2050, our emissions will be 72 per cent below 1990 levels, or eight to 18 per cent of what is needed.

The position is further complicated by the fact that agricultural emissions comprise about half of New Zealand's total greenhouse gas pollution, yet may be more difficult and slower to reduce.

New Zealand, therefore, faces a great challenge. We are paying the cost for delaying action on climate change. We must learn the lesson that early action is vital. The costs of delay are enormous, both in terms of the severity of climate change impacts and in the difficulties posed by reducing greenhouse gas emissions rapidly enough to avoid severe climate impacts.

New Zealand could still meet a national target of 30 per cent reduction in total greenhouse gas emissions by 2020, and 90 per cent by 2050, by adopting the following strategies:

- Retiring carbon-intensive energy infrastructure before its due date (such as Huntly power station and Genesis' e3p). (The model assumes equipment is not retired early).
- Proposing more aggressive demands on the agricultural sector to also rapidly reduce its greenhouse emissions. This would involve a heavy commitment of funding to research and develop new techniques and implement existing knowledge, and might well require a shifting of agricultural practices from dairying to less greenhouse-gas intensive farming practices.
- A possible expansion of the use of biofuels in the transport sector, providing they can be produced sustainably. Any remaining emission reductions should be made up by purchasing credits on the international market, focusing on credits from projects under the Clean Development Mechanism, with emphasis on projects in Pacific Island nations.

Greenpeace calls for New Zealand politicians, policymakers and the New Zealand energy sector to invest in our future and take action now.

political and policy leadership at a critical juncture

New Zealand needs clear and strong political and policy leadership if it is to make a smooth transition to clean energy.

The New Zealand Government is currently developing an Energy Strategy and a Climate Policy Package. These policies will largely determine whether we make the shift to clean energy and advance the global fight against dangerous climate change. Greenpeace has put forward a policy package that will provide the foundation for a clean energy future (see the Climate and energy policy section).

New Zealand's policies must be concrete and ambitious if we are to drive towards a clean energy future.

image A CLOSE-UP OF A SOLAR PANEL.

Policies must be practical and targeted, with a focus on measures that break down barriers to change (structural, financial and social) and create incentives for positive action.

Policies should ensure that vulnerable members of society are looked after during the process of change to a more climate friendly economy.

framing the challenge - national greenhouse targets

New Zealand needs clear, overarching targets to frame the shift to clean energy. The targets must be consistent with keeping temperature rise below the 2°C "dangerous" threshold. New Zealand's minimum targets must be:

- a 30 per cent reduction in greenhouse pollution compared to 1990 levels by 2020;
- a 90 per cent reduction in greenhouse pollution compared to 1990s levels by 2050.

a "price instrument" - the incentive to reduce greenhouse pollution

A polluter-pays "price instrument" forms the backbone of any suite of climate policies. This could be achieved either through a carbon charge or an emissions trading scheme. A price instrument must be implemented immediately and cannot be delayed.

- A broad-based carbon charge should be immediately implemented and remain in place until any alternative price instrument is established. Much of the policy work has already been done on this and could be reasonably implemented by 2008.
- Emissions trading should be implemented in the medium term (eg. from 2012) to allow time for policy development of this complex system.

energy efficiency and savings

New Zealand has huge potential in energy efficiency and savings. Investment in energy efficiency and savings should be given priority over investment in new generation capacity, because it typically provides a better return on investment.

Policy recommendations include:

- Continuing programmes to boost solar water heating.
- Strengthening building codes to increase minimum levels of energy efficiency.
- Retro-fitting homes with insulation.
- Promoting Energy Star-branded appliances.

the new NEECS

The new National Energy Efficiency and Conservation Strategy (NEECS) has the potential to deliver substantial reductions in greenhouse gas emissions, and a more productive economy. In order to be effective, the NEECS should:

- Adopt a 20 per cent reduction target for total energy consumption by 2020.[2] Interim and sectoral targets should be consistent with this overall target.
- Facilitate a major increase in investment in energy efficiency and conservation to at least $300 million to $400 million annually.
- Require the Energy Efficiency and Conservation Authority (EECA) to foster new businesses that deliver energy-efficient services.
- Include an Electricity Demand Management Fund[3] to generate significant funds for energy savings and efficiency.
- Ensure the rapid uptake of smart-metering so that consumers can monitor and more easily respond to national peak usage times by reducing their own usage.
- Require the Government to show a lead in practising energy efficiency and conservation.
- Decouple electricity profits from electricity sales.

renewable energy

New Zealand can and should be a world leader in renewable energy. We have excellent renewable energy resources. We need strong Government policies to promote renewable energy. We are currently lagging behind European countries which have actively supported their renewable energy industries.

New Zealand can achieve a 100 per cent renewable electricity sector and a high proportion of renewable transport by:

- Promoting a diverse range of low-impact renewable technologies.
- Encouraging the development of a geographically dispersed, "distributed" renewable energy system.
- Increasing energy efficiency and conservation in order to lower demand.

Specific incentives for renewable energy are required in addition to a price on greenhouse pollution. Both carrot and stick measures are required to spark a rapid uptake in renewable energy.

references

2 FROM CURRENT LEVELS. THIS IS IN LINE WITH NUMEROUS STUDIES THAT HAVE SHOWN THAT THE EU COULD SAVE AT LEAST 30% OF ITS PRESENT ENERGY CONSUMPTION IN A COST-EFFECTIVE MANNER. SEE COMMISSION OF EUROPEAN COMMUNITIES, COM(2005) 265, GREEN PAPER ON ENERGY EFFICIENCY OR DOING MORE WITH LESS, AT PAGE 4.

3 THE FUND COULD BE A NEW INITIATIVE, OR A MAJOR INCREASE ON THE NZ$2 TO $6 MILLION/YEAR "EFFICIENCY LEVY" CURRENTLY RAISED BY THE ELECTRICITY COMMISSION.

setting goals – renewable energy targets

New Zealand should adopt a legally binding renewable energy target of 100 per cent renewable electricity by 2025.

The Greenpeace Energy Revolution Scenario demonstrates that this is technically and economically achievable.

measures to boost renewable electricity

A feed-in tariff, or guaranteed price system, should be established.

Based on international experience, this is the most effective means of supporting renewable energy. A feed-in tariff provides certainty to investors in renewable energy by providing a guaranteed sale price for electricity they generate over a specific period of time.

The tariff could be set at different levels, with targeted encouragement of particular types of renewable energy that deserve support such as:

- Community-owned wind development.
- Smaller (i.e. less than 20MW) wind developments.
- Newer renewable technologies, such as tidal energy, particularly for smaller pilot projects.

micro generation

Micro-scale (i.e. household) generation deserves specific support.

A feed-in tariff and a net metering initiative are two specific measures that should be introduced.

Net metering protocols should be simplified and streamlined to ensure that micro generators can sell excess energy to the grid

new zealand community wind

A programme to support small community-owned or local New Zealand-owned wind farms should be introduced.

loading order

A variation of the Californian loading order should be adopted whereby electricity providers must first demonstrably consider energy efficiency options to meet demand, and secondly renewable energy.

Additional fossil fuel projects should be ruled out.

resource management act

Climate change is a complex issue, requiring action at all levels - individual, local, regional, corporate, national and international.

The Resource Management Act (RMA) was amended in 2004 to remove regional councils' ability to directly manage and regulate greenhouse emissions.

- The Climate Protection Bill (Resource Management (Climate Protection) Amendment Bill 2006), proposed by the Green Party, should be adopted.

This bill would re-instate the ability of regional authorities to directly regulate greenhouse pollution, and is therefore the best available means of addressing the regulatory vacuum on greenhouse pollution. Once a price on carbon was implemented this could be re-assessed.

end subsidies to fossil fuels

Fossil-fuel energy sources receive an estimated $250 billion to $300 billion in subsidies per year worldwide, heavily distorting markets.

Subsidies artificially reduce the price of fossil fuel energy and block the uptake of renewable energy out of the market place. Eliminating direct and indirect subsidies to fossil fuels would help to move us towards a level playing field across the energy sector.

transport

domestic transport - reducing our dependence on roads

There is great potential to reduce greenhouse gas emissions from New Zealand's transport sector. Our per capita CO_2 emissions from transport are fourth highest in the world.[4]

Steps to reduce transport emissions should follow a hierarchy of action:

- Reduce the need to travel.
- Choose a low-impact means of travel.
- Choose a low-impact propulsion system.
- Improve the efficiency of propulsion.

Reduced transport emissions can be achieved by:

- Ensuring that urban planning processes allow reduced need for travel through more numerous centralised nodes.
- Encouraging information technology, such as video or web-based conferencing, which reduce the need for travel for meetings. Government departments should lead by example on this.
- Shifting urban journeys from road to public transport, walking and cycling.
- Boosting the proportion of the Land Transport Fund spent on public transport from the current 15 per cent to at least 50 per cent by 2010.
- Shifting longer-distance freight from road to rail and sea.
- Shifting domestic air transport to rail and sea-based systems.
- Introducing a mandatory percentage of biofuel to be mixed with regular petrol, starting from 5 per cent and increasing over time.
- Creating a major programme to encourage local production and usage of biofuels, including incentives for retailers to provide greater proportional mixes of biofuel in their petrol.

- Establishing a sustainability certification program for biofuels[5].
- Introducing a range of measures to improve vehicle fleet efficiency and to encourage the uptake of electric plug-in hybrid vehicles. These would include:
  - the introduction of vehicle emissions standards and tests for all vehicles[6];
  - fuel-efficiency standards for newly registered and re-registered vehicles equivalent to those prevailing in the country of manufacture;
  - a ban on the import of used vehicles more than seven years old;
  - a fuel-efficiency labelling scheme for all vehicles;
  - a differential registration or feebate scheme based on fuel efficiency.

international transport

International transport (air and maritime) emissions are not covered in this scenario, but will have to be addressed by New Zealand.

New Zealand should respond proactively by:

- Switching exports by air to more efficient maritime transport.
- Developing sailing or hybrid cargo ships.
- Developing products that have a high value-to-weight ratio.
- Reducing emissions from all levels of production of our products as a response to the rising and inevitable concern about "food miles".
- Encouraging the consumption of domestically produced products.
- The tourism sector should start planning for fewer, but longer and higher-value visits from international visitors, and actively encouraging New Zealanders to holiday domestically.

energy revolution: a sustainable pathway to a clean energy future for new zealand

The Energy Revolution Scenario is a development pathway to a sustainable and secure New Zealand energy supply.

Renewable energy sources such as wind, solar, hydro and biomass account for about 18 per cent of New Zealand's primary energy demand. Biomass (i.e. wood), which is used primarily for heating, is the main renewable energy source. The share of renewable energies for electricity generation was 57 per cent in 2006, with hydro power plants being the largest source. The contribution of renewable sources to heat supply is around 11 per cent. About 82 per cent of the New Zealand primary energy supply is from fossil fuels.

reference

4 IN 2003, NEW ZEALAND WAS THE FOURTH HIGHEST EMITTER AMONGST ANNEX 1 PARTIES WITH RELIABLE DATA, WITH EMISSIONS 15 TO 40% HIGHER THAN THOSE ACHIEVED IN MOST COUNTRIES. NEW ZEALAND IS ALSO UNIQUE AMONGST ANNEX 1 PARTIES IN THAT TRANSPORT EMISSIONS ARE A GROWING SHARE OF ENERGY EMISSIONS, DESPITE RAPID GROWTH IN FOSSIL FUEL USE FOR ELECTRICITY GENERATION.

Exploitation of existing large energy efficiency potentials will reduce the current primary energy demand from 658PJ/a (2003) to 638PJ/a in 2050 while the population increases over the same period by more than 1 million people. This dramatic reduction in primary energy demand is a crucial prerequisite for achieving a significant share of renewable energy sources in the overall energy supply system, and for reducing the consumption of fossil fuels.

- The electricity sector will continue to be the forerunner of renewable energy utilisation. By 2025, 100 per cent of electricity will be produced from renewable energy sources (including hydro). A capacity of 14GW will produce 64TWh/a from renewable energy sources in 2050.
- In the heat supply sector, the contribution of renewable sources will continue to grow, reaching more than 82 per cent in 2050. In particular, biomass and geothermal energy will substitute conventional systems for direct heating and cooling.
- The priority in the transport sector is reducing the need to travel, switching to lower-impact travel methods (such as public transport), switching to more climate-friendly fuels and technologies (such as sustainably sourced biofuels and plug-in hybrid electric cars to store and use excess renewable energy from the grid - predominantly wind energy) and on improving efficiency. Because the use of biomass for CO_2 reduction in stationary applications is more cost effective, the use of biofuels is limited by the availability of biomass sustainably sourced within New Zealand.

By 2050, nearly three quarters of the primary energy demand will be covered by renewable energy sources. A balanced and timely mobilisation of all renewable energy technologies is vitally important to the attractive growth of renewable energy sources. This mobilisation depends on technical potentials, actual costs, cost reduction potentials, and technological maturity.

development of CO_2 emissions

On our current track, New Zealand's CO_2 emissions will more than double by 2050. If we follow the Energy Revolution path, CO_2 emissions will decrease by 72 per cent, from 31.17Mill. t in 2003 to 6.46Mill. t in 2050. Annual per capita emissions will drop from 8 tonnes/capita to 1.3 tonnes/capita. While today the electricity sector contributes about 19 per cent of CO_2 emissions, this will drop to zero by 2025.

references

5 THERE IS A SIGNIFICANT GLOBAL RISK THAT LAND CLEARANCE FOR BIOFUEL PRODUCTION (EG SUGAR CANE AND PALM OIL PLANTATIONS) MAY GENERATE ADVERSE CLIMATE EFFECTS THROUGH LOSS OF CARBON SINKS, ENERGY INTENSIVE PRODUCTION METHODS, AND METHANE FROM ROTTING VEGETATION. THESE CAN OFFSET THE CLIMATE BENEFITS OF BIOFUEL USE. THIS IS IN ADDITION TO THE ECOLOGICAL AND SOCIAL IMPACTS OF INCREASED DEFORESTATION.

6 EMISSIONS TESTING – WHILE NOT DIRECTLY RELATED TO FUEL-EFFICIENCY – WILL HELP REMOVE OLDER HEAVILY WORN VEHICLES FROM THE FLEET.

costs

Electricity generation costs under the Energy Revolution will steadily decrease, while those in the Reference Scenario continue to climb. By 2050, generation costs will be more than 40 per cent less than in the Reference Scenario. Due to growing demand, we face a significant increase in society's expenditure on electricity supply. Under the Reference Scenario, the unchecked growth in demand, the increase in fossil fuel prices and the cost of CO_2 emissions result in total electricity supply costs rising from today's 2.8 billion $ per year to 7.3 billion $ in 2050. However the Energy Revolution Scenario not only achieves significant reductions in CO_2 emissions, but also helps to stabilise energy costs and relieve the economic pressure on society. Increasing energy efficiency and shifting energy supply to renewable sources leads to a reduction of long term costs for electricity supply by more than 40 per cent than in the Reference Scenario. It becomes clear that following stringent environmental targets in the energy sector also pays off economically.

effects on employment

The rapid growth of renewable energy technologies described under the Energy Revolution Scenario will lead to large investment in new technologies. This dynamic market growth results in a shift of employment opportunities from conventional energy-related industries, like coal mining, to new occupational fields in, for example, the wind and solar industry. There are more jobs per kilowatt hour in electricity generated from renewable energy sources than in fossil fuels.

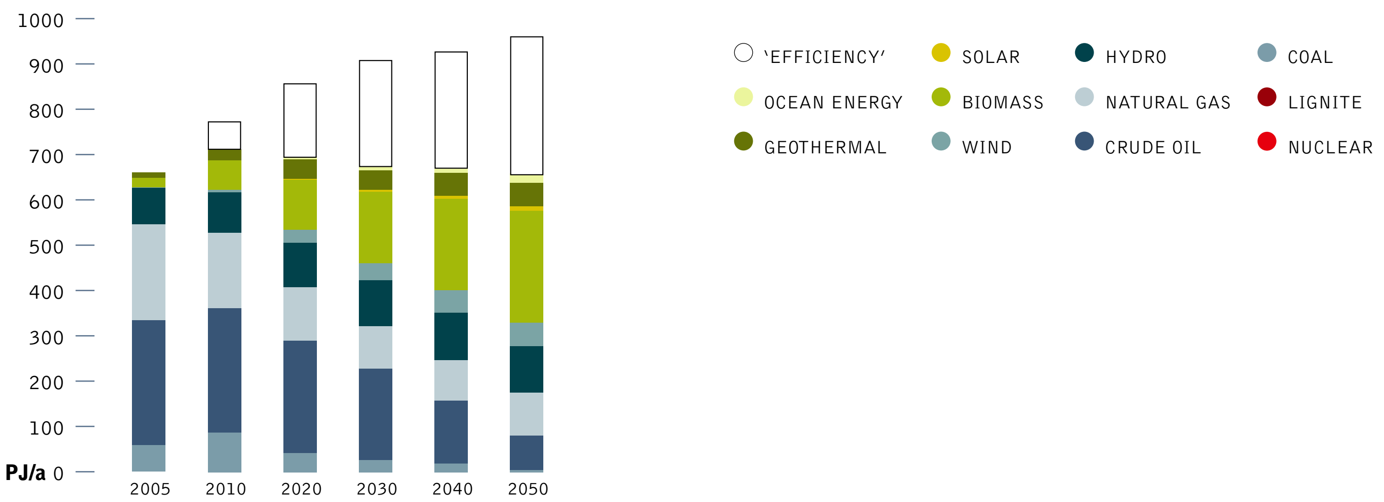
Under the Energy Revolution Scenario, an estimated 2600 to 6000 annual jobs are required to manufacture and install renewable energy electricity generation – a total of 122,000 to 282,000 job years through to 2050. This includes only the direct manufacturing jobs. If ongoing operational and maintenance jobs were included, the figures would be higher still, and a significant number of education and training positions would also be required to train these workers.

to make the energy revolution real and to avoid dangerous climate change, new zealand must:

- Set national greenhouse pollution targets
- Establish an economy-wide cost on carbon for 2008. Leaving it until 2012 will be too late.
- Achieve a 100 per cent renewable electricity supply by 2025, phasing out coal as a first priority and using gas as a transitional fuel until 2025.
- Invest in an effective public transport system.
- Move to a rail and sea-based freight system.

figure 1: new zealand: development of primary energy consumption under the energy revolution scenario

('EFFICIENCY' = REDUCTION COMPARED TO THE REFERENCE SCENARIO)



climate protection

"IF WE DO NOT TAKE URGENT AND IMMEDIATE ACTION TO STOP GLOBAL WARMING, THE DAMAGE COULD BECOME IRREVERSIBLE."

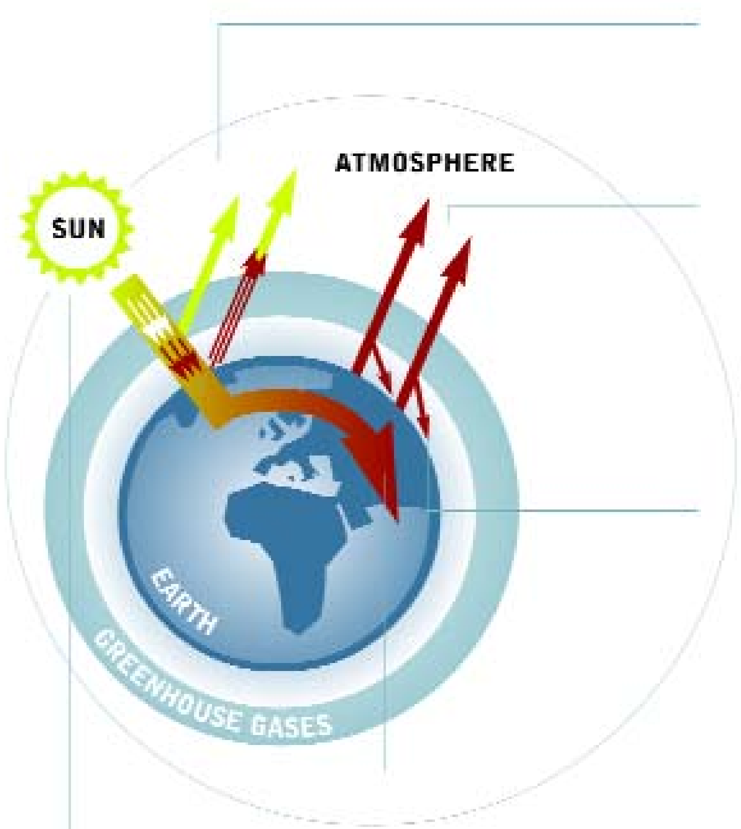
image 1 and 2. ORIGINAL PHOTOGRAPH TAKEN IN 1928 OF THE UPSALA GLACIER, PATAGONIA, ARGENTINA COMPARED WTIH THE RECEEDING GLACIER TODAY.

the greenhouse effect and climate change

The greenhouse effect is the process by which the atmosphere traps some of the sun's energy, warming the earth and moderating our climate. Most climate scientists believe that a human-driven increase in greenhouse gases is increasing this effect artificially, raising global temperatures and disrupting our climate. These gases include carbon dioxide (released by burning fossil fuels and through deforestation) - and methane (released by agricultural practices and landfill sites) - as well as the products of combustion and a variety of industrial chemicals.

Every day we damage our climate by using fossil fuels (oil, coal and gas) for energy and transport. Climate change poses the greatest threat to the planet today and if left unchecked could cause massive environmental, social, economic and cultural upheaval including ecosystem collapse, mass extinctions and the creation of water and food shortages which combined with increased extreme weather events could lead to the creation of millions of climate refugees.

the greenhouse effect



top 10 warmest years between 1850 and 2005

COMPARED TO MEAN GLOBAL TEMPERATURE 1880-2003

YEAR	GLOBAL TEMPERATURE ANOMALY	RANK
1998, 2005	+0.63°C	1
2003	+0.56°C	2 (tie)
2002	+0.56°C	2 (tie)
2004	+0.54°C	4
2001	+0.51°C	5
1997	+0.47°C	6
1995	+0.40°C	7 (tie)
1990	+0.40°C	7 (tie)
1999	+0.38°C	9
2000	+0.37°C	10

source NATIONAL CLIMATIC DATA CENTER

image DEVASTATION IN NEW ORLEANS IN THE WAKE OF HURRICANE KATRINA.

A 2006 report by Nicholas Stern[7], former World Bank economist, warned that the economic costs of climate change could be on a similar scale to that of the First and Second World Wars and the Great Depression of the 20th century, and will run into the trillions of dollars. He estimated that climate change could cost between five and 20 per cent of GDP every year. This is 20 times more than it will cost to take action on climate change, which Stern estimates at 1 per cent of GDP each year.

According to the February 2007 report in from the Intergovernmental Panel on Climate Change (IPCC), the United Nations forum for established scientific opinion, the world's temperature is expected to increase over the next hundred years by up to 6.4° Celsius if we do not dramatically reduce greenhouse pollution.

This is much faster than anything experienced so far in human history. The goal of climate policy should be to keep the global mean temperature rise at less than 2°C above pre-industrial levels. At more than 2°C, damage to ecosystems and disruption to the climate system increases dramatically, and many impacts are likely to become irreversible. To keep global average temperatures below 2°C and avoid these most serious climate impacts, global emissions need to stabilise by 2020 and then halve by 2050. We have very little time, just 10 years or so, within which we can change our energy system to meet these targets.

The IPCC's report warns that the climate is much more sensitive to increases in greenhouse pollution than previously thought. This means that for every tonne of greenhouse pollution released, we will see greater and more rapid warming than expected.

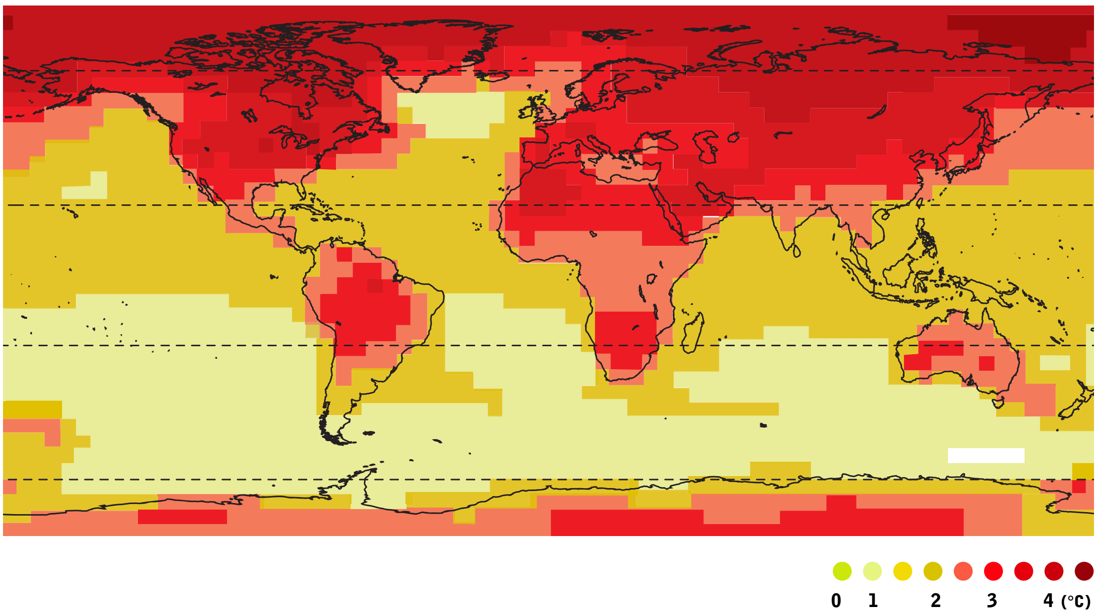
Scientists are learning more about the climate system it is clear that when the climate changes, it often changes very rapidly. It is more like flipping a switch rather than turning a dial.

Climate change is already harming people and ecosystems. Its reality can be seen in disintegrating polar ice, thawing permafrost, dying coral reefs, rising sea levels and fatal heat waves. It is not only scientists who are witnessing these changes. From the Inuit in the far north to islanders near the Equator, including our Pacific neighbours such as Tuvalu, people are already struggling with the impacts of climate change. An average global warming of 2°C threatens millions of people with an increased risk of hunger, malaria, flooding and water shortages.

Never before has humanity been forced to grapple with such an immense environmental crisis. If we do not take urgent and immediate action to stop global warming, the damage could become irreversible. This can only happen through a rapid reduction in the emission of greenhouse gases into the atmosphere. This is an environmental, economic and moral imperative.

mean surface temperature distribution for a global temperature increase of 2°C

+2°C AVERAGE



note EMPLOYED LINEAR PATTERN SCALING METHOD AS IMPLEMENTED IN THE SCENGEN MODEL (BY WIGLEY ET AL.). THE DISPLAYED PATTERN IS THE AVERAGE OF THE DEFAULT SET OF MODELS, NAMELY CSM (1998), ECHAM3 (1995), ECHAM4 (1998), GFDL (1990), HADAM2 (1995), HADAM3 (2000). THE PATTERN HAS BEEN DERIVED FOR A TEMPERATURE INCREASE OF 2°C ABOVE 1990 IN A TRANSIENT RUN WITH EMISSION SCENARIO IPCC SRES B2. NOTE THAT THE EQUILIBRIUM TEMPERATURE PATTERN FOR A 2°C INCREASE ABOVE PRE-INDUSTRIAL LEVELS WILL BE QUANTITATIVELY DIFFERENT, ALTHOUGH QUALITATIVELY SIMILAR.
© MALTE.MEINSHAUSEN@ENV.ETHZ.CH; ETH ZÜRICH 2004

reference
7 STERN REPORT ON THE ECONOMICS OF CLIMATE CHANGE, SIR NICHOLAS STERN, FOR THE UK GOVERNMENT, NOVEMBER 2006.

images 1. FLOOD IN NEW ZEALAND, FEBRUARY 2004. **2.** A FAMILY LIVING NEXT TO THE SEA BUILD A SEA WALL FROM SAND BAGS IN AN ATTEMPT TO PROTECT THEIR PROPERTY FROM UNUSUAL HIGH TIDES CAUSED BY THE 'KING TIDES'. GREENPEACE AND SCIENTISTS ARE CONCERNED THAT LOW LYING ISLANDS FACE PERMANENT INUNDATION FROM RISING SEAS DUE TO CLIMATE CHANGE. **3.** 30TH OCTOBER 2006 - NONTHABURI, THAILAND - VILLAGERS PADDLE A BOAT IN A VILLAGE ON KOH KRED ISLAND WHICH WAS ENGULFED BY RECENT FLOODING. KOH KRED IS A TINY ISLAND IN THE CHAO PHRAYA RIVER, LOCATED IN NONTHABURI PROVINCE IN THE OUTSKIRTS OF BANGKOK. EARLIER IN THE YEAR, SCIENTISTS WARNED THAT THAILAND WOULD EXPERIENCE MORE FREQUENT EXTREME WEATHER EVENTS DUE TO THE IMPACTS OF CLIMATE CHANGE. **4.** THE DARK CLOUDS OF AN ADVANCING TORNADO, NEAR FORT DODGE, IOWA, USA. **5.** THOUSANDS OF FISH DIE AT THE DRY RIVER BED OF MANAQUIRI LAKE, 150 KILOMETRES FROM AMAZONAS STATE CAPITOL MANAUS, BRAZIL.

below is a summary of some likely effects if we allow current trends to continue:

- Sea level rise due to melting glaciers and the thermal expansion of the oceans as global temperature increases.
- Massive releases of greenhouse gases from melting permafrost and dying forests sparking a large increase in warming.
- A high risk of more extreme weather events, such as heat waves, droughts and floods. Already, the global incidence of drought has doubled over the past 30 years.
- Severe regional impacts. In Europe, river flooding will increase, as well as coastal flooding, erosion and wetland loss. Flooding will also severely affect low-lying areas in developing countries such as Bangladesh and South China, and Pacific countries such as Tuvalu.
- Natural systems, including glaciers, coral reefs, mangroves, alpine ecosystems, boreal forests, tropical forests, prairie wetlands and native grasslands, will be severely threatened.
- Increased risk of species extinction and biodiversity loss – The Amazon could be lost as it converts to grassland.

a) the greatest impacts will be on the poorer countries in africa, asia and the pacific that are least able to protect themselves from rising sea levels, the spread of disease and decline in agricultural production. Longer-term catastrophic effects

- Warming from emissions may trigger the irreversible meltdown of the Greenland ice sheet, adding up to seven metres of sea-level rise over several centuries. New evidence also shows that the rate of ice discharge from parts of the Antarctic mean it is also at risk of meltdown.
- Slowing, shifting or shutting down of the Atlantic Gulf Stream current will have dramatic effects in Europe, possibly plunging the region into a mini-ice age, and disrupting the global ocean circulation system.
- Large releases of methane from the oceans will lead to rapid increases of the gas in the atmosphere and consequent warming.

climate impacts in new zealand

- Sea-level rise combined with storm surges will cause coastal erosion and affect coastal properties. Already, people in the United Kingdom can not insure their homes against flooding – New Zealand is likely to follow suit.
- An increased extreme weather events such as droughts, floods and "weather bombs".
- Drier conditions in the east, affecting key agricultural areas such as Canterbury[8]. The risk of severe drought in eastern areas may increase four-fold by 2080.
- Wetter conditions in the west.
- Warmer conditions, with most warming in the north and greatest proportional increases in winter.
- More mosquito-borne diseases such as Dengue Fever are likely to become viable.
- The loss of one-third of the South Island's 3000 glaciers in a few decades if the temperatures rise by 1.5 - 4.5°C. The snowline may also rise several hundred metres, spelling bad news for tourism and skiers.
- New agricultural pests and diseases.
- Increased risk of forest fires and an extended forest fire season[9].

There will be significant economic impacts from these physical changes to our climate. The agricultural sector is particularly vulnerable and is likely to be first and hardest hit. The droughts of the late 1990s alone have already cost the New Zealand economy more than $1 billion, while the February 2004 floods in central New Zealand cost $400 million, with $112 million in insurance payouts and $135 in Government aid to farmers. These floods alone affected some 2600 farmers, and some have now abandoned their farms.

references

8 CLIMATE CHANGE EFFECTS AND IMPACT ASSESSMENT 2004, NATIONAL INSTITUTE OF WATER AND ATMOSPHERIC RESEARCH, FOR THE NEW ZEALAND CLIMATE CHANGE OFFICE, MINISTRY FOR THE ENVIRONMENT

9 CHANGES IN DROUGHT RISK WITH CLIMATE CHANGE 2005, NATIONAL INSTITUTE OF WATER AND ATMOSPHERIC RESEARCH, FOR THE NEW ZEALAND CLIMATE CHANGE OFFICE, MINISTRY FOR THE ENVIRONMENT AND MINISTRY OF AGRICULTURE AND FORESTRY.

kyoto protocol

Recognising these threats, in 1997 more than 50 industrialised nations - responsible for more than 55 per cent of the world's carbon dioxide emissions – came together and negotiated the Kyoto Protocol. The Kyoto Protocol is part of the United Nations Framework Convention on Climate Change, and the Protocol's 166 member-countries meet regularly to discuss progress.

The Kyoto Protocol commits its signatories to reduce their greenhouse gas emissions by the first commitment period of 2008-2012. New Zealand's target is to return to 1990 levels whereas the European Union has an eight per cent reduction target on 1990 levels. The global impact of the agreement will be a 5.2 per cent reduction from 1990 levels by the first commitment period.

Global greenhouse gas emissions will have to be reduced by at least 50 per cent by 2050. Wealthier industrialised countries like New Zealand must take on stronger targets because they have a relatively high historical contribution to the problem, and a greater ability to act. New Zealand should therefore take on national greenhouse targets of 30 per cent below 1990 levels by 2020, and by 90 per cent by 2050. The Energy Revolution Scenario brings us quite close to target on CO_2 emissions, which are reduced by 72 per cent compared with 1990 levels. Other measures would be required to meet the overall greenhouse target (including emissions of methane and nitrous oxide), combined with the purchase of carbon credits through Kyoto mechanisms.

At present, the Kyoto countries are negotiating the second phase of the agreement, covering the period from 2013-2017. Greenpeace is calling for industrialised country emissions to be reduced by 18 per cent from 1990 levels for this second commitment period, and by 30 per cent by the third period, covering 2018-2022. Only with these cuts do we stand a reasonable chance of meeting the 2°C target.

The Kyoto Protocol relies fundamentally on legally binding emissions-reduction obligations. To achieve these targets, carbon is turned into a commodity which can be traded, to encourage the most economically efficient emissions reductions, which in turn will encourage the necessary investment in clean technology from the private sector.

But we are running out of time. Some major industrialised countries, including the United States and Australia, have refused to sign the Kyoto agreement. New Zealand has signed but has actually increased carbon emissions since the agreement came into force.

This is a crucial year. In December, countries will meet in Indonesia and must agree a firm negotiating mandate, in order that the second commitment period of the Kyoto Protocol can be agreed upon in 2008 (or 2009 at the absolute latest) to allow time for it to be ratified and for governments to implement the policies and measures necessary for the next stage of deeper emissions reductions.

the energy revolution

"THE EXPERT CONSENSUS IS THAT THIS FUNDAMENTAL CHANGE MUST HAPPEN WITHIN THE NEXT TEN YEARS IN ORDER TO AVERT THE WORST IMPACTS."

2

image WIND ENERGY PARK NEAR DAHME. WIND TURBINE IN THE SNOW OPERATED BY VESTAS.

image PLATFORM/OIL RIG DUNLIN A IN THE NORTH SEA SHOWING OIL POLLUTION.

The climate change imperative demands nothing short of an energy revolution. The expert consensus is that this fundamental change must begin very soon and be well under way within the next 10 years in order to avert the worst impacts. We do not need nuclear power. What we do need is a complete transformation in the way we produce, consume and distribute energy. Nothing short of such an energy revolution will enable us to limit global warming to less than 20 Celsius, above which the impacts become devastating.

Current electricity generation relies mainly on burning fossil fuels, with their associated CO_2 emissions, in very large power stations which waste much of their primary input energy. More energy is lost as the power is moved around the electricity grid network and converted from high-transmission voltage down to a supply suitable for domestic or commercial consumers. The system is innately vulnerable to disruption: localised technical, weather-related or even deliberately caused faults can quickly cascade, resulting in widespread blackouts. Whichever technology is used to generate electricity within this old-fashioned configuration, it will inevitably be subject to some, or all, of these problems. At the core of the energy revolution, therefore, needs to be a change in the way that energy is both produced and distributed.

five key principles

the energy revolution can be achieved by adhering to five key principles:

1 **implement clean, renewable solutions and decentralise energy systems** There is no energy shortage. All we need to do is use existing technologies to harness energy effectively and efficiently. Renewable energy and energy efficiency measures are ready, viable and increasingly competitive. Wind, solar and other renewable energy technologies have experienced double digit market growth for the past decade.

Just as climate change is real, so is the renewable energy sector. Sustainable, decentralised energy systems produce fewer carbon emissions, are cheaper, and are less dependent on imported fuel. They create more jobs and empower local communities. Decentralised systems are more secure and more efficient. This is what the Energy Revolution must aim to create.

2 **respect natural limits** We must learn to respect natural limits. There is only so much carbon that the atmosphere can absorb. Geological resources of coal could provide fuel for several hundred years, but burning coal, oil and gas releases huge amounts of stored carbon into the atmosphere. Already, the world is emitting some 23 billion tonnes of carbon equivalent; we are literally filling up the sky. Globally, most of the carbon-rich fossil reserves must stay in the ground, and we need to focus first on reducing the fossil fuel that is the worst climate polluter – coal. We must live within the natural limits of the planet. In the words of the former Saudi Arabian oil minister, Sheikh Zaki Yamani, "the Stone Age did not end for lack of stone, and the Oil Age will end long before the world runs out of oil."

3 **phase out dirty, unsustainable energy** New Zealand must phase out existing coal-powered power plants, and must not build new ones, such as the Marsden B station at Whangarei proposed by Mighty River Power. Carbon emissions from burning coal are a real and present danger to the environment, the economy and our society, and are contrary to our Kyoto obligations.

4 **equity and fairness** As long as there are natural limits, there needs to be a fair distribution of benefits and costs within societies, between nations and between present and future generations. At one extreme, a third of the world's population has no access to electricity, whilst the most industrialised countries consume much more than their fair share.

If we are to address climate change, one of the principles must be equity and fairness, so that the benefits of energy services - such as light, heat, power and transport - are available for all. Only in this way can we create true energy security, as well as the conditions for genuine human security.

5 **decouple growth from fossil fuel use** Starting in the developed countries, economic growth must be fully decoupled from fossil fuels. It is a fallacy to suggest that economic growth must be predicated on increased fossil fuel combustion. Instead, we must:

- Use the energy we produce much more efficiently;
- Make the transition to renewable energy and away from fossil fuels quickly to enable clean and sustainable growth.

from principles to practice

Today, renewable energy sources account for 29 per cent of New Zealand's energy demand[10]. Hydro and geothermal are the main renewable energy sources, with a small but rapidly growing wind sector. The share of renewable energy in electricity generation was 66 per cent in 2005[11], but only 57 per cent in the year to September 2006[12]. About 71 per cent of New Zealand's primary energy supply today and 80 per cent globally still comes from fossil fuels.

references

10 NEW ZEALAND ENERGY DATA FILE, MINISTRY OF ECONOMIC DEVELOPMENT, SEPTEMBER 2006.
11 IBID
12 NEW ZEALAND ENERGY STATISTICS - SEPTEMBER 2006 QUARTER, STATISTICS NEW ZEALAND, DECEMBER 2006

use the current "time window"

The time is right to make substantial structural changes in the energy and power sector within the next decade.

Some power plants, such as the Huntly coal-fired power station, are nearing retirement, and over the next 10 years the power sector will decide how to replace its capacity - either by fossil fuels or by the efficient use of renewable energy.

The Energy Revolution Scenario is based on the political framework shifting to favour renewable energy, combined with energy efficiency and conservation. This will need to happen on a large scale and through decentralised, smaller units, which must grow faster than overall energy demand.

infrastructure changes

It is not possible to switch directly from the current large-scale, fossil-fuel based energy system to a full renewable energy supply immediately. Therefore, a transition phase is required to build up the necessary infrastructure. Whilst remaining firmly committed to the promotion of renewable sources of energy, Greenpeace understands that gas, used in appropriately scaled cogeneration plants, is valuable as a transition fuel in the short term, able to drive cost-effective decentralisation of the energy infrastructure. Coal should be phased out in New Zealand by 2025 and no new coal plants should be commissioned.

a development pathway

The Energy Revolution envisages a development pathway which turns the present energy supply structure into a sustainable system. There are two main stages to this.

step 1: energy efficiency and conservation

The Energy Revolution is aimed at the ambitious exploitation of the potential for energy efficiency and conservation. It focuses on current best-practice and available technologies for the future, assuming continuous innovation. The energy savings are fairly equally distributed over the three sectors - industry, transport and domestic/business. Intelligent use, not abstinence, is the basic philosophy for future energy conservation.

The most important energy saving options are improved heat insulation and building design, super efficient electrical machines and drives, replacement of old style electrical water heaters with solar water heaters and a reduction in energy consumption by vehicles used for goods and passenger traffic. New Zealand is a wealthy industrialised country and has low levels of existing energy efficiency. Therefore, there is a great deal of opportunity to reduce our consumption drastically without losing either housing comfort or information and entertainment electronics.

A dramatic reduction in primary energy demand compared to the International Energy Agency's "reference scenario" (see below) – but with the same GDP and population development - is a crucial prerequisite for achieving a significant share of renewable energy sources in the overall energy supply system, reducing the consumption of fossil fuels and phasing out fossil fuel use in the electricity sector.

step 2: structural changes

decentralised energy and large-scale renewable energy

In order to achieve higher fuel efficiencies and reduce distribution losses, the Energy Revolution Scenario makes extensive use of Decentralised Energy (DE).This is energy generated at or near the point of use.

DE is connected to a local distribution network system, supplying homes and offices, rather than the high-voltage transmission system. Siting generation close to consumers allows any waste heat from combustion processes to be piped to buildings nearby, a system known as cogeneration or combined-heat-and-power. This means that nearly all the input energy is put to use, not just a fraction as with traditional centralised fossil-fuel plants. DE also includes stand-alone systems entirely separate from the public networks.

cogeneration

The increased use of combined heat and power generation (CHP) will improve the supply system's energy conversion efficiency, whether using natural gas in the short term or biomass. In the longer term, decreasing demand for heat and the large potential for producing heat directly from renewable energy sources will limit the further expansion of CHP.

renewable electricity

The electricity sector will be the pioneer of renewable energy utilisation. All renewable electricity technologies have been experiencing steady growth over the past 20 to 30 years of up to 35 per cent per year globally and are expected to consolidate at a high level between 2030 and 2050. By 2025, all electricity in New Zealand will be produced from renewable energy sources.

renewable heating

In the heat supply sector, the contribution of renewable sources will increase significantly. Growth rates are expected to be similar to those of the renewable electricity sector. Fossil fuels will be increasingly replaced by more efficient modern technologies, in particular biomass (such as highly efficient wood burners) and geothermal. By 2050, renewable energy technologies will satisfy the major part of heating and cooling demand.

image TRANSPORT POLLUTION.

transport

Before biofuels can play a substantial role in the transport sector, the existing large efficiency potentials have to be exploited. In this study, biomass is primarily committed to stationary applications; the use of biofuels for transport is limited by the availability of sustainably grown biomass.

Overall, to achieve an economically attractive growth in renewable energy sources, a balanced and timely mobilisation of all technologies is of great importance. Such a mobilisation depends on the resource availability, cost reduction potential and technological maturity.

scenario principles in a nutshell

- Smart consumption, generation and distribution
- Energy production moves closer to the consumer
- Maximum use of locally available, environmentally friendly fuels

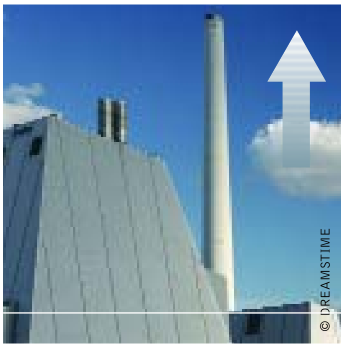
a decentralised energy future

the role of sustainable, clean renewable energy

To achieve the dramatic emissions cuts needed to avoid climate change – in the order of 80 to 90 per cent in OECD countries by 2050 – will require a massive uptake of renewable energy. The targets for renewable energy must be greatly expanded in industrialised countries, both to substitute for discontinued fossil fuel and nuclear generation, and to create the necessary economies of scale necessary for global expansion.

centralised energy infrastructures waste more than two thirds of their energy

61.5 units
LOST THROUGH INEFFICIENT GENERATION AND HEAT WASTAGE



100 units >>
ENERGY WITHIN FOSSIL FUEL

3.5 units
LOST THROUGH TRANSMISSION AND DISTRIBUTION

38.5 units >>
OF ENERGY FED TO NATIONAL GRID

13 units
WASTED THROUGH INEFFICIENT END USE

35 units >>
OF ENERGY SUPPLIED

22 units
OF ENERGY ACTUALLY UTILISED

scenarios for a future energy supply

"ANY ANALYSIS THAT SEEKS TO TACKLE ENERGY AND ENVIRONMENTAL ISSUES NEEDS TO LOOK AHEAD AT LEAST HALF A CENTURY."

3

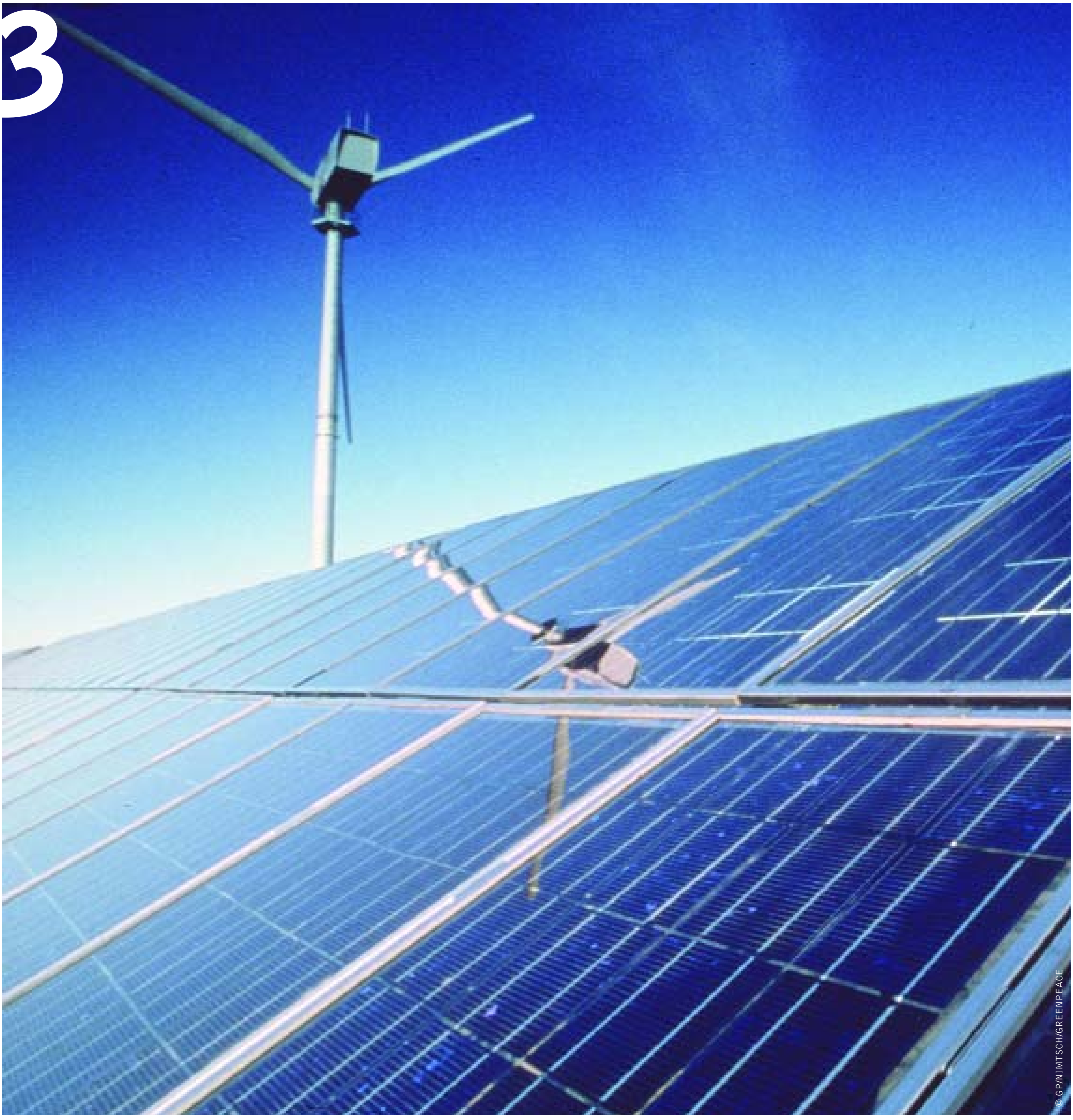


image SOLAR AND WIND-FACILITY NEAR ROSTOCK, GERMANY.

image THE TECHNOLOGY FOR SOLAR PANELS WAS ORIGINAL INSPIRED BY NATURE.

Planning energy supply and climate change mitigation requires a long-term perspective. Energy infrastructure takes time to build up; new energy technologies take time to develop. Policy shifts often need many years to have an effect. Any analysis that seeks to tackle energy and environmental issues therefore needs to look ahead at least half a century.

Scenarios are used to describe possible future development paths. They enable decision-makers to understand how they can shape the future energy system, and the likely consequences of their decisions.

Two different scenarios are used in this report to characterise the wide range of possible development paths for the New Zealand energy supply system: a Reference Scenario (business as usual) and the Energy Revolution Scenario:

the reference scenario is a "business as usual" scenario based on the reference scenario published by the International Energy Agency in World Energy Outlook 2004 (WEO 2004)[13]. It assumes a continuation of current economic trends and energy policies into the future. It is similar to the Base Case scenario developed by the NZ Ministry of Economic Development in its recent Energy Outlook 2030 report.[14] The Reference Scenario provides a baseline reference for comparison with the Energy Revolution Scenario.

the energy revolution scenario is a normative scenario developed in a back-casting process, which provided the pathway to calculate energy consumption and demand, based on available technology. To do this we calculated the average market growth rates of the existing renewable energy sector (combined with the best available technology) on the basis of average exchange rates (for example, people buy new fridges every 10 years). We took our global fixed target of a maximum of 11.5Gtonnes of CO_2 emissions a year by 2050 and worked backwards towards today.

The two key goals under the Energy Revolution Scenario are:

- 100 per cent renewable energy in the electricity sector and;
- large-scale reduction in CO_2 emissions from the energy sector by 2050.

The first goal would establish New Zealand as a world leader in renewable energy, and contribute significantly to achieving an independent and secure energy system. The second goal needs to be in the range of 80 to 90 per cent to be a fair and realistic representation of New Zealand's contribution to global efforts to stabilise the climate. This is based on a global requirement to reduce greenhouse pollution by 50 per cent of 1990 levels by 2050 and thereby stabilise global CO_2 concentrations at a level below 450 ppm. This report shows that New Zealand can achieve 72 per cent reduction in CO_2 emissions from energy by 2050.

To achieve these targets, the Energy Revolution Scenario requires:

- Significant efforts to fully exploit New Zealand's large energy-efficiency potential;
- Uptake of all cost-effective renewable energy potentials, for heat and electricity generation, and for transport.

The model assumes that population development and GDP growth are the same under both the Reference and Energy Revolution Scenarios.

The scenarios describe two potential development paths out of the broad range of possible "futures". The Energy Revolution Scenario is designed to indicate the efforts and actions required to achieve a smooth transition to a clean, safe and secure energy system.

scenario background

Greenpeace commissioned this report from the Department of Systems Analysis and Technology Assessment (Institute of Technical Thermodynamics) at the German Aerospace Centre (DLR). Murray Ellis, of Dialogue Consultants, Wellington, provided technical advice on the New Zealand-specific portions.

The New Zealand report is a subset of global modelling undertaken by Greenpeace and the European Renewable Energy Council. The first report, Energy [R]evolution: A sustainable World Energy Outlook, published in January this year, was developed with more than 30 scientists and engineers from universities, institutes and the renewable energy industry around the world, including Dialogue Consultants. The global report demonstrated how global carbon dioxide emissions could be cut by almost 50 per cent by 2050, whilst providing a secure and affordable energy supply and maintaining steady worldwide economic development. Energy [R]evolution: A sustainable World Energy Outlook is available at: www.greenpeace.org/new-zealand/press/reports/global-energy-report

In both reports, the supply scenarios were calculated using the MESAP/PlaNet simulation model used for a similar study by DLR, covering the EU-25 countries. Energy demand projections were developed by Ecofys – a German based energy consultancy - based on the analysis of future potential for energy efficiency measures.

references
13 INTERNATIONAL ENERGY AGENCY, WORLD ENERGY OUTLOOK 2004, PARIS 2004 – A NEW WORLD ENERGY OUTLOOK HAS BEEN PUBLISHED IN NOVEMBER 2007 – BASIC PARAMETERS SUCH AS GDP DEVELOPMENT AND POPULATION REMAIN IN THE SAME RANGE (SEE BOX "SENSITIVITY ANALYSIS IEA WEO 2004 -> 2006)
14 NZ MINISTRY OF ECONOMIC DEVELOPMENT, NEW ZEALAND'S ENERGY OUTLOOK TO 2030, AUGUST 2006.

energy efficiency study

The aim of the Ecofys study was to develop low energy- demand scenarios for the period 2003 to 2050, on a sectoral level for the International Energy Agency (IEA) regions as defined in the World Energy Outlook report series. Calculations were made for each decade from 2010 onwards. Energy demand was split up into electricity and fuels. The sectors which were taken into account were industry, transport and other consumers, including households and services.

Two low-energy-demand scenarios were developed, a reference version and a more ambitious energy efficiency version. This more advanced scenario focuses on current best-practice and available technologies in the future, assuming continuous innovation in the field of energy efficiency. The energy savings are fairly equally distributed over the three sectors of industry, transport and other uses.

main scenario assumptions

projection of population development

According to Statistics NZ, New Zealand's population is projected to increase to 5.05 million by 2050.[15]

The population growth is expected to slow steadily, particularly after 2030. In the medium to long term, this reduction in growth will help to reduce the pressure on energy resources and the environment.

projection of GDP development

New Zealanders will enjoy further rises in living standards. The Gross Domestic Product, which is considered as an aggregated welfare indicator, is expected to grow by 3.3% in the 2007 year and is then growth rate projected to slow to 1.5% per year in 2050, according to Ministry for Economic Development projections. This will lead to a doubling of today's GDP by 2050.

future development of costs

The cost of electricity supply is a key parameter for the evaluation of future energy scenarios. The main drivers are the prices of fuels, the investment costs of future power plant technologies and the potential costs of CO_2 emissions.

Future energy prices have been based on projections by the IEA, the US Department of Energy and the European Commission and New Zealand sources. Future investment costs for power plants have been estimated using a learning- curve approach. Technology-specific learning factors (progress ratios) have been derived from a literature review. The development of cumulative capacity for each technology is taken from the results of the Energy Revolution Scenario. All prices are given in $2000 (as per the value of the dollar in noted year).

figure 2: new zealand: population development projection

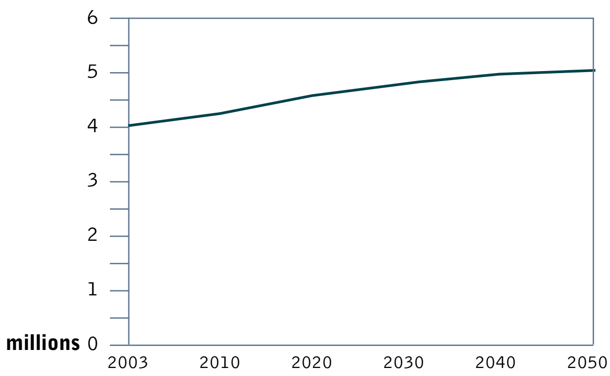
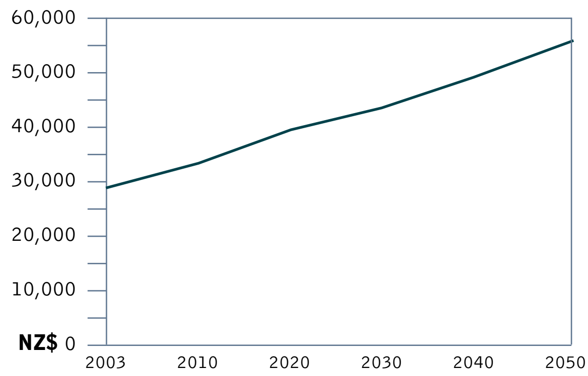


figure 3: new zealand: projection of average GDP per capita development



reference

15 STATISTICS NZ, NATIONAL POPULATION PROJECTIONS, 2004(BASE) – 2051.

image PHOTOVOLTAICS FACILITY AT 'WISSENSCHAFTS UND TECHNOLOGIEZENTRUM ADLERSHOF' NEAR BERLIN, GERMANY. SHEEP BETWEEN THE 'MOVERS' KEEPING THE GRASS SHORT.

a) fossil-fuel price projections

The recent dramatic increase in global oil prices has resulted in much higher forward price projections. Under the 2004 "high oil and gas price" scenario by the European Commission, for example, an oil price of just US$34/bbl was assumed in 2030. Ongoing modelling funded by the Commission (CASCADE-MINTS 2006), on the other hand, assumes an oil price of US$94/bbl in 2050, a gas price of US$15/GJ and an international coal price of US$95/t. Current projections of oil prices in 2030 range from the IEA's US$52/bbl (55 $2005/bbl) up to over US$100.

As the supply of natural gas is limited by the availability of pipeline infrastructure, there is no world market price for natural gas. In most regions of the world the gas price is directly tied to the price of oil. Current projections of gas prices in 2030 range from the US Department of Energy's US$4.5/GJ up to its highest figure of US$6.9/GJ.

The ending of the Maui long-term contract and the emergence of a tight gas supply situation has resulted in a sudden increase in wholesale gas prices in New Zealand to NZ$6 to NZ$7/GJ. These prices are not expected to decline, and only substantial new discoveries will prevent prices rising to parity with imported LNG. This would take prices to above NZ$10/GJ before 2020, or some US$20057.2. Thereafter, gas prices in New Zealand will closely match those in Asia.

Taking into account the recent development of energy prices, these projections might be considered too conservative. Considering the growing global demand for oil and gas we have assumed a price development path for fossil fuels in which the price of oil reaches US$85/bbl by 2030 and US$100/bbl in 2050. Gas prices are assumed to increase to US$10-$10.50/GJ by 2050.

b) biomass price projections

Compared to fossil fuels, biomass prices are highly variable, ranging from no or low costs for residues or traditional biomass in Africa or Asia to comparatively high costs for biofuels from cultivated energy crops. Despite this variability a biomass price was aggregated for Europe[16] up to 2030 and supplemented with our own assumptions up to 2050. The increasing biomass prices reflect the continuing link between biofuel and fossil fuel prices and a rising share of energy crops. For other regions prices were assumed to be lower, considering the large amount of traditional biomass use in developing countries and the high potential of yet unused residues in North America and the Transition Economies.

For New Zealand, the source of biomass is assumed to be largely from forestry. Biofuel is assumed to be manufactured from this biomass, by an efficient process converting the cellulose to liquid fuel. The European prices are based primarily on cropping on arable land (eg. growing crops such as corn for ethanol). This is relatively expensive, since the frequent agricultural operations in tilling, planting, harvesting and weed and pest control in short-rotation crops, all consume considerable fuel. However, in New Zealand and other regions which can use biomass from forestry, the tonne- per unit effort put in is much lower, and the land value is lower. Hence the "other regions" price path is used in Table 2.

table 1: assumptions on fossil fuel price development

FOSSIL FUELS	2003	2010	2020	2030	2040	**2050**
Crude oil in US$2000/bbl	28.0	62.0	75.0	85.0	93.0	**100.0**
Natural gas in US$2000/GJ						
- America	3.1	4.4	5.6	6.7	8.0	**9.2**
- Europe	3.5	4.9	6.2	7.5	8.8	**10.1**
- Asia	5.3	7.4	7.8	8.0	9.2	**10.5**
Hard coal US$2000/t	42.3	59.4	66.2	72.9	79.7	**86.4**

table 2: assumptions on biomass price development

$2000/GJ

BIOMASS	2003	2010	2020	2030	2040	**2050**
Biomass in US$2000/GJ						
- Europe	4.8	5.8	6.4	7.0	7.3	**7.6**
- other Regions incl. nz	1.4	1.8	2.3	2.7	3.0	**3.2**

reference
16 NITSCH ET AL. (2004) AND THE GEMIS-DATABASE (ÖKO-INSTITUT, 2005)

c) cost of CO_2 emissions

Assuming that a CO_2 emissions trading system will be established in all world regions in the long-term, the cost of CO_2 allowances needs to be included in the calculation of electricity generation costs. However, projections of emission costs are even more uncertain than energy prices. The IEA assumes a "CO_2 reduction incentive" of US$25/$t_{CO2}$ in 2050. The European CASCADE-MINTS project, on the other hand, assumes CO_2 costs of US$50/$t_{CO2}$ in 2020 and US$100/$t_{CO2}$ beyond 2030. For this scenario we have assumed CO_2 costs of US$50/$t_{CO2}$ in 2050, which is twice as high as the IEA's projection, but still conservative compared with other studies. We assume that CO_2 emission costs will be accounted for in Non-Annex 1 countries only from 2020.

table 3: assumptions on CO_2 price development
($/T$CO_2$)

COUNTRIES	2010	2020	2030	2040	2050
Annex 1 countries (NZ)	10	20	30	40	**50**
Non-Annex 1 countries		20	30	40	**50**

d) renewable energy price projections

The range of renewable energy technologies available today display marked differences in terms of their technical maturity, costs and development potential. Whereas hydro power has been widely used for decades, other technologies, such as the gasification of biomass, have yet to find their way to market maturity. Some renewable sources by their very nature, including wind and solar power, provide a variable supply, requiring a revised coordination with the grid network. But although in many cases these are 'distributed' technologies - their output generated and used locally to the consumer - the future will also see some large-scale applications. In New Zealand wind farms are already being built and proposed on a large scale on ridge tops, where the topography provides enhanced wind speeds.

By using the individual advantages of the different technologies, and linking them with each other, a wide spectrum of available options can be developed to market maturity and integrated step by step into the existing supply structures. This will eventually provide a complementary portfolio of environmentally friendly technologies for heat and power supply and the provision of fuels.

Most of the renewable technologies employed today are at an early stage of market development. Accordingly, their costs are generally higher than for competing conventional systems. Costs can also depend on local conditions, such as the wind regime, the availability of cheap biomass supplies or the need for nature conservation requirements when building a new hydro power plant. There is a large potential for cost reduction, however, through technical and manufacturing improvements and large-scale production, especially over the long timescale of this study.

figure 4: new zealand: range of current electricity generation costs from renewable energy sources
HIGH (LIGHT SHADING) AND LOW (DARK SHADING) ENDS OF RANGE REFLECT VARYING LOCAL CONDITIONS - WIND SPEED, SOLAR RADIATION ETC.

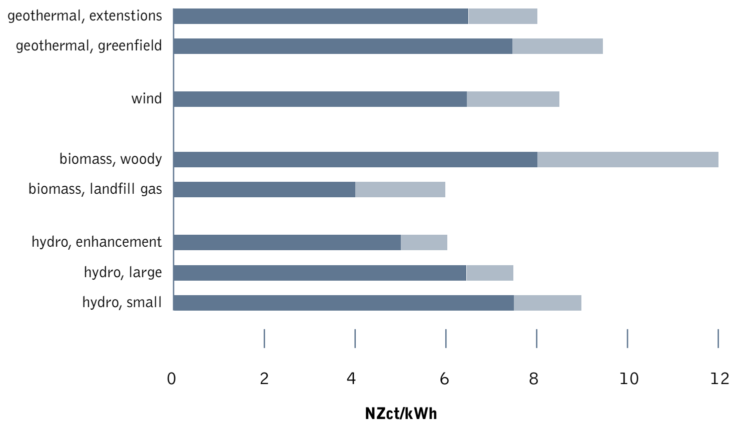
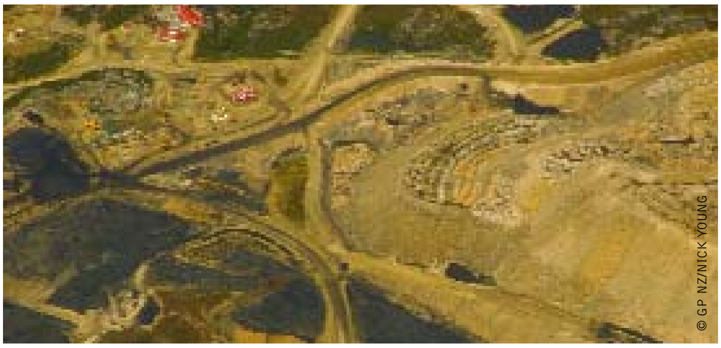


image STOCKTON MINE, NEW ZEALAND.



To identify long-term cost developments, learning curves have been applied which reflect the correlation between cumulative capacity and the development of costs. For many technologies, the learning factor (or progress ratio) falls in the range between 0.75 for less mature systems to 0.95 and higher for well-established technologies. A learning factor of 0.9 means that costs are expected to fall by 10 per cent every time the cumulative output from the technology doubles. Technology specific progress ratios are derived from a literature review[17]. This shows, for example, that the learning factor for PV solar modules has been fairly constant at 0.8 over 30 years whilst that for wind energy varies from 0.75 in the UK to 0.94 in the more advanced German market.

1. photovoltaics (PV)

Although the worldwide PV market has been growing at more than 30 per cent per annum in recent years, the contribution it makes to electricity generation is still very small. Development work is focused on improving existing modules and system components and developing new types of cells in the thin-film sector and new materials for crystalline cells. It is expected that the efficiency of commercial crystalline cells will improve by between 15 and 20 per cent in the next few years, and that thin-film cells using less raw material will become commercially available.

The learning factor for PV modules has been fairly constant over a period of 30 years at around 0.8, indicating a continuously high rate of technical learning and cost reduction. Assuming a globally installed capacity of 2,000 GW in 2050, and a decrease in the learning rate after 2030, we can expect that electricity generation costs of around 5-9 cents/kWh will be possible by 2050[18]. Compared with other technologies for utilising renewable energy, photovoltaic power must therefore be classified as a long-term option. Its importance derives from its great flexibility and its enormous technical potential.

2. concentrating solar power plants

Solar thermal 'concentrating' power stations can only use direct sunlight and are therefore dependent on high irradiation locations. North Africa, for example, has a technical potential which far exceeds local demand. The various solar thermal technologies (parabolic trough, power towers and parabolic dish concentrators) offer good prospects for further development and cost reductions. One important objective is the creation of large thermal energy reservoirs in order to extend the operating time of these systems beyond the sunlight period.

Owing to the small number of Concentrating Solar Power (CSP) plants built to date, it is difficult to arrive at reliable learning factors for this sector. Here it is assumed that the learning factor of 0.88 derived from the data for parabolic trough reflectors built in California will change to 0.95 in the course of market introduction up to 2030. The UN's World Energy Assessment expects solar thermal electricity generation will enjoy a dynamic market growth similar to the wind industry, but with a time lag of 20 years. Depending on the level of irradiation and mode of operation, electricity generation costs of 5-8 cents/kWh are expected. This presupposes rapid market introduction in the next few years.

3. solar thermal collectors for heating and cooling

Small solar thermal collector systems for water and auxiliary heating are well developed today and used for a wide variety of applications, though solar water heating is the main practical implementation of this technology in New Zealand.

Data for the European collector market show a learning factor of nearly 0.90 for solar collectors, which indicates a relatively well-developed system from a technological point of view.

4. wind power

Within a short period of time, the dynamic development of wind power has resulted in the establishment of a flourishing global market. The world's largest wind turbines, several of which have been installed in Germany, have a capacity of 6 MW. The cost of new systems has, however, stagnated in some countries in recent years due to the continuing high level of demand and the manufacturers' considerable advance investment in the development and introduction of a succession of new systems. The result is that the learning factor observed for wind turbines built between 1990 and 2000 in Germany was only 0.94. Nevertheless, since technical developments have led to increases in specific yield, electricity generation costs should reduce further. Owing to the relative lack of experience in the offshore sector, a larger cost reduction potential is expected here, with the learning rate correspondingly higher.

New Zealand has an ample onshore wind resource and few areas of suitable shallow water offshore. Consequently there will be little or no need for New Zealand to move into the higher costs of offshore wind development.

Whilst the IEA's World Energy Outlook 2004 expects worldwide wind capacity to grow to only 330 GW by 2030, the United Nations' World Energy Assessment assumes a global saturation level of around 1900 GW by the same time. The Global Wind Energy Outlook (2006)[19] projects a global capacity of up to 3000 GW by 2050. An experience curve for wind turbines is derived by combining the currently observed learning factors with a high market growth assumption, oriented towards the Global Wind Energy Outlook, indicating that costs for wind turbines will reduce by 40 per cent up to 2050.

references
17 DLR 2006, DR. WOLFRAM KREWITT ET. AL.
18 EPIA/GREENPEACE INTERNATIONAL: SOLARGENERATION 2006
19 EUROPEAN WIND ENERGY ASSOCIATION AND GREENPEACE

5. biomass

The crucial factor for the economics of biomass utilisation is the cost of the feedstock, which today ranges from a negative cost for waste wood (credit for waste disposal costs avoided) through inexpensive residual materials, to the more expensive energy crops. The resulting spectrum of energy generation costs is correspondingly broad. One of the most economic options is the use of waste wood in steam turbine combined heat and power (CHP) plants. As this produces a high proportion of heat it is applicable only in industries with a large demand for heat, such as forest processing plants. Gasification of solid biofuels, on the other hand, which opens up a wide range of applications, is still relatively expensive. In the long term it is expected that favourable electricity production costs will be achieved by using wood gas both in micro CHP units (engines and fuel cells) and in gas-and-steam power plants. Converting crops into ethanol and biodiesel made from rapeseed methyl ester (RME) has become increasingly important in recent years, for example in Brazil and the USA. Processes for obtaining synthetic fuels from biogenic synthesis gases will also play a growing role.

New Zealand has good potential for a biofuel industry based on the conversion of woody material. The conversion process could be based either on synthesis gases, or enzymatic conversion of cellulose. Both routes are being developed, notably in Canada. It is not yet clear which will prove the most cost-effective or energy efficient.

6. geothermal

Geothermal energy has long been used worldwide for supplying heat, whilst electricity generation is limited to a few sites with specific geological conditions. Further intensive research and development work is needed to speed up progress. In particular, the improvement of heat-and-power machines with Organic Rankine Cycle (ORC) must be optimised in future projects.

As a large part of the costs for a geothermal power plant come from deep drilling, data from the oil sector can be used, with learning factors observed there of less than 0.8. Assuming a global average market growth for geothermal power capacity of nine per cent per year until 2020, reducing to four per cent beyond 2030, the result would be a cost reduction potential of 50 per cent by 2050. Thus, despite the present high figures (about 20 cents/kWh), electricity production costs – depending on payments for heat supply – are expected to come down to around six to 10 cents/kWh globally in the long-term. Because of its non-fluctuating supply, geothermal energy is considered to be a key element in a future supply structure based on renewable sources.

New Zealand has a large geothermal resource in the Central North Island/Bay of Plenty region. Unlike most other parts of the world, this region has a resource of energy stored in fields of very hot water buried at fairly shallow depths. As a result, development costs are much reduced from global figures. Future costs in New Zealand range from 6.5 to 9.5 cents/kWh. Some fields have been developed, and provided 6.5 per cent of New Zealand's electricity in 2005. There is a considerable potential for this to be increased, although conflicts with other values, notably tourism, restricts development of several fields.

7. hydro power

Hydro power is a mature technology that has long been used for economic generation of electricity. Additional potential can be exploited primarily by modernising and expanding existing systems. The remaining limited cost reduction potential will probably be offset by increasing site development problems and growing environmental requirements. It can be assumed that for small scale systems, where power generation costs are generally higher, the need to comply with ecological requirements will involve proportionately higher costs than for large systems.

New Zealand has a very substantial hydro potential, only part of which has been developed. Remaining potential is for both large and smaller scale low-impact projects, although Greenpeace favours smaller projects and extensions of existing projects. Many potential projects conflict with other values, notably scenic, recreational and conservation, limiting acceptable development.

summary of renewable energy cost development

Figure 5 summarises the cost trends for renewable energy technologies as derived from the respective learning curves. It should be emphasised that the expected cost reduction is basically not a function of time, but of cumulative capacity, so dynamic market development is required. Most of the technologies will be able to reduce their specific investment costs to between 30 per cent and 60 per cent of current levels by 2020, and to between 20 per cent and 50 per cent once they have achieved full development (after 2040).

Reduced investment costs for renewable energy technologies lead directly to reduced heat and electricity generation costs, as shown in Figure 6. Generation costs today are around eight to $40-70/MWh for the most important technologies, with the exception of photovoltaics. Gas, wind and hydro are the least expensive options. At 2020 costs are expected to converge around $75/MWh for the most important renewable energy technologies, while fossil fuel generation costs increase to between $88 to over $100/MWh. By 2050 renewable energy technologies have settled at around 80$/MWh whereas if any fossil fuels were still in place, they would cost between $100 to over $126/MWh. These estimates depend on site-specific conditions, such as the local wind regime or the availability of biomass at reasonable prices.

image GREENPEACE DONATES A SOLAR POWER SYSTEM TO A COASTAL VILLAGE IN ACEH, INDONESIA, ONE OF THE WORST HIT AREAS BY THE TSUNAMI IN DECEMBER 2004. IN COOPERATION WITH UPLINK, A LOCAL DEVELOPMENT NGO, GREENPEACE OFFERED ITS EXPERTISE ON ENERGY EFFICIENCY AND RENEWABLE ENERGY AND INSTALLED RENEWABLE ENERGY GENERATORS FOR ONE OF THE BADLY HIT VILLAGES BY THE TSUNAMI LAST YEAR.

figure 5: future development of investment costs

NORMALISED TO CURRENT COST LEVELS) FOR RENEWABLE ENERGY TECHNOLOGIES, DERIVED FROM LEARNING CURVES

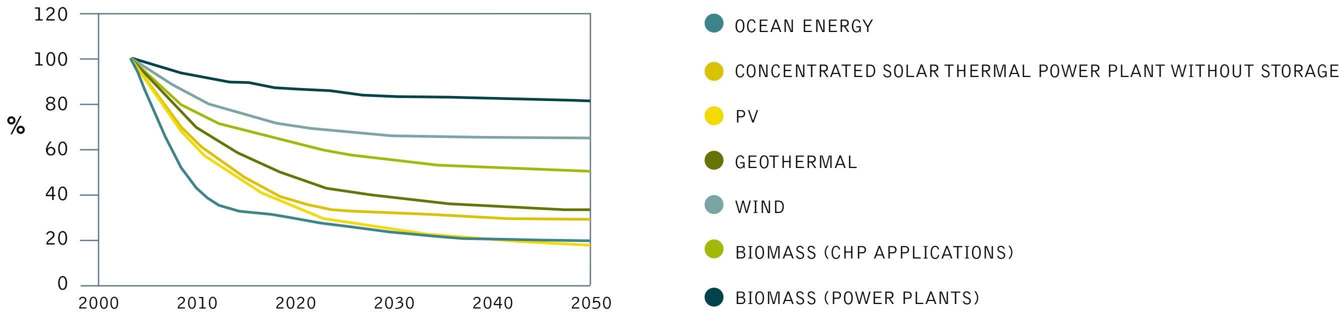
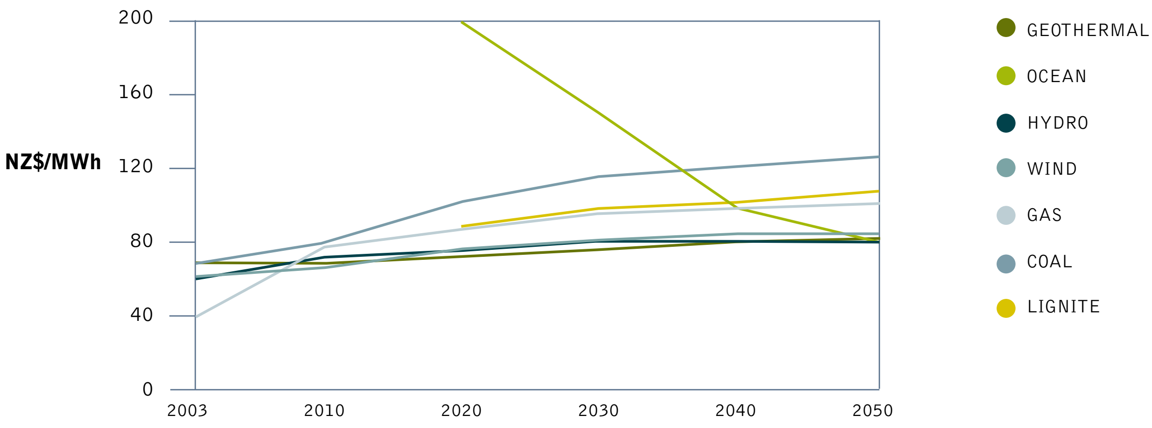


figure 6: new zealand: expected development of electricity generation costs from fossil fuel and renewable energy options

(GENERATION COSTS DEPEND PARTLY ON SITE SPECIFIC FUEL COSTS)



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OPTIONS, CHOICES, DECISIONS, MERIDIAN ENERGY LIMITED, 2006

key results of the new zealand energy revolution scenario

"AN INCREASE IN ECONOMIC ACTIVITY AND A GROWING POPULATION DOES NOT NECESSARILY HAVE TO RESULT IN AN EQUIVALENT INCREASE IN ENERGY DEMAND."

4

image SOLAR PANELS ON REFRIGERATION PLANT (FOR KEEPING FISH FRESH). LIKIEP ATOLL, MARSHALL ISLANDS.

image NEW ZEALAND NATIVE FOREST.

the development of future energy demand is determined by three key factors:

- Population development - the number of people consuming energy or using energy services;
- Economic development - for which Gross Domestic Product (GDP) is the most commonly used indicator. In general, an increase in GDP triggers an increase in energy demand;
- Energy intensity - how much energy is required to produce a unit of GDP. Energy intensity can be reduced by becoming more energy efficient.

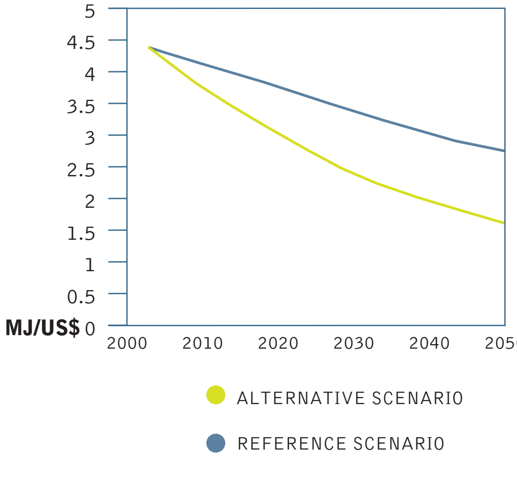
Both the Reference and the Energy Revolution Scenarios are based on the same projections for population and economic development. However, future levels of energy intensities differ - taking into account the measures to improve energy efficiency under the Energy Revolution Scenario.

Data on population growth and GDP figures for New Zealand have already been outlined in the assumptions section. (Figure 5.4.1 and figure 5.4.2 respectively)

projection of energy intensities

An increase in economic activity and a growing population does not necessarily have to result in an equivalent increase in energy demand. There is still a large potential for exploiting energy efficiency measures. Under the Reference Scenario, we assume that energy intensity will reduce over time, leading to a reduction of final energy demand per unit GDP by about 35 per cent between 2003 and 2050. Under the Energy Revolution Scenario, it is assumed that due to active policy support the technical support for efficiency measures will lead to an even higher reduction in energy intensity of about 63 per cent.

figure 7: oecd pacific region: projection of energy intensities under the reference and energy revolution scenarios



development of total energy demand in new zealand

Combining the projections on population development, GDP growth and energy intensities results in future development pathways for final energy demand in New Zealand. These are shown in Figure 8 for both the Reference and the Energy Revolution Scenarios. Under the Reference Scenario, total energy demand almost doubles from 658PJ/a in 2003 to 954PJ/a in 2050. In the Energy Revolution Scenario, however, while consumption continues to increase until 2010, it then declines steadily through to 2050, when it reaches 638PJ/a, just below 2003 levels.

An accelerated increase in energy efficiency, which is a crucial prerequisite for achieving a sufficiently large share of renewable sources in energy supply, will be beneficial not only for the environment but from an economic point of view. Taking into account the full life cycle, in most cases the implementation of energy efficiency measures saves money compared to increasing energy supply. A dedicated energy-efficiency strategy therefore helps to compensate in part for the additional costs required during the market introduction phase of renewable energy sources.

Under the Energy Revolution Scenario, electricity demand is expected to increase to a disproportionate extent, with households and services the main source of growing consumption ("Other sectors in Figure 9). With the exploitation of efficiency measures, however, an even higher increase can be avoided, leading to electricity demand of around 58TWh/a in the year 2050. Compared to the Reference Scenario, efficiency measures avoid the generation of 10 TWh/a in 2020 and 4 TWh/a in 2050. This saving would wipe out the need for a power station the size of Huntly coal and gas station, simply through energy efficiency.

This reduction in energy demand can be achieved in particular by introducing highly efficient electronic devices using the best available technology in all demand sectors. Employment of energy efficient design features in both residential and commercial buildings will help to reduce energy demand for heating and cooling. The use of solar water heaters is an effective way to lower electricity demand.

There is also the creation of a new electricity demand sector with the introduction of the plug-in hybrid vehicle in 2020.

Efficiency gains in the heat supply sector are even larger. Under the Energy Revolution Scenario, the final energy demand for heat supply will be reduced by 23 per cent by 2050 (Figure 10). Compared to the Reference Scenario, which involves less effort in the implementation of energy efficiency measures, consumption equivalent to 84PJ/a is avoided through efficiency gains by 2050. This will be achieved through the energy-related retrofit of existing building stock, combined with the "smart' and efficient building standards for construction and highly efficient wood burners. New Zealanders will be able to enjoy improved comfort and energy services, whilst also achieving much lower future energy demand.

In the transport sector, it is assumed under the Energy Revolution Scenario that the energy demand will increase and peak by 2010 then decrease to 224PJ/a, 3 per cent below current levels by 2050. In comparison, transport energy in the reference scenario does not reduce at all but climbs steadily until it is 46 per cent above starting levels.

The Energy Revolution Scenario saves 34 per cent compared to the Reference Scenario in 2050. This reduction can be achieved by increasing public transport infrastructure, shifting the transport of goods from road to rail and sea, the introduction of highly efficient vehicles including plug-in hybrid vehicles and by changes in mobility-related behaviour patterns.

figure 8: new zealand: projection of total energy demand by sector for both the reference and energy revolution scenarios

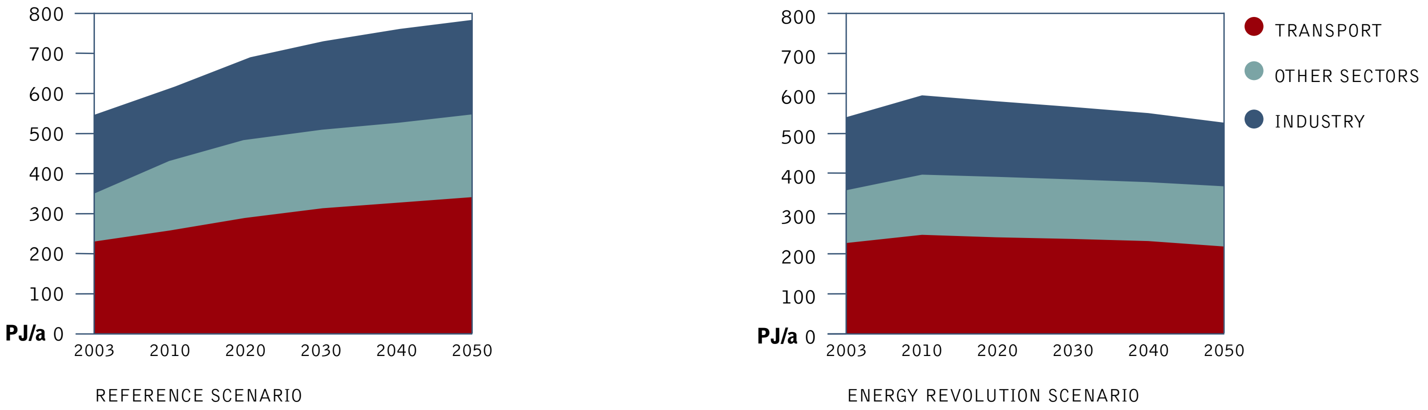


figure 9: new zealand: development of final energy demand for electricity by demand sectors

('EFFICIENCY' = REDUCTION COMPARED TO THE REFERENCE SCENARIO; OTHER SECTORS = SERVICES, HOUSEHOLDS)

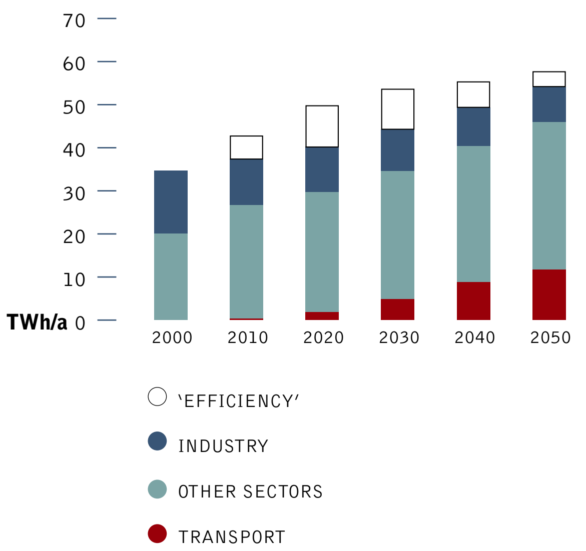


figure 10: new zealand: development of heat supply energy demand in the energy revolution scenario

('EFFICIENCY' = REDUCTION COMPARED TO THE REFERENCE SCENARIO)

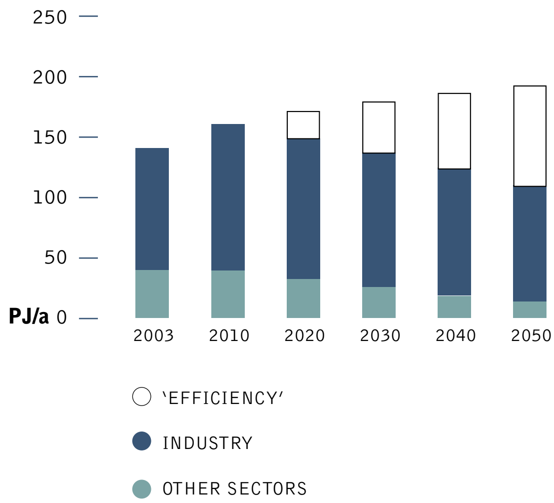


image SOUTH ISLAND, NEW ZEALAND.

electricity generation

The development of the electricity supply sector is characterised by a dynamically growing renewable energy market and an increasing share of renewable electricity. This will compensate for the phasing out of fossil fuel power plants by 2025. Under the Energy Revolution scenario, only negligible amounts of fossil fuel capacity will still remain by 2020 and the remainder will be completely phased out by 2030. The most likely date by which 100 per cent of the electricity produced in New Zealand will come from renewable energy sources is 2025.

The following strategy paves the way to a 100 per cent renewable electricity supply:

- Existing fossil fuel capacity must be phased out by 2025, with Huntly coal station to be decommissioned within 10 years. A switch to gas over this phase-out period would also reduce emissions.
- No more fossil fuel plants should be approved. Marsden B must not proceed if New Zealand is to achieve 100 per cent renewable electricity by 2025. Fossil-fuel projects which have completed all resource consent processes and/or are currently under construction are assumed in this scenario to be built, but then phased out by 2025.
- The phasing out of fossil fuels and rising electricity demand will be met by bringing additional renewable generation online, mostly wind up to 2020 with geothermal, hydro and biomass making up the rest. From 2020 there is also an increasing amount of some ocean energy sources and a small amount of solar (photovoltaics) in 2050 (see figure12 and table 4).
- The renewable generation will be sufficiently diverse to ensure that electricity supply remains stable and reliable. In particular:
  - Hydro will remain important as a flexible and storable means of generation;
  - As a more predictable and stable renewable energy source, geothermal and biomass will be an important element in the overall generation mix;
  - Wind generation increases will be substantial from the current low level of development of the resource. However, from 2020 an increasing amount of wind generation will be used to power plug-in hybrid vehicles, thus boosting the renewable energy component of the transport sector and providing a valuable method of storing the variable electricity from wind energy. This assists in allowing wind energy in the grid than would otherwise be stable. Demand for plug in hybrids rises from 3PJ/a in 2020 up to 30PJ/a in 2050. In 2020, 10 per cent of wind energy generation will be used for plug-in hybrids by 2050 more than half of electricity generated from wind will be stored and used in plug-in hybrid vehicles.
- Because of nature conservation aspects, the use of large-scale hydro power will be limited and emphasis should be put on more smaller-scale projects, or projects expanding existing additional schemes. Much additional potential can be exploited by modernising large run-of-river power plants, such as the additional almost 200MW added to the Manapouri scheme through efficiency upgrades.
- Achieving 100 per cent renewable electricity will require policy support and well-designed policy instruments. There will be considerable demand for investment into new generation over the next 20 years. As investment cycles in the power sector are long, decisions for restructuring the electricity supply system need to be taken now.

To achieve an economically attractive growth in renewable energy sources, a balanced and timely mobilisation of all technologies is of great importance. This mobilisation depends on technical potentials, cost reduction and technological maturity. Figure 13 shows the comparative evolution of the different renewable technologies over time. Up to 2020, wind and some geothermal and hydro will remain the main contributors to the growing market share. From 2020, the continuing growth of wind will also be complemented by electricity from biomass, ocean and solar energy.

figure 11: new zealand: development of the electricity generation under the reference scenario

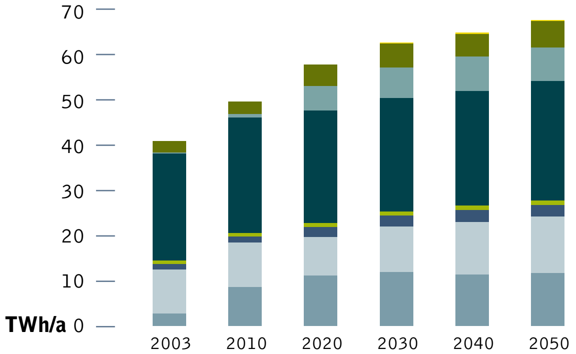


figure 12: new zealand: development of electricity generation under the energy revolution scenario

'EFFICIENCY' = REDUCTION COMPARED TO THE REFERENCE SCENARIO

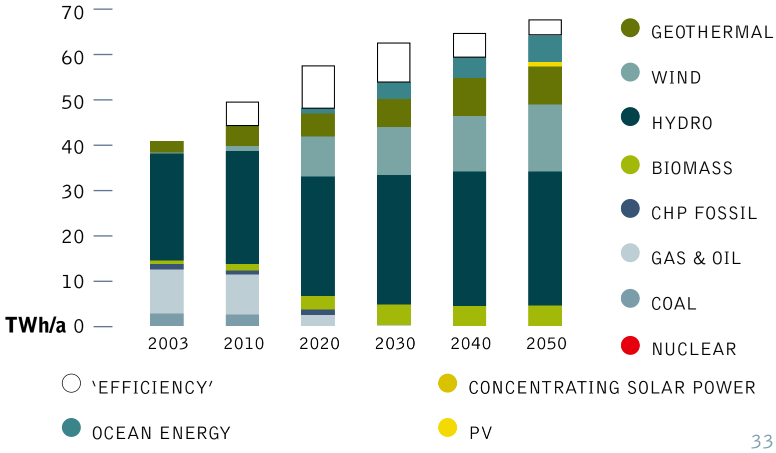


figure 13: new zealand: growth of renewable electricity generation under the energy revolution scenario, by source

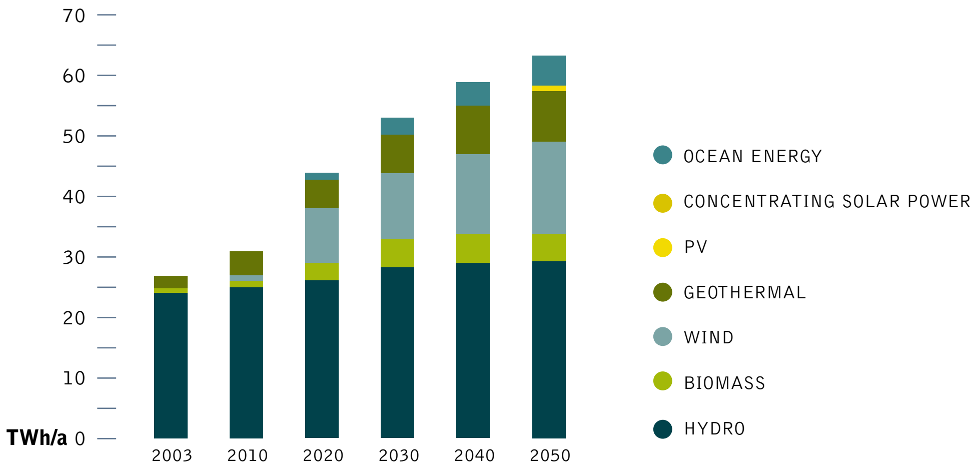


table 4: new zealand: projection of renewable electricity generation capacity under the energy revolution scenario

IN MW

	2003	2010	2020	2030	2040	2050
Hydro	5,222	5,501	5,707	5,922	6,079	6,108
Biomass	184	174	440	768	881	1,007
Wind	38	353	2,272	2,922	3,421	3,895
Geothermal	406	584	824	923	1,118	1,231
PV	0	0	0	71	286	436
Ocean energy	0	0	106	596	787	1,106
Total	**5,850**	**6,612**	**9,349**	**11,202**	**11,572**	**13,783**

nuclear energy

Nuclear energy is often cited as a solution to climate change, but it would just result in a multitude of environmental problems and divert attention from clean renewable energy investment. Nuclear is never safe.

- There is still no solution to the nuclear waste threat. Every stage of the nuclear cycle produces radioactive waste which remains dangerous for hundreds of thousands of years.
- Nuclear energy requires large subsidies paid for by the tax payer. After 50 years and more than $1 trillion dollars in public subsidies globally, no nuclear reactor can compete in an open market.
- Nuclear energy is very expensive, costing at least 20 per cent more, and up to 10 times more per kilowatt hour, than renewable energy or energy efficiency.
- New Zealand does not have the infrastructure or expertise to deal with nuclear energy.
- Even the smallest commercially viable nuclear reactor is too big to fit into New Zealand's electricity system.
- Nuclear energy undermines renewable energy and energy efficiency – the real solutions to climate change. It can not contribute to reducing carbon dioxide emissions in the time necessary to avoid dangerous climate change. Nuclear power still emits greenhouse gases, particularly through uranium mining.
- Nuclear power is inextricably linked to nuclear weapons proliferation. Every country that has nuclear power capability is only months away from nuclear weapons capability, according to the International Atomic Energy Agency Director General.

source SAVING NUCLEAR POWER, DESTROYING THE CLIMATE, GREENPEACE INTERNATIONAL BRIEFING PAPER, OCTOBER 2006 image GEOTHERMAL POWER STATION, NORTH ISLAND, NEW ZEALAND.

heat supply

Development of renewable energy sources in the heat supply sector raises different issues. Renewable sources currently provide 8 per cent of primary energy demand for heat supply, the main contribution coming from the use of biomass. This increases to 62 per cent by 2050 (figures 14 and 15 development of heat supply).

- Energy efficiency measures can decrease the current demand for heat supply by 17 per cent, whilst also improving living standards.
- For direct heating, biomass as well as geothermal energy will increasingly substitute fossil fuel-fired systems.
- A shift from oil and coal to natural gas in the remaining conventional applications will lead to a further reduction of CO_2 emissions.

figure 14: new zealand: development of heat supply under the reference scenario

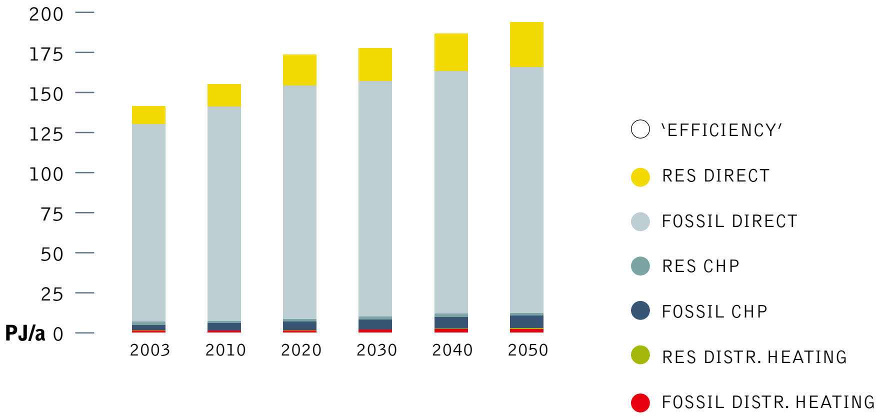
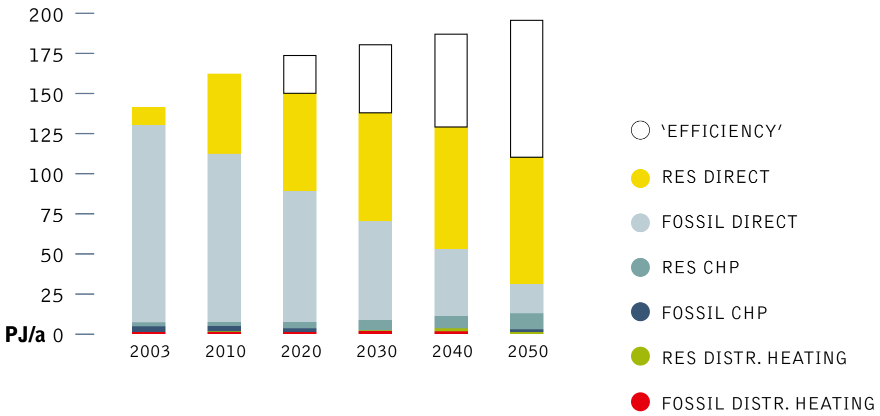


figure 15: new zealand: development of heat supply under the energy revolution scenario

('EFFICIENCY' = REDUCTION COMPARED TO THE REFERENCE SCENARIO)



transport energy

The Energy Revolution Scenario will achieve major reductions in demand for fossil fuels. Oil and petroleum consumption will be reduced from 231PJ/a (2003) to just 60PJ/a in 2050, a 74 per cent reduction and a saving of 84 per cent for the same year in the reference scenario. This will achieve major savings on expenditure on oil imports. During the 2005/06 financial year, New Zealand spent $4.94 billion on petroleum imports,[20] which is around the amount the country spends on educating our children every year.

The shift to a clean energy transport sector (figures 16 and 17) will be achieved by:

- Significantly reducing demand for liquid fuels by:
  - reducing the need for travel, through good urban planning, enhanced information technologies (such as video conferencing), and more flexible work arrangements;
  - shifting urban transit from cars to active and public transport;
  - shifting freight from roads to more efficient rail and sea freight;
  - shifting domestic air transport to more efficient rail and sea passenger transport;
  - introducing significant amounts of 100% renewable-electricity-powered public and private transport. Electrical public transport has been used in New Zealand for decades. Electric "plug-in hybrid" cars are expected to be introduced within a decade, and to eventually be followed by fully electric vehicles. "Plug-in hybrids" that are plugged into the electricity grid when the wind is blowing and generating electricity at wind farms but demand is low, allow this energy to be stored in the car battery to be used later. In this way, they can act as a battery storage for excess electricity generated by wind farms in non-peak times. This feature allows a greater proportion of wind generation in the electricity system than would normally be practical as it helps address the storage of energy from an intermittent source. 30PJ/a is used by plug-in hybrid vehicles in 2050;
  - ensuring increases in the energy efficiency of all forms of transport.

figure 16: new zealand: development of the transport sector under the reference scenario

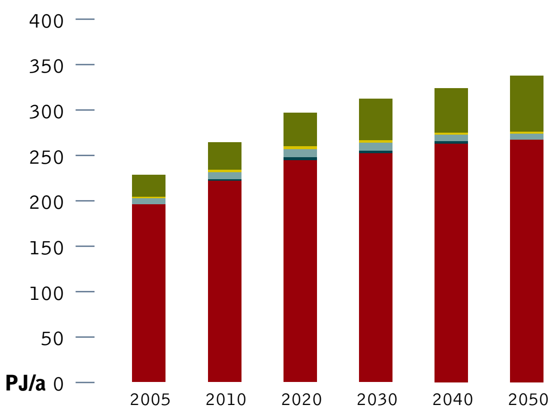
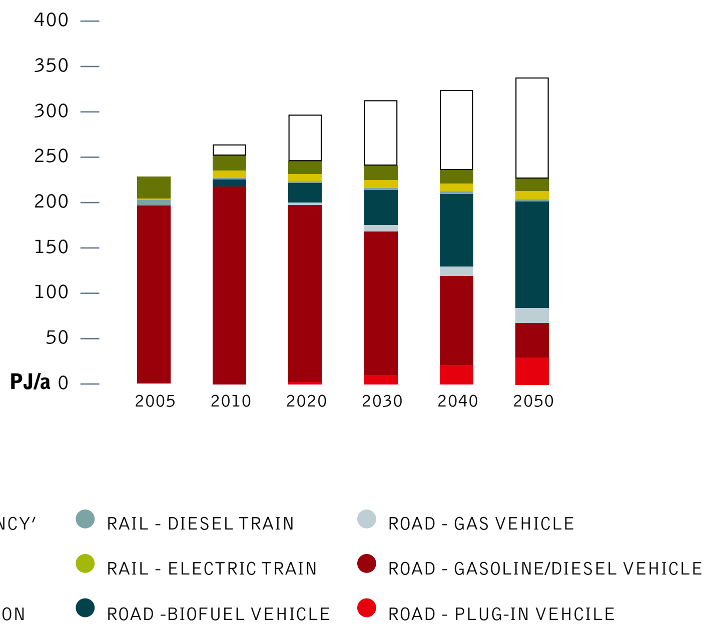


figure 17: new zealand: development of the transport sector under the energy revolution scenario

('EFFICIENCY' = REDUCTION COMPARED TO THE REFERENCE SCENARIO)



- Ensuring that the remaining demand for liquid fuels is primarily met through biofuels (both biodiesel and ethanol). These biofuels should be sourced from sustainably managed resources to avoid deforestation pressures in areas such as the Amazon for biofuel crops. New Zealand could meet the biofuel requirments of the Energy Revolution Scenario from domestic sources alone by utilising 1.8 million hectares of marginal land earning less then $350 per hectare per year, less than 1000m elevation and less than 15 degrees of slope (to avoid erosion), excluding Department of Conservation land and any land currently being used for dairying, horticulture or pine forestry. This represents about 60 per cent of such land currently available in New Zealand[21]. All this land is also close to geothermal steam, which would provide heat energy for processing, thus reducing biorefining costs.

primary energy consumption

Taking into account the assumptions discussed above, the resulting primary energy consumption under the Energy Revolution Scenario is shown in Figure 19. Overall energy demand will be only two-thirds of the demand in the Reference Scenario in 2050. Around 73 per cent of primary energy demand will be supplied by renewable sources.

figure 18: new zealand: development of primary energy consumption under the reference scenario

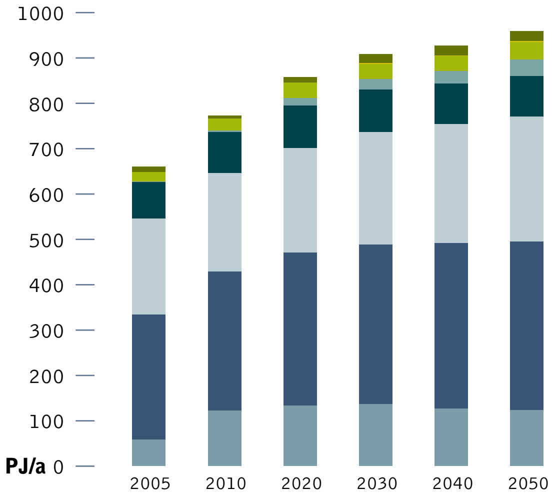
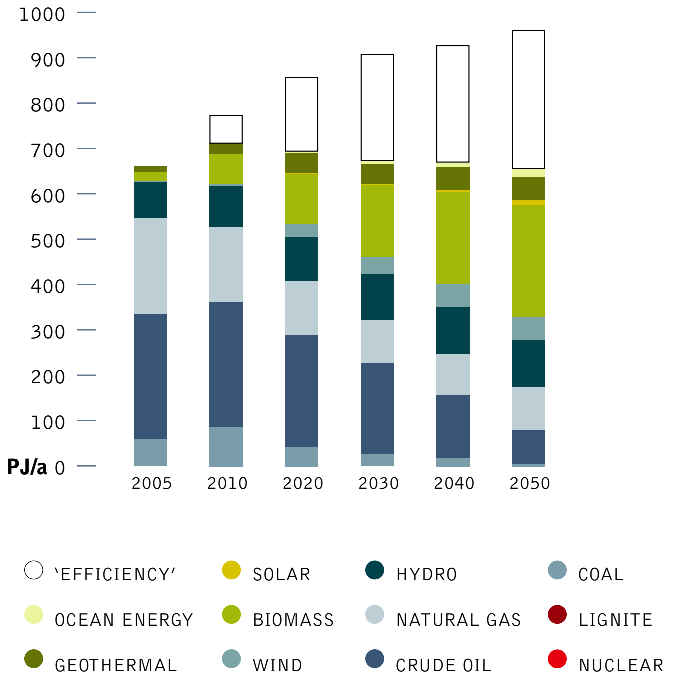


figure 19: new zealand: development of primary energy consumption under the energy revolution scenario
('EFFICIENCY' = REDUCTION COMPARED TO THE REFERENCE SCENARIO)



reference
20 STATISTICS NEW ZEALAND, INFOS DATABSE. TOTAL FIGURE REPRESENTS THE SUM OF MERCHANDISE CATEGORIES 2709 TO 2715.
21 2020: ENERGY OPPORTUNITIES REPORT OF THE ENERGY PANEL OF THE ROYAL SOCIETY OF NEW ZEALAND, THE ROYAL SOCIETY OF NEW ZEALAND, 23 AUGUST 2006.

development of CO_2 emissions

Under the Reference Scenario, by 2050, New Zealand's emissions of CO_2 will increase by 47 per cent from 2003 levels - and more than double 1990 levels (see figure 21). In contrast, under the Energy Revolution Scenario, emissions will decrease from 31.17 million tonnes / year in 2003 to 6.46 million tonnes / year in 2050. In percentage terms, the Energy Revolution Scenario achieves a reduction in energy sector emissions of 79 per cent from 2003 levels, or 72 per cent from 1990 levels. Annual per capita emissions will drop from eight tonnes / capita to 1.3 tonnes / capita.

figure 20: new zealand: development of co_2 emissions by sector under the reference scenario

('EFFICIENCY' = REDUCTION COMPARED TO THE REFERENCE SCENARIO)

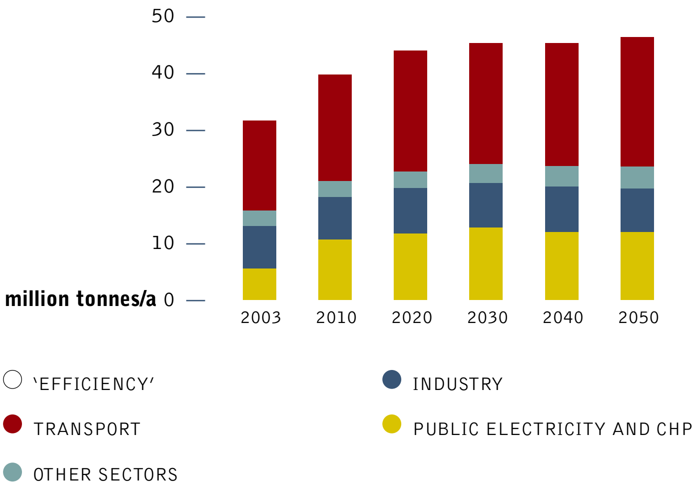
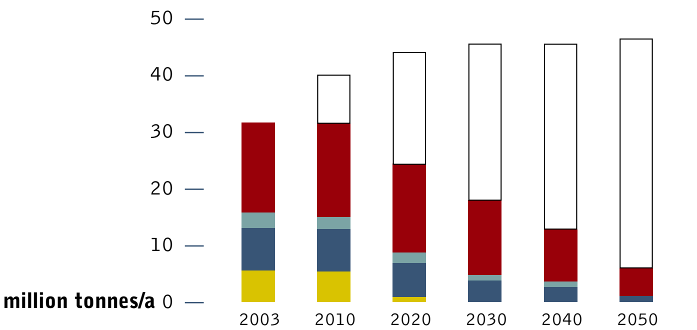


figure 21: new zealand: development of co_2 emissions by sector under the energy revolution scenario

('EFFICIENCY' = REDUCTION COMPARED TO THE REFERENCE SCENARIO)



energy efficiency in the energy revolution scenario

A range of options has been considered in this study for reducing the demand for energy in the period up to 2050. The analysis focuses on best-practice technologies. The scenario assumes continuous innovation in the field of energy efficiency, so that best practice technologies keep improving. The table below shows those which have been applied in the three sectors – industry, transport and households/services. A few examples are elaborated here.

table 5: energy efficiency measures

SECTOR	REDUCTION OPTION
Industry	
General	Efficient motor systems
General	Heat integration/pinch analysis
General	Improved process control
Aluminium	Increase secondary aluminium
Iron and steel	Blast furnace - coal injection
Iron and steel	BOF (Basic Oxygen Furnace) gas + heat recovery
Iron and steel	Thin slab casting
Chemical industry	Membrane product separation
Transport	
Passenger cars	Efficient passenger cars (hybrid fuel)
Freight	Efficient freight vehicles
Buses	Efficient buses
Others	
Households & services	Efficient electric appliances
Services	Efficient cooling equipment
Households & services	Efficient lighting
Households & services	Reduce stand-by losses
Households & services	Improved heat insulation
Services	Reduce electricity use during non-office hours
Agriculture & non-specified others	Energy efficiency improvement

reference

22 THE OUTPUT FROM THE MODEL FOR CARBON DIOXIDE EMISSIONS IN 2003 WAS 2.7% HIGHER THAN THE GOVERNMENT'S FIGURES FOR THE SAME YEAR, SO ALL OF THE EMISSION FIGURES HAVE BEEN ADJUSTED ACCORDINGLY IN OUR GRAPHS.

image GEOTHERMAL POWER STATION, NORTH ISLAND, NEW ZEALAND.

industry

The electricity market in New Zealand is dominated by industry which comprises 45 per cent of demand, with the commercial sector making up another 21 per cent[23]. Business and industry have a substantial role to play in energy efficiency and conservation gains.

Approximately 65 per cent of electricity consumption by industry is used to drive electric motor systems. This can be reduced by employing variable speed drives, high-efficiency motors and using efficient pumps, compressors and fans. The savings potential is up to 40 per cent[24].

The production of primary aluminium from alumina (which is made out of bauxite) is a very energy-intensive process. It is produced by passing a direct current through a bath with alumina dissolved in a molten cryolite electrode. Another option is to produce aluminium out of recycled scrap. This is called secondary production. Secondary aluminium uses only five to 10 per cent of the energy demand for primary production because it involves remelting the metal instead of an electrochemical reduction process.

households/services

Solar water heating offers a significant opportunity to reduce household energy demand. A solar water heater could save the average household between $350 and $450 a year, at current electricity prices, according to the Energy Efficiency and Conservation Authority (EECA).

If each household in New Zealand installed a solar water heater, carbon dioxide emissions from electricity generation would be reduced by about two million tonnes per year. Solar water heaters can work all around New Zealand, from Invercargill to the Far North, although the amount of solar radiation varies according to location and time of year. Standard solar water heating systems can produce around 75 per cent of a household's water heating in summer, and between 25 and 45 per cent in winter, according to EECA. Solar water heaters could save 1,900GWh/year in generated electricity[25].

Better building design, such as passive solar design to maximise energy inputs from the sun and effective, double glazing and other heat insulation could save up to two thirds of the average heat demand for new buildings[26]. The NOW home, by Beacon Pathway in Auckland, is designed to meet such reductions using current energy efficiency technologies. Other studies indicate potential energy efficiency savings in new homes and offices at 70 to 80 per cent[27] with one study showing 88 per cent reduction in energy use at long term least cost[28]. Future technology developments are likely to improve on this further.

Energy efficiency in office buildings could be improved by about 22 per cent, according to the Electricity Commission's commercial building programme.

Energy use by household appliances, such as washing machines, dishwashers, TVs and refrigerators, can be reduced by 30 per cent using the best available options, and by 80 per cent with advanced technologies. Energy use by office appliances can be reduced by 50 to 75 per cent through a combination of power management and energy efficient computer systems[29]. The Energy Star brand will increasingly become important in New Zealand, as it has already become in the United States, as a way in which to rate the efficiency of appliances.

Use of stand-by mode for appliances is on average responsible for about five per cent of electricity use by households in New Zealand and costs a total of more than $65 million each year[30]. Replacement of existing appliances with those with the lowest losses would reduce standby power consumption by 70 per cent. Switching appliances off at the wall after use would eliminate standby use altogether.

future costs of electricity generation

Figure 22 shows that electricity generation costs will be similar for both scenarios with the Energy Revolution costs being slightly lower. By 2020 costs under the Energy Revolution Scenario steadily decrease, while those in the Reference Scenario continue to climb. By 2050, generation costs will be over 40% less than in the Reference Scenario. Note that any increase in fossil fuel prices beyond the projection given in Table 6 will reduce the cost gap between the two scenarios.

Due to growing demand, we face a significant increase in society's expenditure on electricity supply. Under the Reference Scenario, the unchecked growth in demand, the increase in fossil fuel prices and the cost of CO_2 emissions result in total electricity supply costs rising from today's $2.8 billion per year to $7.3 billion per year in 2050. Figure 23 shows that the Energy Revolution Scenario not only achieves significant reductions in CO_2 emissions, but also helps to stabilise energy costs and relieve the economic pressure on society. Increasing energy efficiency and shifting energy supply to renewable sources leads to a reduction of long term costs for electricity supply by over 40% than in the Reference Scenario. It becomes clear that following stringent environmental targets in the energy sector also pays off economically.

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29 [#] ECOFYS REPORT, 2006.
30 ENERGY EFFICIENCY AND CONSERVATION AUTHORITY.

figure 22: new zealand: development of electricity generation costs under the two scenarios

(CO₂ EMISSION COSTS IMPOSED FROM 2010 IN INDUSTRIALISED REGIONS, FROM 2020 IN ALL REGIONS, WITH INCREASE FROM US15 $/TCO₂ IN 2010 TO US50 $/TCO₂ IN 2050)

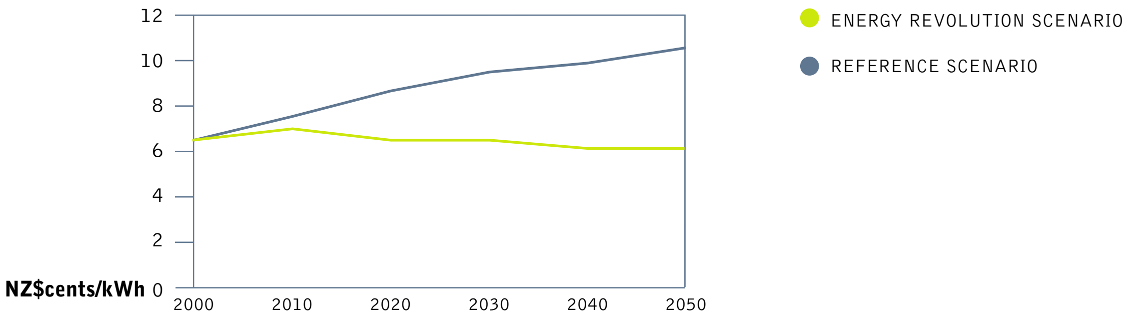
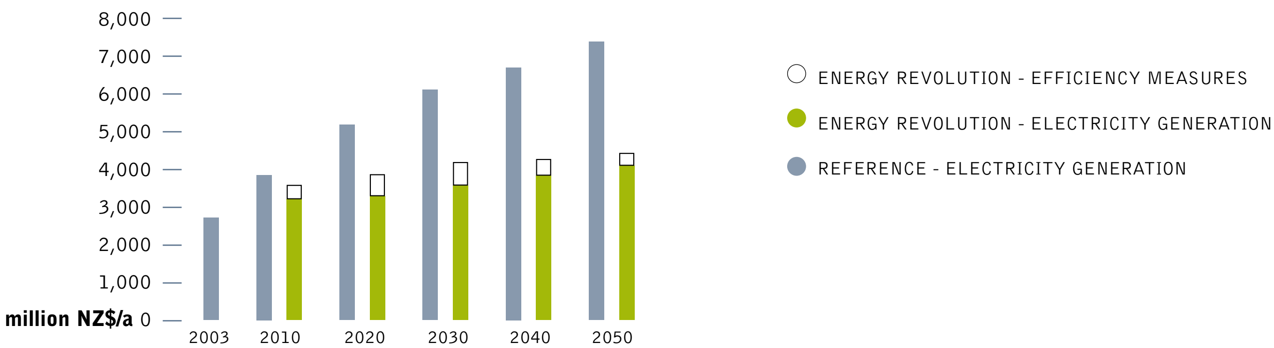


figure 23: new zealand: development of total electricity supply costs



employment effects

The rapid growth of renewable energy technologies described under the Energy Revolution Scenario will lead to large investment in new technologies. This dynamic market growth results in a shift of employment opportunities from conventional energy-related industries, like coal mining, to new occupational fields in, for example, the wind and solar industry. There are more jobs per kilowatt hour in electricity generated from renewable energy sources than in fossil fuels.

The number of manufacturing jobs varies according to the sector. In the wind energy sector the New Zealand manufacturing employment estimates range from 41-325[31] per year for 100MW installed, up to 92-571, depending on the amount of New Zealand manufacturing undertaken.

In the Energy Revolution Scenario an estimated 2,600 to 6,000 annual jobs are required to manufacture and install renewable energy electricity generation – a total of 122,000 to 282,000 job years through to 2050. This only includes the direct manufacturing jobs and the range in the number of jobs depends on the percentage of New Zealand manufacturing involved. If ongoing operational and maintenance jobs were included, the figures would be higher still, and a significant number of education and training positions would also be required to train these workers.

The New Zealand employment estimates are based on New Zealand Trade and Enterprise accepted calculations of manufacturing import substitution and employment effects.

reference
31 MANUFACTURING OPPORTUNITIES FROM THE NEW ZEALAND WIND FARM INDUSTRY, ENERGY INFORMATION SERVICES AND WISE ANALYSIS, FOR INDUSTRY CAPABILITY NETWORK NEW ZEALAND, AUGUST 2004. (HTTP:// WWW.ICN.GOVT.NZ/WFR.PDF)

climate and energy policy for new zealand

"….POLICIES MUST BE PRACTICAL AND TARGETED, WITH A FOCUS ON MEASURES THAT BREAK DOWN BARRIERS TO CHANGE… AND CREATE INCENTIVES FOR POSITIVE ACTION."

5

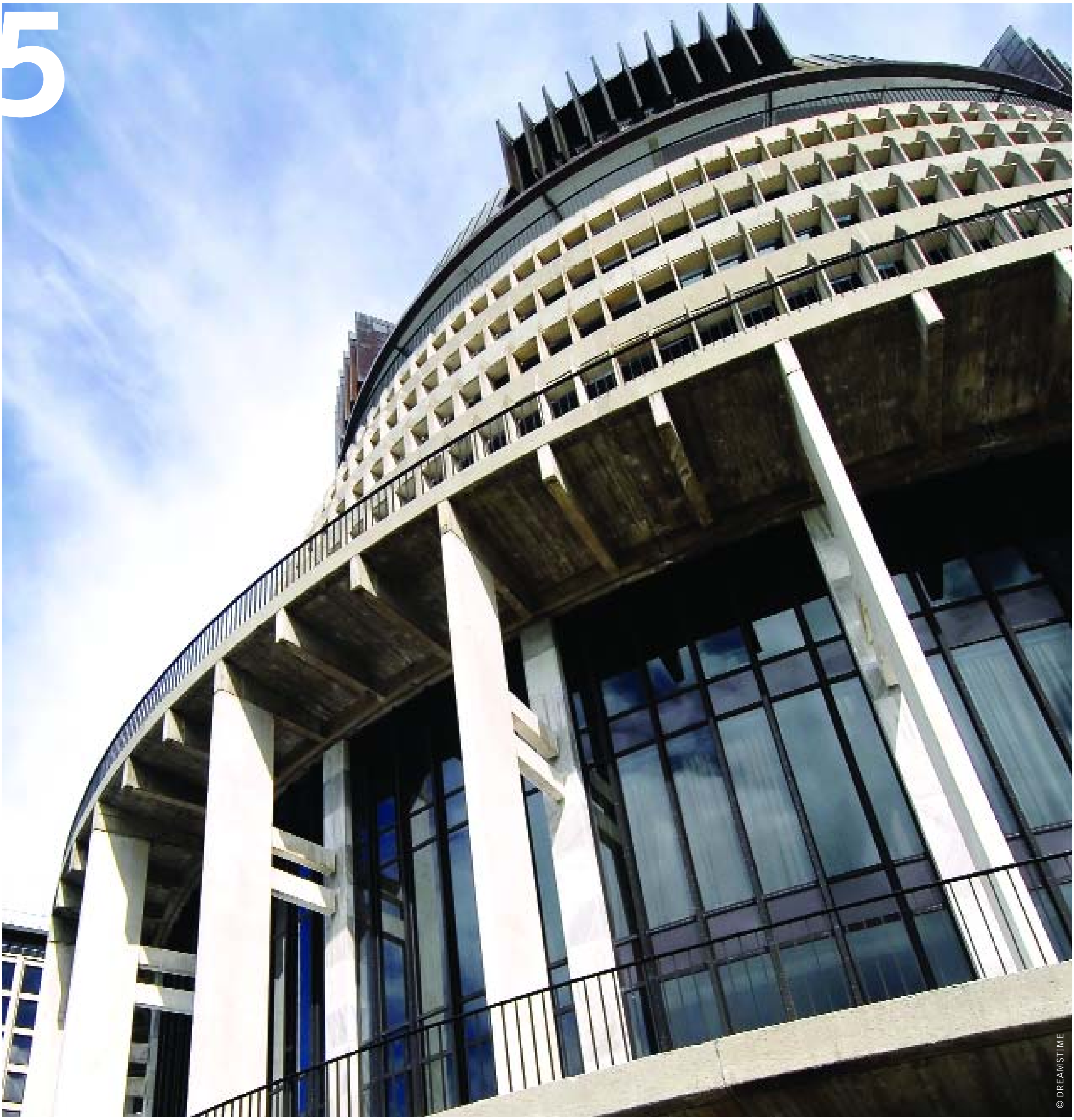


image THE BEEHIVE, PARLIAMENT BUILDINGS, WELLINGTON, NEW ZEALAND.

the case for leadership

There is a strong case for New Zealand leadership on clean energy and climate protection:

- We are already a leader in renewable energy. We have vast renewable energy resources - including wind, hydro, biomass, geothermal, solar, wave and tidal energy. And we have experience with renewable energy. Our largest electricity company is 100 per cent renewable, and just 20 years ago our electricity system was more than 80 per cent renewable. New Zealand is perfectly placed to become a 100% renewable electricity nation.
- We have huge potential in energy savings and efficiency. Discovering that potential will reduce our energy expenditure, and result in a more productive economy.
- Moving to energy independence (through renewable sources and biofuels) will be good for national security because it will reduce our reliance on energy imports, and our susceptibility to high oil prices.[32]
  - We also have a responsibility to take a leading world role on climate change because: per person, New Zealanders are heavy greenhouse polluters. Since 1990, our levels of CO_2 pollution from energy have increased 38 per cent. We must take action to reverse that trend;
  - New Zealanders are good innovators and historically early adoptors of new technologies. (Christchurch company Windflow Technologies Ltd is a good example of a New Zealand company that is designing and manufacturing wind turbines especially for the unique New Zealand conditions, and is the first such company to do so).
  - New Zealanders already leads the world in rejecting polluting and unsafe energy sources with its ban on all forms of nuclear power;
  - New Zealanders are also relatively wealthy. We can hardly expect emerging economies (including China and India) to reduce their emissions first – when on a per capita basis they are poorer and less polluting than is New Zealand.

strong, practical and targeted policies

A strong set of concrete and ambitious policies is needed to drive New Zealand to a clean energy future.

Policies must be practical and targeted, with a focus on measures that break down barriers to change (structural, financial and social) and create incentives for positive action.

reference
32 DURING THE 2005/06 FINANCIAL YEAR, NEW ZEALAND SPENT $4.94 BILLION ON PETROLEUM IMPORTS. EXPENDITURE ON PETROLEUM IMPORTS INCREASED 148% (FROM $1.99 BILLION) IN JUST 6 YEARS. SOURCE: STATISTICS NEW ZEALAND, INFOS DATABASE. TOTAL FIGURE REPRESENTS THE SUM OF MERCHANDISE CATEGORIES 2709 TO 2715.

framing the challenge - national greenhouse targets

New Zealand needs a clear, overarching target to frame the shift to clean energy. That target should be expressed in terms of a national reduction in greenhouse gas pollution that is consistent with keeping temperature rise below the 2°C "dangerous" threshold. New Zealand should adopt targets of at least:

- a 30 per cent reduction in greenhouse pollution compared to 1990 levels by 2020;
- a 90 per cent reduction in greenhouse pollution compared to 1990 levels by 2050.

This is in line with the thinking in many leading nations and states, including the United Kingdom, California, and the Australian States of Victoria and South Australia, who have already committed to substantial mid-and-long-term greenhouse targets.

The European Union recently indicated that it will push for 30 per cent cuts by 2020 if the rest of the Annex 1 countries follow suit and the Netherlands has proposed the same national target of a 30 per cent reduction by 2020.

Ten major US companies have announced this year that they want the US to commit to 10 to 30 per cent reductions over the next 15 years.

This report shows that New Zealand can come close to meeting these targets in carbon dioxide, although it will lag behind by approximately 10 years. This is the cost of delayed action on climate change in this country and is not an excuse to shirk our responsibilities as a relatively wealthy, greenhouse gas-intensive country. We are in the top 15 most greenhouse gas polluting countries per capita in the world.

New Zealand can still meet these targets by adopting the following strategies:

- Retiring carbon-intensive energy infrastructure before its due date (such as Huntly power station or Genesis' e3p). (The model assumes equipment is not retired early).
- Proposing more aggressive demands on the agricultural sector to also rapidly reduce its greenhouse emissions. This would involve a heavy commitment of funding to research and develop new techniques and implement existing knowledge, and might well require a shifting of agricultural practices from dairy to less greenhouse gas-intensive processes.
- A possible expansion of the use of biofuels in the transport sector, providing they are produced sustainably.
- Any remaining emission reductions should be made up by purchasing credits on the international market, focusing on credits from projects under the Clean Development Mechanism, with emphasis on projects in Pacific Island nations

image DETAIL OF A LAKE BED DEMONSTRATING THE EFFECTS OF A LOCAL DROUGHT, NEW ZEALAND.

a "price instrument" - the incentive to reduce greenhouse pollution

A polluter-pays "price instrument" forms the backbone of any suite of climate policies:

- A price instrument is the best means of creating an incentive to reduce greenhouse pollution, because it puts greenhouse pollution on the balance sheet.
- A price instrument can (and should) be used to generate revenue that can then be recycled directly into climate change solutions – for example energy efficiency programs.

It is absolutely essential that New Zealand introduce an economy-wide price-based measure by 2008.

polluter pays – levelling the playing field The real cost of energy production from fossil fuels includes expenses absorbed by society, such as health impacts and local and regional environmental degradation, ranging from mercury pollution to acid rain – as well as global negative impacts from climate change. A polluter-pays system introduces a charge that reflects those wider costs on society. Adoption of a polluter pays measure is a pre-requisite to fairer competition amongst energy sources.

basic principles for pricing greenhouse pollution

It is absolutely essential that New Zealand introduces a price instrument that is **broad-based, long-term and effective from 2008.** This approach will be:

- **fair** In contrast, a narrow scheme will place an unfair burden on a particular sector of the economy.
- **efficient** A broader scheme will create a more dynamic carbon market – because there will be a wider range of opportunities to reduce emissions.
- **smooth** If business and investors are provided with certainty, they will lead a smooth transition to a low-carbon economy.

carbon charge or emissions trading?

Greenpeace's preferred price instrument for New Zealand in the short-term is a broad-based carbon charge. Much of the policy work has already been done on this and could be reasonably implemented by 2008. It will be extremely difficult to establish an emissions trading scheme within the next few years due to the complex nature of the policy, however, in the medium-term an emissions trading scheme would be an acceptable alternative, provided that the following potential faults are avoided:

- There should be no "grandfathering" of permits to polluters, whereby those businesses that have caused greenhouse pollution in the past are given the equivalent of a tax exemption. In the European Union, grandfathering has provided some heavy polluters with windfall profits. Grand parenting typically places an unfair burden on individual consumers.
- The caps set under the emissions trading scheme must be consistent with the national greenhouse targets mentioned above.
- Treaty of Waitangi issues associated with the creation of a new property right (emissions permits) must be satisfactorily negotiated.

These issues are likely to take many years to resolve and to develop the appropriate policy mechanisms, so if emissions trading was adopted, an interim price on carbon must be implemented in the short term (from 2008) to ensure that businesses and decision makers receive clear signals upon which to base investment and policy decisions. New Zealand must not delay for five years or more putting a price on greenhouse pollution while it waits for an emission trading scheme to be established. A carbon charge could fill this gap.

energy efficiency and savings

New Zealand has huge potential in energy efficiency and savings.

In the European Union it is estimated that current energy demand can be cut in a cost-effective manner by as much as 30 per cent, while the technical potential for improvement of energy use is even higher, as high as 40 per cent of current energy consumption. It is reasonable to assume that New Zealand is currently less energy efficient than Europe – and therefore has even greater potential to save energy.

Investment in energy efficiency and savings should be given priority over investment in new generation capacity – because it typically provides a better return on investment.

"ENERGY SAVING IS WITHOUT DOUBT THE QUICKEST, MOST EFFECTIVE AND MOST COST-EFFECTIVE MANNER FOR REDUCING GREENHOUSE GAS EMISSIONS".[33]

California will invest $US2.7 billion in efficiency and conservation between 2006 and 2008, with an expected savings to consumers of $5.4 billion. The cost of building and running several large power stations will be avoided.[34]

Continuing programmes to boost solar water heating, strengthening building codes to increase minimum levels of energy efficiency, retrofitting homes with insulation and promoting Energy Star branded appliances will all play an important role in improving energy efficiency (see Energy Efficiency section of the New Zealand Energy Revolution Scenario chapter).

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the new NEECS

The new National Energy Efficiency and Conservation Strategy (NEECS) has the potential to deliver substantial reductions in greenhouse gas emissions, and a more productive economy. In order to be effective, the NEECS should:

- Adopt an overall target of a 20% reduction in total energy consumption by 2020.[35] Interim and sectoral targets should be consistent with this overall target.
- Facilitate a major increase in investment in energy efficiency and conservation to at least $300-$400 million annually. This would still be a relatively small investment when compared to current billion-dollar proposals for investment in new generation. For example, the State-owned energy company Meridian already plans to spend $1.2 billion on its Project Hayes windfarm, and New Zealand spends $11.3 billion annually on electricity, petrol and diesel[36]. For energy efficiency and conservation to become a serious part of the energy market, it will require significant financial boosting.
- Require the Energy Efficiency and Conservation Authority (EECA) to foster new business that deliver energy-efficient services.
- Include an Electricity Demand Management Fund.[37] A small levy on electricity sales would generate significant funds for energy savings and efficiency. The funds would be distributed to the private sector by a tender process. In Australia, the State of New South Wales has an A$200 million fund of this type. This could be an expansion of the Electricity Commission levy.
- Ensure the rapid uptake of smart metering – a measure that has already been specifically recommended by the Parliamentary Commissioner for the Environment.[38] The Canadian State of Ontario plans to have 100 per cent of electricity consumers on smart meters by 2010.
- Require the Government to lead in practice. Government Departments should be set energy efficiency savings targets and required to report on them annually.
- Incorporate a measure to "decouple" electricity profits from electricity sales. Electricity companies that assist customers to save electricity could be financially compensated for any losses in electricity sales.

references

35 FROM CURRENT LEVELS. THIS IS IN LINE WITH NUMEROUS STUDIES THAT HAVE SHOWN THAT THE EU COULD SAVE AT LEAST 30% OF ITS PRESENT ENERGY CONSUMPTION IN A COST-EFFECTIVE MANNER. SEE COMMISSION OF EUROPEAN COMMUNITIES, COM(2005) 265, GREEN PAPER ON ENERGY EFFICIENCY OR DOING MORE WITH LESS, AT PAGE 4.
36 SOURCE FOR ELECTRICITY: MED ENERGY DATA FILE JAN 2006. SOURCE FOR PETROL AND DIESEL: STATISTICS NEW ZEALAND, INFOS DATABASE.
37 THE FUND COULD BE A NEW INITIATIVE, OR A MAJOR INCREASE ON THE NZ$2 TO $6 MILLION/YEAR "EFFICIENCY LEVY" CURRENTLY RAISED BY THE ELECTRICITY COMMISSION.

new zealand as a world leader in renewable energy

New Zealand can and should be a world leader in renewable energy. We have excellent renewable energy resources. We need strong Government policies to promote renewable energy, so that we can build – and then export – our expertise.

Our renewable energy sector is currently lagging behind European countries that have actively supported their renewable energy industries. It is no accident that the world's leading renewable energy companies are located in countries like Denmark, Germany and Spain, where strong policies to encourage renewable energy uptake are well established.

New Zealand can achieve a 100 per cent renewable electricity sector and a high proportion of renewable transport if we:

- Promote a diverse range of renewable technologies (i.e. a blend of wind, hydro, geothermal, solar, biomass and ocean energy).
- Encourage the development of a geographically dispersed, "distributed"[39] renewable energy system. This will increase energy security and reduce the need for additional investment in transmission infrastructure.
- Increase energy efficiency and conservation to lower demand.

Specific incentives for renewable energy are required in addition to a price on greenhouse pollution. Both carrot and stick measures are required to spark a rapid uptake in renewable energy. Many European countries such as Germany have used incentives for renewable energy combined with a price on greenhouse pollution under the European Emissions Trading Scheme to reduce their emissions and increase renewable energy uptake.

setting goals – renewable energy targets

New Zealand should adopt a legally binding renewable energy target of:

- 100 per cent renewable electricity by 2025.

The Greenpeace Energy Revolution Scenario demonstrates that this is technically and economically achievable.

references

38 "THE PCE RECOMMENDS THAT THE COMMISSION DEVELOP A PROGRAM WITH A SET TIME FRAME TO INCREASE THE INSTALLATION AND USE OF SMART METERS IN ALL MARKET SECTORS." PCE, ELECTRICITY, ENERGY, AND THE ENVIRONMENT: ENVIRONMENTAL PERFORMANCE ASSESSMENT 1 JULY 2004–30 JUNE 2005, MAY 2006.
39 THE PCE DEFINES "DISTRIBUTED GENERATION" AS: ANY ELECTRICITY GENERATION FACILITY, USUALLY SMALL-SCALE, THAT PRODUCES ELECTRICITY FOR USE AT THE POINT OF LOCATION, OR SUPPLIES ELECTRICITY TO OTHER CONSUMERS THROUGH A LOCAL LINES DISTRIBUTION NETWORK. WE NOTE THAT IN AUGUST 2006 THE PCE IS SCHEDULED TO RELEASE A REPORT WHICH WILL EXPLORE THE POTENTIAL FOR DISTRIBUTED GENERATION IN NEW ZEALAND. THE FINDINGS OF THIS REPORT SHOULD BE INCORPORATED INTO THE NEECS.

image GEOTHERMAL POWER STATION, TAUPO, NEW ZEALAND.

measures to boost renewable electricity

Based on international experience, a feed-in tariff is the most effective means of supporting renewable energy. A feed-in tariff provides certainty to investors in renewable energy, by providing a guaranteed sale price for electricity they generate – over a specific period of time.

The tariff could be set at different levels, with targeted encouragement of particular types of renewable energy that deserve support. For example: ≈ emerging technologies (e.g. tidal power) and micro (household) generation:

- Community-owned wind development is not occurring in New Zealand. This contrasts with countries like Denmark, where community ownership has helped make wind power popular with rural communities, and injected valuable income into regional economies.
- Smaller (i.e. less than 20MW) wind developments are not occurring in New Zealand. A key reason is that small players do not have the expertise or ability to negotiate favourable sales prices with energy purchasers. A feed-in tariff would overcome this barrier. "Small wind" deserves particular support because it could play an important role in achieving a more distributed energy system and reduce stress on already stretched transmission infrastructure.[40]
- Newer renewable technologies such as tidal energy should also be supported by a feed-in tariff, particularly for smaller pilot projects. It is no accident that pilot tidal and wave energy projects are currently based in Portugal – where a feed-in tariff has been put in place.

micro generation

Micro-scale (i.e. household) generation deserves specific support. A feed-in tariff and a net metering initiative are two specific measures that should be introduced. Micro generation would deliver benefits in energy independence (and security). It would also contribute to a more distributed generation system, again reducing stress on transmission infrastructure (and the need for additional investment in transmission).

Net metering protocols should be simplified and streamlined to ensure that micro generators can sell excess energy to the grid.

new zealand community wind

A program to support small community-owned or "local New Zealand-owned" wind farms should be introduced. This would consist of the above mentioned targeted feed-in tariff, and assistance with streamlining grid connection and planning issues. Identification and support of pilot projects would also be required.[41]

New Zealand's Parliamentary Commissioner for the Environment has specifically recommended that the Government investigate the potential for community wind development in New Zealand.

loading order

Adopting a variation of the Californian loading order policy would be another effective way to increase renewable energy development. Under this system, any electricity provider wanting to develop more generation must first demonstrably consider if the demand could be met through energy efficiency and conservation programmes. If not, it must then consider renewable energy options to meet the demand. If all preceding options are proven to be unviable, then it may consider fossil fuel options. One important variation for New Zealand would be that no more fossil fuel could be considered so that we can meet a 100 per cent renewable electricity target by 2025.

resource management act

Climate change is a complex issue, requiring action at all levels - individual, local, regional, corporate, national and international.

The Resource Management Act (RMA) was amended in 2004 to remove regional councils' ability to directly manage and regulate greenhouse emissions.

Greenpeace has successfully argued in the High Court that the benefits of renewable energy development in reducing climate change can be considered under section 104E of the RMA (The proceedings are part of Greenpeace's challenge of plans by Mighty River Power to build the Marsden B coal-fired power station. Mighty River Power and Genesis Energy have appealed the High Court ruling). What remains, though, is a gaping hole in New Zealand's regulation of greenhouse pollution.

a) the Resource Management Act does not allow regional councils to generally consider climate change, or to directly regulate greenhouse pollution, outside the constraints of section 104E; and

b) there is no national regulation of greenhouse pollution.

The Climate Protection Bill (Resource Management (Climate Protection) Amendment Bill 2006) proposed by the Green Party would re-instate the ability of local and regional authorities to directly regulate greenhouse pollution, and is therefore the best available means of addressing the problem in a timely manner. This could be reassessed once a price on greenhouse pollution is implemented.

Greenpeace urges Parliament's Local Government and Environment Select Committee which is currently considering the Bill, to recommend the enactment of the Climate Protection Bill.

references

40 THE PCE DEFINES "DISTRIBUTED GENERATION" AS: ANY ELECTRICITY GENERATION FACILITY, USUALLY SMALL-SCALE, THAT PRODUCES ELECTRICITY FOR USE AT THE POINT OF LOCATION, OR SUPPLIES ELECTRICITY TO OTHER CONSUMERS THROUGH A LOCAL LINES DISTRIBUTION NETWORK. WE NOTE THAT IN AUGUST 2006 THE PCE IS SCHEDULED TO RELEASE A REPORT WHICH WILL EXPLORE THE POTENTIAL FOR DISTRIBUTED GENERATION IN NEW ZEALAND. THE FINDINGS OF THIS REPORT SHOULD BE INCORPORATED INTO THE NEECS.
41 FOR EXAMPLE, THE VICTORIAN GOVERNMENT RECENTLY (AUGUST 2006) PROVIDED A GRANT OF NEARLY A$1 MILLION FOR AUSTRALIA'S FIRST COMMUNITY OWNED WIND FARM, THE HEPBURN COMMUNITY WIND PARK.

end subsidies to fossil fuels

Fossil-fuel energy sources receive an estimated $365-440 billion in subsidies per year worldwide, heavily distorting markets.

Subsidies artificially reduce the price of fossil fuel energy, and block the uptake of renewable energy in the market place. Eliminating direct and indirect subsidies to fossil fuels would help move us towards a level playing field across the energy sector.

Key fossil fuel subsidies that exist in NZ and should be removed include the following:

- The failure to make greenhouse polluters pay for the damage to the environment that they are causing. The New Zealand Government has failed to introduce a cost on carbon in the energy sector, which means that more than 31 million tonnes of CO_2 are emitted each year by the energy sector at zero cost to the polluter. A conservative costing of this subsidy is $446 million each year.[42]
- In June 2004, the Government introduced a suite of subsidies for gas exploration, worth up to $100 million.[43]
- The Government's agreement with Genesis Energy to compensate Genesis if the company cannot secure enough gas to operate the e3p gas power station. The contingent liability arising out of the guarantee is uncertain, but could be significant if gas supplies run low.
- In mid-2006, Meridian Energy paid an $800 million special dividend to the Government. The Government chose to funnel the renewable energy company's profits directly into fast-tracking the nation's road projects. The absurd outcome will likely be an increase in greenhouse pollution from road transport.

Removing fossil fuel subsidies would save taxpayers' money and reduce current energy market distortions. It would also dramatically reduce the need for renewable energy support.

references

42 IN 2005, NEW ZEALAND'S ENERGY-RELATED CO_2 EMISSIONS WERE 31.38 MILLION TONNES (SEE NZ MINISTRY FOR ECONOMIC DEVELOPMENT, NEW ZEALAND'S ENERGY GREENHOUSE GAS EMISSIONS, 1990-2005, JUNE 2006). TREASURY'S MOST RECENT (AUGUST 2006) ESTIMATE OF THE COST OF POLLUTION PERMITS ON THE INTERNATIONAL MARKET IS US$9.65/TONNE CO_2, OR $NZ14.20/TONNE CO_2 (SEE HTTP://WWW.TREASURY.GOVT.NZ/RELEASE/KYOTO/). THIS IS, IN OUR VIEW, A RELATIVELY LOW ESTIMATE. [31.38 MT X NZ$14.20 = $445.6 MILLION.

43 THIS IS SPLIT BETWEEN:
* FUNDING SEISMIC EXPLORATION TO INCREASE UNDERSTANDING OF NEW ZEALAND'S PETROLEUM BASINS (UP TO AROUND $15 MILLION);
* ACTIVE MARKETING OF NEW ZEALAND AS AN EXPLORATION DESTINATION, INCLUDING FACILITATION OF EXPLORATION ACTIVITIES (AROUND $5 MILLION);
* TEMPORARY ADJUSTMENTS TO THE PETROLEUM ROYALTY REGIME (UP TO AROUND $80 MILLION).

clean and secure transport energy

There is great potential to reduce greenhouse gas emissions from New Zealand's transport sector. Our per capita CO_2 emissions from transport are fourth highest in the world.[44]

the co-benefits of clean transport energy

Shifting to clean transport energy would have substantial co-benefits in terms of improved health, energy security and the balance of trade.

- Recent research indicates that our annual deaths from vehicle emissions at 400 per year[45] are on a par with deaths from road crashes.[46]
- During the 2005/06 financial year New Zealand spent $4.94 billion on petroleum imports. Expenditure on petroleum imports has increased 148% (from $1.99 billion) in just six years.[47]

domestic transport - reducing our dependence on roads

Significant progress in transport emissions can only be achieved by reducing our dependence on road transport.

- Road transport accounts for around 90 per cent of New Zealand's transport sector CO_2 emissions.[48]
- Around 70 per cent of transport CO_2 emissions are from cars.[49]

Steps to reduce transport emissions should follow the hierarchy of action that underlies most thinking on reducing the environmental impacts of transport. The 1998 Select Committee inquiry in the environmental effects of road transport summarised that summary as follows:

- reducing the need to travel ;
- choosing a low impact means of travel;
- choosing a low impact propulsion system;
- improving the efficiency of propulsion.Following this hierarchy, reduced transport emissions can be achieved without adverse impacts on quality of life and with significant co-benefits by:

- Ensuring that urban planning processes emphasis town planning that allows reduced need for travel through more numerous centralised nodes.

references

44 IN 2003, NEW ZEALAND WAS THE FOURTH HIGHEST EMITTER AMONGST ANNEX 1 PARTIES WITH RELIABLE DATA, WITH EMISSIONS 15 TO 40% HIGHER THAN THOSE ACHIEVED IN MOST COUNTRIES. NEW ZEALAND IS ALSO UNIQUE AMONGST ANNEX 1 PARTIES IN THAT TRANSPORT EMISSIONS ARE A GROWING SHARE OF ENERGY EMISSIONS, DESPITE RAPID GROWTH IN FOSSIL FUEL USE FOR ELECTRICITY GENERATION.

45 WWW.TRANSPORT.GOVT.NZ/ASSETS/PDFS/NZVESP-RESOURCE-DOC22NOV04.PDF

46 HEALTH EFFECTS DUE TO MOTOR VEHICLE AIR POLLUTION IN NEW ZEALAND, REPORT TO THE MINISTRY OF TRANSPORT, JANUARY 2002 – AVAILABLE AT HTTP://DEV.SILVERSTRIPE.COM/BASE2/MOT/ASSETS/NEWPDFS/NIWA-REPORT.PDF

47 SOURCE: STATISTICS NEW ZEALAND, INFOS DATABASE. TOTAL FIGURE REPRESENTS THE SUM OF MERCHANDISE CATEGORIES 2709 TO 2715.

48 NEW ZEALAND NATIONAL COMMUNICATION 2005, APPENDIX 8

49 SURFACE TRANSPORTATION COSTS AND CHARGES: MAIN REPORT, MINISTRY OF TRANSPORT 2005 ANNEX B12. THESE ARE COST ESTIMATES FOR 2001 DATA BUT AS ALL GREENHOUSE EMISSIONS ARE COSTED EQUALLY, THE RATIOS REFLECT EMISSIONS.

image AIRPORT, NEW ZEALAND.

- Actively encouraging information technology (such as video or web-based conferencing) which reduce the need for travel for meetings. Government departments should lead by example on this by using and promoting these technologies internally and for interacting with the public.
- Shifting urban journeys from road to public transport, walking and cycling. This will be partly achieved through increased emphasis on these issues during urban planning. Significant investment in public transport (powered by renewable energy) will also be required. The proportion of the Land Transport Fund spent on public transport must be significantly increased from the current 15 per cent to at least 50 per cent by 2010.
- Shifting longer-distance freight from road to rail and sea. This will have additional benefits in terms of improved road safety[50] and reduced road maintenance costs[51]. The rail network has both significant spare capacity and a major backlog of deferred maintenance and investment. Significant public investment is required to address this backlog. Rail also has significant economies of scale.[52] Government rail access charges ought to be set to encourage growth in freight rather than achieve full-cost recovery.
- Shifting domestic air transport to rail and sea-based systems.
- The remaining demand for liquid fuels should primarily be met through biofuels. This can be achieved by introducing a mandatory percentage of biofuel to be mixed with regular petrol, starting from 5 per cent and increasing over time; a major programme to encourage local production and usage of biofuels, including incentives for retailers to provide greater proportional mixes of biofuel in their petrol; and a sustainability certification programme for biofuels[53].
- Introducing a range of measures to improve vehicle fleet efficiency and to encourage the uptake of electric plug-in hybrid vehicles. These would include:
  - the introduction of vehicle emissions standards and tests for all vehicles[54];
  - fuel efficiency standards for newly registered and re-registered vehicles equivalent to those prevailing in the country of manufacture;
  - a ban on the import of used vehicles more than seven years old;
  - a fuel efficiency labelling scheme for all vehicles;
  - a differential registration or feebate scheme based on fuel efficiency.

references
50 THE SURFACE COSTS AND CHARGES STUDY (SECTION B10.5) CONCLUDED THAT "THE MOST 'VULNERABLE' ROAD USER GROUPS (MOTORCYCLES, CYCLES, PEDESTRIANS) SUFFER SUBSTANTIALLY GREATER COSTS THAN THEY CAUSE [WHILST] THE CONVERSE IS TRUE OF THE LEAST 'VULNERABLE' GROUPS, PARTICULARLY TRUCKS."
51 ROAD MAINTENANCE COSTS RISE WITH THE AXLE LOADING OF A VEHICLE IN A NON-LINEAR FASHION. A TEN-FOLD DIFFERENCE IN AXLE LOADING LEADS TO BETWEEN ONE AND TEN THOUSAND DIFFERENCE IN ROAD DAMAGE.
52 RAIL MARGINAL COSTS ARE ABOUT 65% OF AVERAGE COSTS, ACCORDING TO THE SURFACE COSTS AND CHARGES STUDY FINAL REPORT.

international transports

International transport (air and maritime) emissions are not covered in this scenario, but will have to be addressed by New Zealand.

Air transport is a significant source of greenhouse pollution. Pressure to address the climate effects of international aviation will continue to grow, and to result in regulation. The European Union is already moving to bring air transport pollution within its Emissions Trading System. In addition, the aviation sector faces major challenges from rising fuel prices.

Given New Zealand's distance from suppliers and markets, any regulatory changes will bear heavily on this country. Increased international awareness of "food miles" will also negatively affect our exports. For example, Tescos supermarkets in the United Kingdom are putting labels on all products in its stores that have been transported by air, and is to implement a more comprehensive programme including labelling of full greenhouse emissions of all products.

New Zealand should respond proactively by:

- Moving to reduce international transport emissions to reduce any economic exposure to future regulatory changes. This could be achieved by switching exports from air to maritime transport (which is very fuel efficient on a tonne / kilometre basis to other modes) and developing sailing or hybrid cargo ships.
- New Zealand should look to develop products that have a high value-to-weight ratio and can be carried on maritime transport
- Responding to the rising and inevitable international concern about food miles by reducing emissions from all levels of production of our products, from agriculture, manufacturing and transport, and promoting low-emission products through labelling.
- Encouraging the consumption of domestically produced products.
- Planning for less, but longer and higher-value visits from international visitors, and actively encouraging New Zealanders to holiday domestically.

These are all prudent and necessary steps in making a well-planned economic shift to a carbon-constrained world. This change is inevitable, but we can make the transition easier and reap economic benefits from making an early and proactive transition to a low carbon world.

references
53 THERE IS A SIGNIFICANT GLOBAL RISK THAT LAND CLEARANCE FOR BIOFUEL PRODUCTION (EG SUGAR CANE AND PALM OIL PLANTATIONS) MAY GENERATE ADVERSE CLIMATE EFFECTS THROUGH LOSS OF CARBON SINKS, ENERGY INTENSIVE PRODUCTION METHODS, AND METHANE FROM ROTTING VEGETATION. THESE CAN OFFSET THE CLIMATE BENEFITS OF BIOFUEL USE. THIS IS IN ADDITION TO THE ECOLOGICAL AND SOCIAL IMPACTS OF INCREASED DEFORESTATION.
54 EMISSIONS TESTING – WHILE NOT DIRECTLY RELATED TO FUEL-EFFICIENCY – WILL HELP REMOVE OLDER HEAVILY WORN VEHICLES FROM THE FLEET.

appendix

"THE ENERGY REVOLUTION SCENARIO IS FOCUSED ON THE POTENTIAL FOR ENERGY SAVINGS AND RENEWABLE SOURCES, PRIMARILY IN THE ELECTRICITY AND HEAT GENERATING SECTORS."

image GEOTHERMAL VENTS, ROTORUA, NEW ZEALAND.

appendix 1: energy technologies

This appendix provides a global overview of the range of technologies available now and in the future to satisfy the world's energy demand. The Energy Revolution Scenario is focused on the potential for energy savings and renewable sources, primarily in the electricity and heat generating sectors. Although fuel use in transport is accounted for in the scenarios of future energy supply, no detailed description is given here of technologies, such as bio fuels for vehicles, which offer an alternative to the currently predominant oil.

renewable energy technologies

Renewable energy covers a range of natural sources which are constantly renewed and therefore, unlike fossil fuels and uranium, will never be exhausted. Most of them derive from the effect of the sun and moon on the earth's weather patterns. They also produce none of the harmful emissions and pollution associated with "conventional" fuels. Although hydroelectric power has been used on an industrial scale since the middle of the last century, the serious exploitation of other renewable sources has a more recent history.

solar power (photovoltaics)

There is more than enough solar radiation available all over the world to satisfy a vastly increased demand for solar power systems. The sunlight which reaches the earth's surface is enough to provide 2,850 times as much energy as we can currently use. On a global average, each square metre of land is exposed to enough sunlight to produce 1,700 kWh of power every year.

Photovoltaic (PV) technology involves the generation of electricity from light. The secret to this process is the use of a semi-conductor material which can be adapted to release electrons, the negatively charged particles that form the basis of electricity. The most common semi-conductor material used in photovoltaic cells is silicon. All PV cells have at least two layers of such semi-conductors, one positively charged and one negatively charged. When light shines on the semi-conductor, the electric field across the junction between these two layers causes electricity to flow, is generating DC current. The greater the intensity of the light, the greater the flow of electricity. A photovoltaic system does not therefore need bright sunlight in order to operate, and can generate electricity even on cloudy days. Solar PV is different from a solar thermal collecting system (see below) where the sun's rays are used to generate heat, usually for hot water in a house, swimming pool etc.

types of PV system

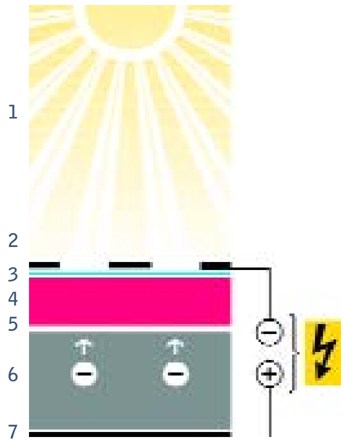
- **grid connected** The most popular type of solar PV system for homes and businesses in the developed world. If connection to the local electricity network can be established through a net metering system, excess power produced to be sold to the utility. Electricity is imported from the network outside daylight hours. An inverter is used to convert the DC power produced by the system to AC power for running normal electrical equipment.

- **grid support** A system can be connected to the local electricity network as well as a back-up battery. Any excess solar electricity produced after the battery has been charged is then sold to the network. This system is ideal for use in areas of unreliable power supply.

- **off-grid** Completely independent of the grid, the system is connected to a battery via a charge controller, which stores the electricity generated and acts as the main power supply. An inverter can be used to provide AC power, enabling the use of normal appliances. Typical off-grid applications are repeater stations for mobile phones or rural electrification. Rural electrification means either small solar home systems (SHS) covering basic electricity needs or solar mini grids, which are larger solar electricity systems providing electricity for several households.

- **hybrid system** A solar system can be combined with another source of power - a biomass generator, a wind turbine or diesel generator - to ensure a consistent supply of electricity. A hybrid system can be grid connected, stand alone or grid support

photovoltaics technology



1. LIGHT (PHOTONS)
2. FRONT CONTACT GRID
3. ANTI-REFLECTION COATING
4. N-TYPE SEMICONDUCTOR
5. BOARDER LAYOUT
6. P-TYPE SEMICONDUCTOR
7. BACK CONTACT

solar thermal collectors

Solar thermal collecting systems are based on a centuries-old principle: the sun heats up water contained in a dark vessel.

solar domestic hot water and space heating

Domestic hot water production is the most common application. Depending on the conditions and the system's configuration, up to almost 100 per cent of the hot water requirements can be provided by solar energy. Larger systems can additionally cover a substantial part of the energy needed for space heating. There are two main types of technology:

- **vacuum tubes:** The absorber inside the vacuum tube absorbs radiation from the sun and heats up the fluid inside. Additional radiation is picked up from the reflector behind the tubes. Whatever the angle of the sun, the round shape of the vacuum tube allows it to reach the absorber. Even on a cloudy day, when the light is coming from many angles at once, the vacuum tube collector can still be effective.
- **flat panel:** This is basically a box with a glass cover which sits on the roof like a skylight. Inside is a series of copper tubes with copper fins attached. The entire structure is coated in a black substance designed to capture the sun's rays. These rays heat up a water and antifreeze mixture which circulates from the collector down to the building's boiler.

solar assisted cooling

Solar chillers use thermal energy to produce cooling and/or dehumidify the air in a similar way to a refrigerator or conventional air-conditioning. This application is well-suited to solar thermal energy, as the demand for cooling is often greatest when there is most sunshine. Solar cooling has been successfully demonstrated and large-scale use can be expected in the future.

flat panel solar technology

image SOUTH ISLAND, NEW ZEALAND.

image SOLON AG PHOTOVOLTAICS FACILITY IN ARNSTEIN, GERMANY OPERATING 1500 HORIZONTAL AND VERTICAL SOLAR 'MOVERS'.

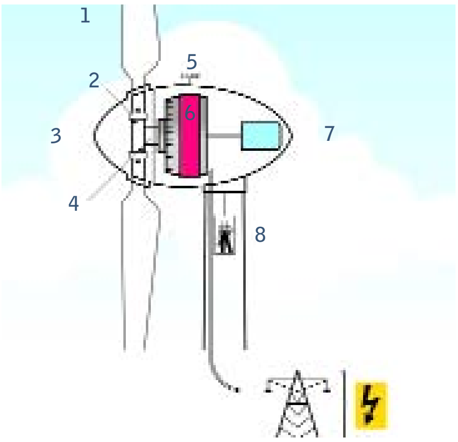
wind power

Over the past 20 years, wind energy has become the world's fastest growing energy source. Today's wind turbines are produced by a sophisticated mass production industry employing a technology that is efficient, cost effective and quick to install. Turbine sizes range from a few kW to over 5000 kW, with the largest turbines reaching more than 100m in height. One large wind turbine can produce enough electricity for about 5000 households. State-of-the-art wind farms today can be as small as a few turbines and as large as several hundred MW.

The global wind resource is enormous, capable of generating more electricity than the world's total power demand. New Zealand has enough wind energy potential to meet its electricity needs three times over, according to EECA. Wind turbines can be operated not just in the windiest coastal areas but also inland. The wind resource out at sea is even more productive than on land, encouraging the installation of offshore wind parks with foundations embedded in the ocean floor. In Denmark, a wind park built in 2002 uses 80 turbines to produce enough electricity for a city with a population of 150,000. The additional costs of offshore wind parks means that wind development in New Zealand is likely to remain onshore in the short term.

Smaller wind turbines can produce power efficiently in areas that otherwise have no access to electricity. This power can be used directly or stored in batteries. A new technology for using the wind's power is being developed for densely populated cities where buildings are virtually stacked on top of one another. This new technology has been dubbed 'urban turbines'.

wind turbine technology



1. ROTOR BLADE
2. BLADE ADJUSTMENT
3. NACELL
4. ROTOR SHAFT
5. WIND MEASUREMENT
6. GENERATOR
7. SYSTEM CONTROL
8. LIFT

wind turbine design

SSignificant consolidation of wind turbine design has taken place since the 1980s. The majority of commercial turbines now operate on a horizontal axis with three evenly spaced blades. These are attached to a rotor from which power is transferred through a gearbox to a generator. The gearbox and generator are contained within a housing called a nacelle. Some turbine designs avoid a gearbox by using direct drive. The electricity output is then channelled down the tower to a transformer and eventually into the local grid.

Wind turbines can operate from a wind speed of three to four metres per second, up to about 25 m/s. Limiting their power at high wind speeds is achieved either by "stall" regulation – reducing the power output – or "pitch" control – changing the angle of the blades so that they no longer offer any resistance to the wind. Pitch control has become the most common method. The blades can also turn at a constant or variable speed, with the latter enabling the turbine to follow more closely the changing wind speed.

Although the existing offshore market is only 0.4 per cent of the world's land-based installed capacity, the latest developments in wind technology are primarily driven by this emerging potential. This means that the focus is on the most effective ways to make very large turbines.

Modern wind technology is available for a range of sites - low and high wind speeds, desert and arctic climates. Turbine size has increased year-on-year - from units of 20-60 kW in California in the 1980s up to the latest multi-MW machines with rotor diameters over 100 m. The average size of turbines installed around the world during 2005 was 1282 kW, whilst the largest machine in operation is the Enercon E112, with a capacity of up to 6MW. This is targeted at the developing offshore market.

This growth in turbine size has been matched by the expansion of both markets and manufacturers. More than 80,000 wind turbines now operate in more than 50 countries around the world. The German market is the largest, but there has also been impressive growth in Spain, Denmark, India and the United States.

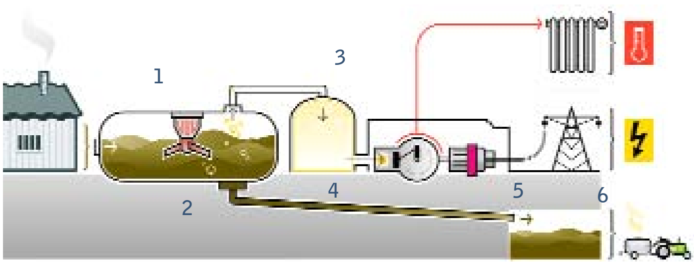
biomass energy

Biomass is a broad term used to describe material of recent biological origin that can be used as a source of energy. This includes wood, crops, algae and other plants, as well as agricultural and forest residues. Biomass can be used for a variety of end uses: heating, electricity generation or as fuel for transportation. The term '"bioenergy" is used for biomass energy systems that produce heat and/or electricity, and "biofuels" for liquid fuels for transport. Biodiesel manufactured from various crops has become increasingly used as vehicle fuel, especially as the cost of oil has risen.

Biological power sources are renewable, easily stored, and, if sustainably harvested, CO_2 neutral. This is because the gas emitted during their transfer into useful energy is balanced by the carbon dioxide absorbed when they were growing plants.

Electricity generating biomass power plants work just like natural gas or coal power stations, except that the fuel must be processed before it can be burned. These power plants are generally not as large as coal power plants because their fuel supply needs to grow as near as possible to the power plant. Heat generation from biomass power plants can result either from utilising the heat produced in a Combined Heat and Power plant (CHP), piping the heat to nearby homes or industry, or through dedicated heating systems. Small heating systems using specially produced pellets made from waste wood, for example, can be used to heat single family homes instead of natural gas or oil.

biomass technology



1. HEATED MIXER
2. CONTAINMENT FOR FERMENTATION
3. BIOGAS STORAGE
4. COMBUSTION ENGINE
5. GENERATOR
6. WASTE CONTAINMENT

biomass technology

A number of processes can be used to convert energy from biomass. These divide into thermal systems, which involve direct combustion of either solids, liquids or a gas via pyrolysis or gasification, and biological systems, which involve decomposition of solid biomass to liquid or gaseous fuels by processes such as anaerobic digestion and fermentation.

thermal systems

- **direct combustion** Direct combustion is the most common way of converting biomass to energy, for heat as well as electricity. Worldwide it accounts for more than 90 per cent of biomass generation. Technologies can be distinguished as either fixed-bed, fluidised-bed or entrained-flow combustion. In fixed-bed combustion, such as a grate furnace, primary air passes through a fixed bed, in which drying, gasification and charcoal combustion takes place. The combustible gases produced are burned after the addition of secondary air, usually in a zone separated from the fuel bed. In fluidised-bed combustion, the primary combustion air is injected from the bottom of the furnace with such high velocity that the material inside the furnace becomes a seething mass of particles and bubbles. Entrained-flow combustion is suitable for fuels available as small particles, such as sawdust or fine shavings, which are pneumatically injected into the furnace.
- **gasification** Biomass fuels are increasingly being used with advanced conversion technologies, such as gasification systems, which offer superior efficiencies compared with conventional power generation. Gasification is a thermo-chemical process in which biomass is heated with little or no oxygen present to produce a low energy gas. The gas can then be used to fuel a gas turbine or a combustion engine to generate electricity. Gasification can also decrease emission levels compared to power production with direct combustion and a steam cycle.
- **pyrolysis** Pyrolysis is a process whereby biomass is exposed to high temperatures in the absence of air, causing the biomass to decompose. The products of pyrolysis always include gas ('biogas'), liquid ('bio-oil') and solid ('char'), with the relative proportions of each depending on the fuel characteristics, the method of pyrolysis and the reaction parameters, such as temperature and pressure.

biological systems

These processes are suitable for very wet biomass materials such as food or agricultural wastes, including slurry.

- **anaerobic digestion** Anaerobic digestion means the breakdown of organic waste by bacteria in an oxygen-free environment. This produces a biogas typically made up of 65 per cent methane and 35 per cent carbon dioxide. Purified biogas can then be used both for heating or electricity generation.
- **fermentation** Fermentation is the process by which plants of high sugar and starch content are broken down with the help of micro-organisms to produce ethanol and methanol. The end product is a combustible biofuel that can be used in vehicles.

New Zealand has the potential to also use tallow from the agricultural sector to create biodiesel. It is estimated that five per cent of our current diesel requirements could come from tallow.

Biomass power station capacities typically range up to 15 MW, but larger plants are possible of up to 400 MW capacity, with part of the fuel input potentially being fossil fuel, for example pulverised coal. The world's largest biomass fuelled power plant is located at Pietarsaari in Finland. Built in 2001, this is an industrial CHP plant producing steam (100 MW_{th}) and electricity (240 MW_e) for the local forest industry and district heat for the nearby town. The boiler is a circulating fluidised bed boiler designed to generate steam from bark, sawdust, wood residues, commercial biofuel and peat.

A 2005 study commissioned by Greenpeace Netherlands concluded that it was technically possible to build and operate a 1000 MW_e biomass-fired power plant using fluidised bed combustion technology and fed with wood residue pellets.[55]

Greenpeace believes that bioenergy is part of the solution to combat climate change. However, bioenergy is not a silver bullet for unsustainable energy usage and must be used in conjunction with other measures, both political and social, to reduce energy consumption and increase energy use efficiency.

Bioenergy sources should be limited only to those grown within the framework of sustainable agriculture, do not directly or indirectly lead to the destruction of intact ecosystems, and do not hinder the ability of any nation to achieve food security and sovereignty.

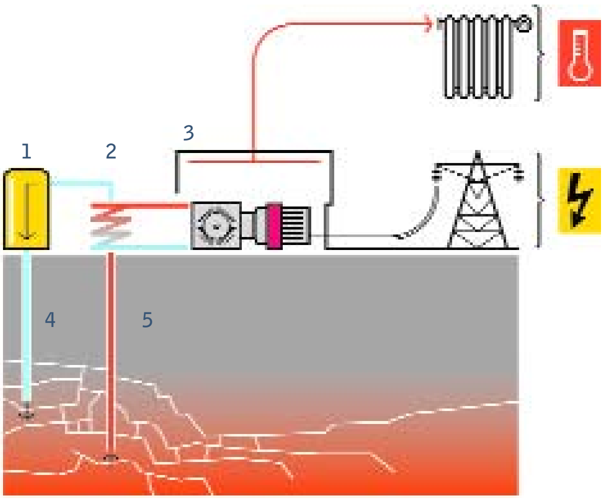
reference
55 "OPPORTUNITIES FOR 1,000 MWE BIOMASS-FIRED POWER PLANT IN THE NETHERLANDS", GREENPEACE NETHERLANDS, MARCH 2005.

geothermal energy

Geothermal energy is heat derived from deep underneath the earth's crust. In most areas, this heat reaches the surface in a very diffuse state. However, due to a variety of geological processes, some areas, including New Zealand, the western part of the USA, west and central eastern Europe, Iceland and Asia are underlain by relatively shallow geothermal resources. These are classified as low temperature (less than 90°C), moderate temperature (90° - 150°C) and high temperature (greater than 150°C). The uses to which these resources can be put are also influenced by temperature. The highest temperature is generally used only for electric power generation. Current global geothermal generation capacity totals approximately 8000 MW. Uses for low and moderate-temperature resources can be divided into two categories: direct use and ground-source heat pumps.

Geothermal power plants use the earth's natural heat to vaporise water or an organic medium. The steam created powers a turbine which produces electricity. In New Zealand and Iceland, this technique has been used extensively for decades. Geothermal heat plants require lower temperatures and the heated water is used directly.

geothermal technology



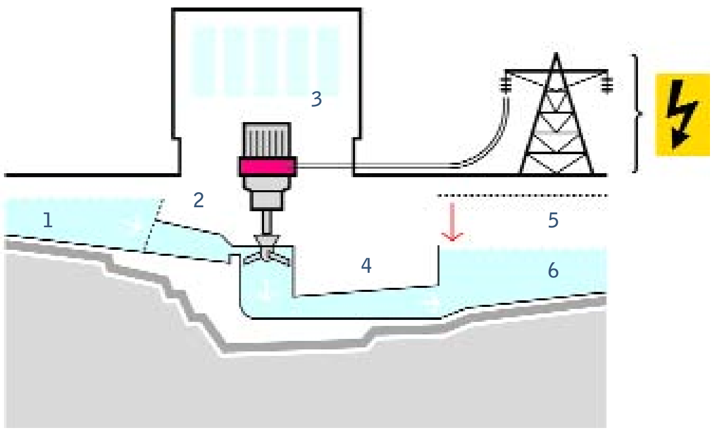
1. PUMP
2. HEAT EXCHANGER
3. GAS TURBINE & GENERATOR
4. DRILLING HOLE FOR COLD WATER INJECTION
5. DRILLING HOLE FOR WARM WATER EXTRACTION

hydro power

Water has been used to produce electricity for about a century. Today, around one-fifth of the world's electricity is produced from hydro power. However, large hydroelectric power plants with concrete dams and extensive collecting lakes often have very negative effects on the environment, requiring the flooding of habitable areas. Smaller run-of-the-river power stations, which are turbines powered by one section of running water in a river, can produce electricity in an environmentally friendly way.

The main requirement for hydro power is to create an artificial head so that water, diverted through an intake channel or pipe into a turbine, discharges back into the river downstream. Small hydro power is mainly run-of-the-river and does not collect significant amounts of stored water, requiring the construction of large dams and reservoirs. There are two broad categories of turbines: impulse turbines (notably the Pelton), in which a jet of water impinges on the runner designed to reverse the direction of the jet and thereby extract momentum from the water. This turbine is suitable for high heads and 'small' discharges. Reaction turbines (notably Francis and Kaplan), run full of water and in effect generate hydrodynamic "lift" forces to propel the runner blades. These turbines are suitable for medium to low heads, and medium to large discharges.

hydro technology



1. INLET
2. SIEVE
3. GENERATOR
4. TURBINE
5. HEAD
6. OUTLET

ocean energy

tidal power

Tidal power can be harnessed by constructing a dam or barrage across an estuary or bay with a tidal range of at least five metres. Gates in the barrage allow the incoming tide to build up in a basin behind it. The gates then close so that when the tide flows out the water can be channelled through turbines to generate electricity. Tidal barrages have been built across estuaries in France, Canada and China, but a mixture of high cost projections, coupled with environmental objections to the effect on estuarial habitats, has limited the technology's further expansion.

wave and tidal stream power

In wave power generation, a structure interacts with the incoming waves, converting this energy to electricity through a hydraulic, mechanical or pneumatic power take-off system. The structure is kept in position by a mooring system, or placed directly on the seabed/seashore. Power is transmitted to the seabed by a flexible submerged electrical cable and to shore by a sub-sea cable.

Wave power converters can be made up from connected groups of smaller generator units of 100 to 500 kW, or several mechanical or hydraulically interconnected modules can supply a single larger turbine-generator unit of two to 20 MW. The large waves needed to make the technology more cost effective are mostly found at great distances from the shore, however, requiring costly sub-sea cables to transmit the power. The converters themselves also take up large amounts of space. Wave power has the advantage of providing a more predictable supply than wind energy and can be located in the ocean without much visual intrusion.

There is no commercially leading technology on wave power conversion at present. Different systems are being developed at sea for prototype testing. These include a 50 kW PowerBuoy floating buoy device installed in Hawaii, a 750 kW Pelamis device, with linked semi-submerged cyclindrical sections, operating in Scotland, a 300 kW underwater tidal current turbine operating in south-west England, a 150 kW seabed-mounted Stingray, also using tidal currents, and a 500 kW coastline wave energy generator operating on the island of Islay, Scotland. Most development work has been carried out in the UK.

image BENMORE HYDRO DAM, NEW ZEALAND.

fossil fuel technologies

The most commonly used fossil fuels for power generation around the world are coal and gas. Oil is still used where other fuels are not readily available, for example islands or remote sites, or where there is an indigenous resource. Together, coal and gas currently account for over half of global electricity supply.

coal combustion technologies

In a conventional coal-fired power station, pulverised or powdered coal is blown into a combustion chamber where it is burnt at high temperature. The hot gases and heat produced converts water flowing through pipes lining the boiler into steam. This drives a steam turbine and generates electricity. More than 90 per cent of global coal-fired capacity uses this system. Coal power stations can vary in capacity from a few hundred megawatts up to several thousand megawatts.

When burnt, coal produces 72 per cent more carbon dioxide (the main driver of climate change) than gas.

A number of so called clean coal methods have been introduced in an attempt to improve the environmental performance of conventional coal combustion. These techniques rely on shifting pollution from one pollution stream to another - they do not remove pollution entirely. These include coal cleaning (to reduce the ash content) and various "bolt-on" or "end-of-pipe" technologies to reduce emissions of particulates, sulphur dioxide and nitrogen oxide, the main pollutants resulting from coal firing apart from carbon dioxide. Flue gas desulphurisation (FGD), for example, most commonly involves "scrubbing" the flue gases using an alkaline sorbent slurry, which is predominantly lime or limestone based.

Mercury is a particular problem. According to the United Nations Environment Programme (UNEP), mercury and its compounds are highly toxic and pose a 'global environmental threat to humans and wildlife'. Coal-fired power and heat production are the largest single source of atmospheric mercury emissions. There are no commercially available technologies to prevent mercury emissions from coal-fired power plants.

The coal industry is investing billions of dollars in experimental ways to burn coal for power, including techniques such as Integrated Gasification Combined Cycle, where the coal is reacted with oxygen and steam to form a "syngas" (of mainly of hydrogen and carbon monoxide) which burned in a gas turbine to generate electricity and produce steam to drive a steam turbine.

image WEST COAST, SOUTH ISLAND.

gas combustion technologies

Natural gas can be used for electricity generation, through the use of either gas turbines or steam turbines.

gas turbine plants use the heat from gases to directly operate the turbine. Turbines fueled by natural gas can start rapidly and are therefore often used to supply energy during periods of peak demand, although at higher cost than base load plants.

Particularly high efficiencies can be achieved through combining gas turbines with a steam turbine in combined cycle mode. In a **combined cycle gas turbine** (CCGT) plant, a gas turbine generator generates electricity and the exhaust gases from the gas turbine are then used to make steam to generate additional electricity. The efficiency of modern CCGT power stations can be more than 50 per cent. Most new gas power plants built since the 1990s have been of this type.

carbon capture and storage technologies

Whenever coal or gas is burned, carbon dioxide (CO_2) is produced. Depending on the type of power plant, a large quantity of the gas will dissipate into the atmosphere and contribute to climate change. A hard-coal power plant discharges roughly 720 grams of carbon dioxide per kilowatt hour; a modern gas-fired plant about 370g CO_2/kWh.

The fossil fuel industry is researching ways to capture and store this greenhouse gas from power stations. Carbon capture and storage techniques are experimental, unproven technology. And emissions would not be completely removed - between 60 and 150g CO_2/kWh - would continue to be emitted.

carbon dioxide storage

Captured CO_2 at the point of incineration would need to be stored somewhere. Options being explored include trapping it in the oceans or under the earth's surface at a depth of more than a kilometre. As with nuclear waste, however, the question is whether this will just displace the problem elsewhere.

dangers of ocean storage

Ocean storage could result in greatly accelerated acidification (reduction of pH) of large areas and would be detrimental to a great many organisms, if not entire ecosystems, in the vicinity of injection sites. CO_2 disposed of in this way is likely to get back into the atmosphere in a relative short time. The oceans are both productive resources and a common natural endowment for this and future generations worthy of safekeeping. Direct disposal of CO_2 to the ocean, sea floor, lakes and other open reservoir structures must be ruled out.

dangers of underground storage

Empty oil and gas fields are also being explored as possible storage sites but they are riddled with holes drilled during their exploration and production phases. These holes would have to be sealed over. Usually, special cement is used, but carbon dioxide is relatively reactive with water and attacks metals or cement, so that even sealed drilling holes present a safety hazard. To many experts the question is not if but when leakages will occur.

Sudden leakage of CO_2 can be fatal. Carbon dioxide is not itself poisonous, and is contained (approx. 0.04 per cent) in the air we breathe. But as concentrations increase it displaces the vital oxygen in the air. Air with concentrations of 7 to 8 per cent CO_2 by volume, causes death by suffocation after 30 to 60 minutes.

There are also health hazards when large amounts of CO_2 are explosively released. Although the gas normally disperses quickly after leaking, it can accumulate in depressions in the landscape or closed buildings, since carbon dioxide is heavier than air.

The dangers from such leaks are known from natural volcanic CO_2 degassing. Gas escaping at the Lake Nyos crater lake in Cameroon, Africa in 1986 killed more than 1700 people. At least 10 people have died in the Lazio region of Italy in the past 20 years as a result of CO_2 being released.

Further, New Zealand is a geologically unstable country which would make any underground storage of CO_2 very challenging and risky.

liability

Under the Kyoto Protocol, New Zealand has binding commitments to reduce emissions. This means that any release of carbon from storage sites raises questions of liability. Who will pay for those emissions? With an international cost on carbon set to rise over the coming decades, this is a risk that will increase over time. In 2006, the New Zealand Climate Change Minister indicated that the Government was likely to pick up at least some of the liability for such leaks, which would be both an enormous and uncosted liability to the Crown, and a further subsidy for fossil fuels.

image NUCLEAR POWER STATION.

carbon storage and climate change targets

Can carbon capture and storage (CCS) contribute to climate change mitigation? In order to avoid dangerous climate change, we need to reduce CO_2 globally by 50 per cent in 2050. However the International Panel on Climate Change says that the environmental and economic issues associated with CCS won't be resolved until the middle of the century to allow wide-scale deployment in the electricity sector. This means they will not make any contribution towards protecting the climate for decades, yet scientists warn we have only 10 years in which to act to avoid very dangerous levels of climate change and to be on track for the 50 per cent global reductions required by the middle of the century. It also puts it outside the timescale of the Kyoto targets.

Nor is CO_2 storage of any great help in attaining the goal of an 80 to 90 per cent reduction by 2050 in OECD countries. If it does become available in 2020, most of the world's new power plants will have just finished being modernised. All that could then be done would be for existing power plants to be retrofitted and CO_2 captured from the waste gas flow. As retrofitting existing power plants is highly expensive, a high carbon price would be needed. The potentially more effective method of removing CO_2 before incineration would have to wait its turn.

Employing CO_2 capture will also increase the price of electricity from fossil fuels. Although the costs of storage depend on a lot of factors, including the technology used for separation, transport and the kind of storage installation, experts from the UN Intergovernmental Panel on Climate Change calculate the additional costs at between 3.5 and 5.0 cents/kWh of power. Since modern wind turbines in good wind locations are already cost competitive with new build coal-fired power plants today, the costs will probably be at the top end. This means the technology would more than double the cost of electricity today.

conclusion

Renewable energy sources are already available. In many cases they are cheaper and without the negative environmental impacts that are associated with fossil fuel exploitation, transport and processing. It is renewable energy, together with energy efficiency and energy conservation, and NOT carbon capture and storage, that has to increase world-wide so that the primary cause of climate change - the burning of fossil fuels like coal, oil and gas - is stopped.

In that light, every dollar spent on carbon capture and storage technology is effectively wasted because it diverts money away from renewable energy and energy efficiency technologies. All research and development should be borne by the coal industry, and should not be at the expense of research and development funding for sustainable energy options of renewable energy and energy efficiency.

nuclear energy technologies

Generating electricity from nuclear power involves transferring the heat produced by a controlled nuclear fission reaction into a conventional steam turbine generator. The nuclear reaction takes place inside a core and is surrounded by a containment vessel of varying design and structure. Heat is removed from the core by a coolant (gas or water), and the reaction is controlled by a moderating element or moderator.

Across the world, over the past two decades, there has been a general slow-down in building new nuclear power stations. This has been caused by a variety of factors: fear of a nuclear accident, following the events at Three Mile Island, Chernobyl and Monju; increased scrutiny of economics; and environmental factors, such as waste management and radioactive discharges.

Nuclear power is not an option for New Zealand. In the 1980s, New Zealand led the world in declaring itself nuclear free, and climate change should not be used as an excuse to change that position. There is still no solution to the nuclear waste threat. Every stage of the nuclear cycle produces radioactive waste which remains dangerous for hundreds of thousands of years. New Zealand does not have the infrastructure or expertise to deal with nuclear energy, and even the smallest commercially viable nuclear reactor is too big to fit into New Zealand's electricity system.

Further, nuclear energy requires large subsidies paid for by the taxpayer and is very expensive, costing at least 20 per cent more (and up to 10 times more per kilowatt hour) than renewable energy or energy efficiency.

Nuclear energy undermines renewable energy and energy efficiency – the real solutions to climate change. It can not contribute to reducing carbon dioxide emissions in the time necessary to avoid dangerous climate change. Nuclear power still emits greenhouse gases, particularly through uranium mining.

Nuclear power is inextricably linked to nuclear weapons proliferation. According to the International Atomic Energy Agency Director Genera, every country that has nuclear power capability is only months away from nuclear weapons capability.

energy efficiency – more with less

Energy efficiency often has multiple positive effects. For example, an efficient clothes washing machine or dishwasher uses less water. Efficiency also usually provides a higher level of comfort. For example, a well-insulated house will feel warmer in the winter, cooler in the summer and be healthier to live in. An efficient refrigerator will make less noise, have no frost inside, no condensation outside and will probably last longer. Efficient lighting will offer you more light where you need it. This is what efficiency is – more with less.

Efficiency has enormous potential. There are very simple steps that householders can take, such as putting additional insulation in the roof, using super-insulating glazing, or buying a high-efficiency washing machine when the old one wears out. All these examples will save both money and energy. But the biggest savings will not be found in such incremental steps. The real gains come from rethinking the whole concept, e.g. the whole house, the whole car, or even the whole transport system. Surprisingly often, this approach can lead to energy needs being cut back four to 10 times current usage.

Take the example of a house: by insulating the whole outer shell (from roof to basement) properly, which requires an additional investment, the demand for heat will be so low that a smaller and cheaper heating system can be used – offsetting the cost of the extra insulation. The result is a house that needs only one-third of the energy of a conventionally built house without being any more expensive to construct. By insulating even further, and installing a high-efficiency ventilation system, heating demand is reduced to one tenth. Thousands of these super-efficient houses have been successfully built in Europe over the past 10 years. This is no dream for the future, but part of everyday life.

electricity

There is a huge potential to save electricity in a relatively short period of time. By simply switching off the standby mode and changing to energy-efficient light bulbs, consumers would save electricity and money in every household. If the majority of households did this, several large power plants could be switched off almost immediately. The following table provides a brief overview of medium-term measures for industry and household appliances:

examples of electricity saving potential

SECTOR	EFFICIENCY MEASURE	ELECTRICITY SAVINGS
Industry	Efficient motor systems	30-40%
	Higher aluminium recycling rate	35-45%
Other sectors	Efficient household appliances	30-80%
	Efficient office appliances	50-75%
	Efficient cooling systems	30-60%
	Efficient lighting	30-50%
	Reduced stand by losses	50-70%
	Reduced electricity use during non-office hours	up to 90%

source ECOFYS 2006, GLOBAL ENERGY DEMAND SCENARIOS

heating

Insulation and thermal design can dramatically reduce heat loss and help stop climate change. Energy demand for heating in existing buildings can be reduced on average by 30 to 50 per cent. Typical weak points through which heat can be lost are window panes and frames and thin walls below windows, where radiators are commonly positioned and insulation should be optimal.

More information on energy efficiency and conservation can be found in the Energy Revolution section.

image HOT-RIVETED STEEL PENSTOCKS AT AN OLD HYDRO-ELECTRIC POWER STATION, LAKE COLERIDGE, CANTERBURY, NEW ZEALAND.

appendix 2: reference scenario

electricity generation

TWh/a

	2003	2010	2020	2030	2040	2050
Power plants	**38.7**	**47.4**	**54.9**	**59.1**	**61.1**	**63.7**
Coal	2.9	8.9	11.3	12	11.4	11.6
Lignite	0	0	0	0	0	0
Gas	9.5	9.4	8.6	10.5	11.5	12.5
Oil	0	0	0	0	0	0
Nuclear	0	0	0	0	0	0
Biomass	0	0	0	0	0	0
Hydro	23.5	25	25.2	25.2	25.5	26
Wind	0.2	1.4	5.2	6.6	7.5	8
PV	0	0	0	0.1	0.2	0.3
Geothermal	2.6	2.7	4.6	4.7	5.0	5.3
Solar thermal power plants	0	0	0	0	0	0
Ocean energy	0	0	0	0	0	0
Combined heat & power production	**2.3**	**2.4**	**2.8**	**3.2**	**3.7**	**3.9**
Coal	0.1	0.4	0.3	0.3	0.3	0.3
Lignite	0	0	0	0	0	0
Gas	1.3	1.4	1.8	2.1	2.5	2.6
Oil	0	0	0	0	0	0
Biomass	0.9	0.6	0.7	0.8	0.9	1
Geothermal	0	0	0	0	0	0
CHP by producer						
Main acitivity producers	0	0	0	0	0	0
Autoproducers	2.3	2.4	2.8	3.2	3.7	3.9
Total generation	**41**	**49.8**	**57.7**	**62.3**	**64.8**	**67.6**
Fossil	13.8	20.1	22	24.9	25.7	26.9
Coal	3	9.3	11.6	12.3	11.7	11.8
Lignite	0	0	0	0	0	0
Gas	10.8	10.8	10.4	12.6	14	15.1
Oil	0	0	0	0	0	0
Nuclear	0	0	0	0	0	0
Renewables	**27.2**	**29.7**	**35.7**	**37.4**	**39.2**	**40.7**
Hydro	23.5	25	25.2	25.2	25.5	26
Wind	0.2	1.4	5.2	6.6	7.5	8
PV	0	0	0	0.1	0.2	0.3
Biomass	0.9	0.6	0.7	0.8	0.9	1
Geothermal	2.6	2.7	4.6	4.7	5	5.3
Solar thermal	0	0	0	0	0	0
Ocean energy	0	0	0	0	0	0
Import	0	0	0	0	0	0
Import RES	0	0	0	0	0	0
Export	0	0	0	0	0	0
Distribution losses	2.3	2.7	3.1	3.4	3.5	3.6
Own consumption electricity	1.6	1.8	2.1	2.3	2.4	2.5
Final energy consumption (electricity)	**37**	**45**	**52**	**57**	**59**	**61**
Fluctuating RES (PV, Wind, Ocean)	0	1	5	7	8	8
Share of fluctuating RES	0.4%	2.8%	9.0%	10.8%	11.9%	12.3%
RES share	**66.3%**	**59.6%**	**61.8%**	**60.0%**	**60.4%**	**60.2%**

installed capacity

GW

	2003	2010	2020	2030	2040	2050
Power plants	**8.7**	**10.4**	**12.1**	**13.6**	**14.2**	**14.9**
Coal	0.5	1.5	1.9	2	1.9	1.9
Lignite	0	0	0	0	0	0
Gas	2.5	2.5	2.5	3.5	3.8	4.2
Oil	0	0	0	0	0	0
Nuclear	0	0	0	0	0	0
Biomass	0	0	0	0	0	0
Hydro	5.2	5.5	5.5	5.5	5.4	5.4
Wind	0	0.4	1.4	1.8	2	2.1
PV	0	0	0	0.1	0.1	0.2
Geothermal	0.5	0.5	0.8	0.9	1	1.1
Solar thermal power plants	0	0	0	0	0	0
Ocean energy	0	0	0	0	0	0
Combined heat & power production	**0.4**	**0.4**	**0.5**	**0.6**	**0.7**	**0.7**
Coal	0	0.1	0.1	0.1	0.1	0.1
Lignite	0	0	0	0	0	0
Gas	0.2	0.2	0.3	0.4	0.5	0.5
Oil	0	0	0	0	0	0
Biomass	0	0.1	0.1	0.1	0.1	0.1
Geothermal	0	0	0	0	0	0
CHP by producer						
Main activity producers	0	0	0	0	0	0
Autoproducers	0.4	0.4	0.5	0.6	0.7	0.7
Total generation≈	**9.2**	**10.8**	**12.6**	**14.2**	**14.9**	**15.6**
Fossil	3.2	4.4	4.7	6	6.3	6.7
Coal	0.5	1.6	2	2.1	2	2
Lignite	0	0	0	0	0	0
Gas	2.7	2.8	2.7	3.9	4.3	4.7
Oil	0	0	0	0	0	0
Nuclear	0	0	0	0	0	0
Renewables	**5.9**	**6.5**	**7.8**	**8.2**	**8.6**	**9**
Hydro	5.2	5.5	5.5	5.4	5.4	5.4
Wind	0	0.4	1.4	1.8	2	2.1
PV	0	0	0	0.1	0.1	0.2
Biomass	0.2	0.1	0.1	0.1	0.1	0.1
Geothermal	0.5	0.5	0.8	0.9	1	1.1
Solar thermal	0	0	0	0	0	0
Ocean energy	0	0	0	0	0	0
Fluctuating RES (PV, Wind, Ocean)	0	0.4	1.4	1.8	2.1	2.3
Share of fluctuating RES	0.5%	3.6%	11.4%	13%	14.2%	14.8%
RES share	**64.5%**	**59.8%**	**62.5%**	**58.1%**	**57.8%**	**57.3%**

primary energy demand

PJ/A

	2003	2010	2020	2030	2040	2050
Total	**658**	**778**	**861**	**905**	**928**	**954**
Fossil	**541**	**647**	**703**	**738**	**751**	**771**
Hard coal	60	119	133	134	123	121
Lignite	0	0	0	0	0	0
Natural gas	209	220	230	250	263	275
Crude oil	272	308	340	354	366	375
Nuclear	**0**	**0**	**0**	**0**	**0**	**0**
Renewables	**117**	**131**	**147**	**167**	**176**	**183**
Hydro	85	90	91	91	92	94
Wind	1	5	19	24	27	29
Solar	0	0	0	1	1	2
Biomass	22	25	30	33	36	37
Geothermal	10	11	19	19	20	22
Ocean Energy	0	0	0	0	0	0
RES share	**17.9%**	**16.8%**	**18.3%**	**18.4%**	**19.0%**	**19.2%**

heat supply

PJ/A

	2003	2010	2020	2030	2040	2050
District heating plants	**1.3**	**1.5**	**1.5**	**1.9**	**2.3**	**2.7**
Fossil fuels	1.2	1.3	1.3	1.6	2	2.2
Biomass	0	0	0	0.1	0.1	0.2
Solar collectors	0	0	0	0	0	0
Geothermal	0.1	0.1	0.2	0.2	0.2	0.3
Heat from CHP	**6.1**	**6.4**	**7.4**	**8.5**	**9.8**	**10.3**
Fossil fuels	3.6	4.8	5.6	6.4	7.2	7.5
Biomass	2.4	1.5	1.7	2	2.4	2.7
Geothermal	0.1	0.1	0.1	0.1	0.1	0.1
Direct heating[1]	**135**	**149**	**164**	**170**	**175**	**181**
Fossil fuels	123	133	144	147	149	153
Biomass	12	15	19	21	23	24
Solar collectors	0	0	0	0	0	1
Geothermal	0	0	0	0	0	0
Total heat supply[1]	**142**	**157**	**173**	**180**	**187**	**194**
Fossil fuels	127	139	151	155	157	163
Biomass	14	17	20	23	25	27
Solar collectors	0	0	0	0	1	1
Geothermal	0	0	0	0	1	1
RES share (including RES electricity)	**10.6%**	**11.4%**	**12.6%**	**13.9%**	**15.1%**	**15.7%**

1) heat from electricity (direct and from electric heat pumps) not included; covered in the model under 'electric appliances'

CO_2 emissions

MILL t/a

	2003	2010	2020	2030	2040	2050
Condensation power plants	**6.27**	**11.20**	**12.23**	**12.67**	**11.82**	**11.51**
Coal	2.67	7.76	9.22	9.17	8.16	7.71
Lignite	0	0	0	0	0	0
Gas	3.58	3.43	3	3.49	3.66	3.8
Oil	0.02	0.02	0.02	0.01	0	0
Combined heat & power production	**0.34**	**0.55**	**0.63**	**0.75**	**0.9**	**0.96**
Coal	0.03	0.18	0.14	0.13	0.14	0.15
Lignite	0	0	0	0	0	0
Gas	0.31	0.36	0.49	0.62	0.76	0.81
Oil	0	0	0	0	0	0
CO_2 emissions electricity & steam generation	**6.61**	**11.75**	**12.86**	**13.42**	**12.72**	**12.47**
Coal	2.70	7.94	9.36	9.3	8.3	7.86
Lignite	0	0	0	0	0	0
Gas	3.89	3.799	3.49	4.11	4.42	4.61
Oil & diesel	0.02	0.02	0.02	0.01	0	0
CO_2 emissions by sector	**32.01**	**40.19**	**44.02**	**45.94**	**46.24**	**47.18**
% of 2000 emissions	100%	126%	138%	143%	144%	147%
Industry	7	7	8	8	8	8
Other sectors	3	3	3	4	4	4
Transport	16	18	20	22	22	23
Electricity & steam generation	6	11	12	13	12	12
District heating	0	0	0	0	0	0
Population (Mill.)	4	4	4.56	4.82	4.99	5.04
CO_2 emissions per capita (t/capita)	**8**	**9.4**	**9.6**	**9.5**	**9.3**	**9.4**

The numbers provided in the table are the data from the model. The estimation for the 2003 CO_2 emissions is 2.7% below the Government's figure for the same year (31.17 Mill t/a). For consistency, we have corrected the figures accordingly and used these to estimate the CO_2 emission reductions.

appendix 2: alternative scenario

electricity generation

TWh/a

	2003	2010	2020	2030	2040	2050
Power plants	**39**	**42**	**45**	**50**	**55**	**60**
Coal	3	3	0	0	0	0
Lignite	0	0	0	0	0	0
Gas	10	8	3	0,1	0	0
Oil	0	0	0	0	0	0
Diesel	0	0	0	0	0	0
Nuclear	0	0	0	0	0	0
Biomass	0	0	1	1.9	1.9	2.1
Hydro	24	25	26.3	27.7	28.8	29.3
Wind	0	1	8.9	11.3	13	14.8
PV	0	0	0	0.1	0.4	0.6
Geothermal	3	4	5.3	5.8	7.1	7.8
Solar thermal power plants	0	0	0	0	0	0
Ocean energy	0	0	0.5	2.8	3.7	5.2
Combined heat & power production	**2**	**2**	**3**	**3**	**4**	**4**
Coal	0	0	0	0	0	0
Lignite	0	0	0	0	0	0
Gas	0	1	1	0	0	0
Oil	0	0	0	0	0	0
Biomass	1	1	2	3	3	3
Geothermal	0	0	0	0	0	1
CHP by producer						
Main acitivity producers	0	0	0	0	0	0
Autoproducers	2	2	3	3	4	4
Total generation	**41**	**44**	**48**	**53**	**59**	**64**
Fossil	14	13	4	0	0	0
Coal	3	3	0.1	0	0	0
Lignite	0	0	0	0	0	0
Gas	11	10	4	0	0	0
Oil	0	0	0	0	0	0
Nuclear	0	0	0	0	0	0
Renewables	**27**	**31**	**44**	**53**	**59**	**64**
Hydro	24	25	26	28	29	29
Wind	0	1	9	11	13	15
PV	0	0	0	0	0	1
Biomass	1	1	3	5	5	5
Geothermal	3	4	5	6	8	8
Solar thermal	0	0	0	0	0	0
Ocean energy	0	0	1	3	4	5
Import	0	0	0	0	0	0
Import RES	0	0	0	0	0	0
Export	0	0	0	0	0	0
Distribution losses	2.3	2.7	3.1	3.4	3.5	3.6
Own consumption electricity	1.6	1.8	2.1	2.3	2.4	2.5
Final energy consumption (electricity)	**37**	**40**	**43**	**47**	**53**	**58**
Fluctuating RES (PV, Wind, Ocean)	0	1	9	14	17	21
Share of fluctuating RES	0.4%	3.2%	19.6%	26.8%	29.1%	32.3%
RES share	**66.3%**	**70.9%**	**92.1%**	**99.7%**	**99.8%**	**99.7%**
'Efficiency' savings (compared to REF.)	**0**	**6**	**10**	**9**	**6**	**4**

installed capacity

GW

	2003	2010	2020	2030	2040	2050
Power plants	**9**	**9**	**10**	**11**	**12**	**14**
Coal	0	1	0	0	0	0
Lignite	0	0	0	0	0	0
Gas	3	2	1	0	0	0
Oil	0	0	0	0	0	0
Nuclear	0	0	0	0	0	0
Biomass	0	0	0	0	0	0
Hydro	5.2	5.5	5.7	5.9	6.1	6.1
Wind	0	0	2	3	3	4
PV	0	0	0	0	0	0
Geothermal	0	1	1	1	1	2
Solar thermal power plants	0	0	0	0	0	0
Ocean energy	0	0	0	1	1	1
Combined heat & power production	**0**	**0**	**0**	**1**	**1**	**1**
Coal	0	0	0	0	0	0
Lignite	0	0	0	0	0	0
Gas	0	0	0	0	0	0
Oil	0	0	0	0	0	0
Biomass	0	0	0	0	0	0
Geothermal	0	0	0	0	0	0
CHP by producer						
Main acitivity producers	0	0	0	0	0	0
Autoproducers	0	0	0	1	1	1
Total Generation	**9**	**10**	**11**	12	**13**	**14**
Fossil	3	3	1	0	0	0
Coal	1	1	0	0	0	0
Lignite	0	0	0	0	0	0
Gas	3	2	1	0	0	0
Oil	0	0	0	0	0	0
Nuclear	0	0	0	0	0	0
Renewables	**6**	**7**	**10**	**12**	**13**	**14**
Hydro	5	6	6	6	6	6
Wind	0	0	2	3	3	4
PV	0	0	0	0	0	0
Biomass	0	0	0	1	1	1
Geothermal	0	1	1	1	1	2
Solar thermal	0	0	0	0	0	0
Ocean energy	0	0	0	1	1	1
Fluctuating RES (PV, Wind, Ocean)	0	0.4	2.5	3.7	4.5	5.4
Share of fluctuating RES	0.5%	4.0%	23.8%	32.0%	34.9%	38.4%
RES share	**64.5%**	**69.3%**	**90.7%**	**99.6%**	**99.8%**	**99.7%**

primary energy demand

PJ/A

	2003	2010	2020	2030	2040	2050
Total	**658**	**715**	**681**	**666**	**657**	**638**
Fossil	**541**	**528**	**407**	**324**	**249**	**171**
Hard coal	60	86	40	27	18	5
Lignite	0	0	0	0	0	0
Natural gas	209	162	120	95	92	91
Crude oil	272	279	247	201	139	76
Nuclear	**0**	**0**	**0**	**0**	**0**	**0**
Renewables	**117**	**187**	**274**	**342**	**408**	**467**
Hydro	85	90	95	100	104	106
Wind	1	5	32	41	47	53
Solar	0	0	2	4	7	8
Biomass	22	64	109	156	202	246
Geothermal	10	28	36	42	49	54
Ocean Energy	0	0	2	10	13	19
'Efficiency' savings (compared to Ref.)	**0**	**63**	**179**	**239**	**270**	**316**
RES share	**17.9%**	**26.2%**	**40.2%**	**51.3%**	**62.1%**	**73.2%**

heat supply

PJ/A

	2003	2010	2020	2030	2040	2050
District heating plants	**1**	**2**	**1**	**1**	**1**	**1**
Fossil fuels	1	1	1	1	1	0
Biomass	0	0	0	0	1	1
Solar collectors	0	0	0	0	0	0
Geothermal	0	0	0	0	0	0
Heat from CHP	**6**	**6**	**7**	**9**	**10**	**11**
Fossil fuels	4	4	2	0	0	1
Biomass	2	3	5	8	9	9
Geothermal	0	0	0	1	1	2
Direct heating[1)]	**135**	**154**	**141**	**127**	**113**	**98**
Fossil fuels	123	103	82	60	40	19
Biomass	12	36	41	45	46	52
Solar collectors	0	0	2	3	5	6
Geothermal	0	14	14	16	18	19
Total heat supply[1)]	**142**	**162**	**150**	**137**	**124**	**110**
Fossil fuels	127	108	85	61	41	20
Biomass	14	39	46	53	56	61
Solar collectors	0	39	2	3	5	6
Geothermal	0	14	15	17	19	20
RES share (including RES electricity)	**10.6%**	**33.4%**	**43.2%**	**55.5%**	**66.7%**	**82.1%**
'Efficiency' savings (compared to Ref.)	**0**	**-5**	**23**	**43**	**63**	**84**

1) heat from electricity (direct and from electric heat pumps) not included; covered in the model under 'electric appliances'

CO_2 emissions

MILL t/a

	2003	2010	2020	2030	2040	2050
Condensation power plants	**6**	**6**	**1**	**0**	**0**	**0**
Coal	3	3	0	0	0	0
Lignite	0	0	0	0	0	0
Gas	4	3	1	0	0	0
Oil	0	0	0	0	0	0
Combined heat & power production	**0**	**0**	**0**	**0**	**0**	**0**
Coal	0	0	0	0	0	0
Lignite	0	0	0	0	0	0
Gas	0	0	0	0	0	0
Oil	0	0	0	0	0	0
CO_2 emissions electricity & steam generation	**7**	**6**	**1**	**0**	**0**	**0**
Coal	3	3	0	0	0	0
Lignite	0	0	0	0	0	0
Gas	4	3	1	0	0	0
Oil & diesel	0	0	0	0	0	0
CO_2 emissions by sector	**32.015**	**32.328**	**23.651**	**17.907**	**12.449**	**6.638**
% of 2000 emissions	100%	101%	73.9%	55.9%	38.9%	20.7%
Industry	7	7	6	4	3	1
Other sectors	3	2	2	1	1	0
Transport	16	17	15	13	9	5
Electricity & steam generation	6	6	1	0	0	0
District heating	0	0	0	0	0	0
Population (Mill.)	4	4	5	5	5	5
CO_2 emissions per capita (t/capita)	**8**	**7.6**	**5.2**	**3.7**	**2.5**	**1.3**
'Efficiency' savings (compared to REF.)	**0**	**8**	**20**	**28**	**34**	**41**

The numbers provided in the table are the data from the model. The estimation for the 2003 CO_2 emissions is 2.7% below the Government's figure for the same year (31.17 Mill t/a). For consistency, we have corrected the figures accordingly and used these to estimate the CO_2 emission reductions.

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