A Framework for a Sustainable Energy Future for New Zealand

This framework is the output from an informal workshop of six SEF members in July 2005. It is offered to SEF and other groups as a starting point for the development of a path toward a sustainable energy future for New Zealand.

This framework is not complete! It is only a start!
We want your input so that it can continue to be improved!
Please send your comments to the SEF Office: office@sef.org.nz

Introduction

Members of the Sustainable Energy Forum, through their email discussion group, have called for the development of a framework to assist SEF in presenting the concepts and actions needed to build a sustainable energy future for New Zealand.

This document is a response to that call. It is based on the outcomes of a workshop by a group of SEF members with long experience and detailed knowledge of energy matters, both in New Zealand and overseas.

This report offers objectives, a brief SWOT type analysis, and suggested actions to improve New Zealand's energy sustainability. In less detail it outlines some barriers to effective action, and foreshadows further work on indicators, modelling to monitor progress towards energy sustainability, and research needs. The framework shows the interrelationships between various measures and actions.

Sustainable energy challenges

New Zealand needs a more secure and sustainable energy sector.

The media are quick to report specific demands to expand energy supply, saying for example that Auckland faces blackouts unless new transmission lines are built; new gas fields must be found to replace Maui; we must develop coal as a reliable and affordable long-term energy option; we need new motorways to cut energy-wasting traffic congestion as oil prices rise, resource management act objections are preventing essential projects from being built.

Less often reported are the equally passionate advocates of sustainable energy, who say that climate change threatens coastal settlements, farm production and biological diversity; new roads increase traffic and vehicles' energy use; it is cheaper to improve energy efficiency than to build new power stations and transmission lines. "Sustainability" is actually "security from a long term perspective".

Controversy, and political and institutional lethargy, have delayed many decisions until almost too late. Now only large-scale projects, especially for electricity, are presumed able to supply enough energy quickly enough to prevent shortages. But quick fixes can create new problems.

The Whirinaki power station was built in a year, to ensure New Zealand wouldn't run out of electricity if the next year was dry. But Whirinaki lies behind a transmission constraint, and some distance from a port although it needs shiploads instead of truckloads of fuel to meet its objective. The site was chosen only because the resource consent was already in place.

A 400 kV transmission line would insure Auckland's electricity supply against the threat of system collapse in the face of high peak demands. But where will the energy come from to generate the predicted 800 GWh/year of demand growth? Liquefied natural gas? Imported or locally mined coal? Even the proposed giant wind farm at Makara could meet only one year's demand growth.

And what does the world think of New Zealand's continuing growth in greenhouse gas emissions? Between1990 and 2003, our carbon dioxide emissions from petrol vehicles rose by 33%, but diesel vehicle emissions rose by a massive 230%. Aircraft emissions rose by 60%, and emissions from electricity generation, by 90%. New Zealand, a developed country bathed in high-quality renewable energy and enjoying a benign climate, will not be seen as playing its proper role in protecting the planet's climate if we simply expand conventional supply to meet demand growth.

Energy solutions that focus on long-term sustainability are not quick fixes. Auckland's demand peaks could be cut significantly if most houses were better insulated and had efficient appliances. But government programmes to date have insulated only a few thousand houses, not the tens or hundreds of thousands required for a sustainable future. Even a switch to compact fluorescent bulbs is slow, due to poor recognition of the national and private benefits that could be gained.

Many moves to improve efficiency of energy use are nominally cost-effective, but simply are not happening. We need to find out why, and commit to removing the barriers. These include prices that do not reflect actual costs – including high domestic fixed charges, and transmission pricing which protects sunk assets but poorly reflects forward costs. Today's consumer information and general education fail to satisfy a widespread desire for a more sustainable energy sector. Further major barriers are the confused institutional arrangements for both regulation and government support of energy investments, and the culture of corporatisation and deregulation which still pervades much of the energy sector.

To enable decisions to support long-term sustainability requires agreement on realistic objectives, and an understanding of New Zealand's strong and weak points. It requires an understanding of how New Zealand's energy is used, as well as how it is produced and transported. The framework below canvasses issues under those headings.

Some factors favour an early transition. Climate change is real and mitigation action is urgent. Industry is increasingly willing to accept some regulation to reduce the pressure for ad-hoc political action. There is increasing recognition that the future will be different from the present. Resources concentrated over geological time or by geographic good fortune will be progressively replaced or augmented by locally sourced energy, often from low-value materials. The portfolio of new energy investments should be as flexible and as technologically modern as can be achieved.

New Zealand needs to carefully prioritise its technology development. The small size of its power system suggests that nuclear power, or even carbon sequestration from coal, are less relevant than (for example) the use of waste heat to dry biomass for efficient combustion, or development of supercapacitors for electric vehicles or other electricity storage systems. The prospect of really efficient and widespread domestic wood burning might argue against an Auckland transmission upgrade – but a breakthrough in electric vehicles might argue instead for a very large HVDC link. It is important to keep options open – yet not to defer decisions until only large-scale projects will serve.

Trying to create a "sustainable energy plan" is, therefore, about as sensible as trying to herd cats. Corner one or two and the rest will scatter. The task is instead to create a framework for describing an environment friendly to sustainable energy, to help the interrelationships of various actions to become self-evident. Competition is a good principle, but only within a framework that enables appropriate coordination.

A framework for considering solutions

The framework below considers objectives and problem statements before listing possible solutions. It considers transport energy before stationary energy, as the former has received less attention in public debate. It addresses demand-side solutions before supply-side ones, so that energy resources will not be committed to serving wasteful uses. And it addresses barriers to apparently cost-effective solutions.

We assume that New Zealand will remain an open and economically efficient trading economy, though responsive to the challenges of peak oil. We assume the world will continue to notice our global environmental performance, whether measured by Kyoto obligations or some other mechanism. We also assume we will maintain strategic oil reserves, as required by the International Energy Agency. National objectives for a sustainable energy strategy will follow – security, and environmental and social acceptability.

To understand the issues that may arise in pursuing those objectives, we begin with a list of good and bad features of New Zealand's society and energy sector. We then look at potential actions, noting areas where further research is needed. We note where short-term actions can give early results, and where long-term results will require early and progressive action. Our emphasis will be on actions that are cost-effective over appropriate time horizons, actions that include replacing energy commodities (electricity, gas, oil etc) by other mechanisms to deliver desired results (video conferencing, passive solar heat etc).

Some of the likely changes needed to today's energy strategies would include:

- Government commitment to action, including regulation and control where appropriate;
- Increased and ongoing collection of data on energy use and supply;
- Research programmes on New Zealand's energy resources and essential energy uses;
- Modelling the results of a range of energy policy constraints and strategies;
- A realisation that the future energy infrastructure will feature distributed energy sources whereas the present energy sources are mostly concentrated.
- Development of skills (human capital) on aspects of energy management;
- Town planning and improved telecommunications to reduce need for fuel-powered travel;
- Refocus transport planning and urban design to reverse the priority of the car over other transport modes
- An early start to a programme for all new buildings to be designed and constructed for inherently low energy use;

Indicators will need to be developed and implemented to monitor progress towards sustainability of energy development and utilisation, and towards the achievement of environmental and social objectives. Appropriate engineering-economic-social models will be needed to support, predict and verify any actual targets that are set. Both these activities are needed to support a sustainable energy strategy, but are not part of this proposed framework.

In presenting a recent report offering a vision of a sustainable energy future, the Parliamentary Commissioner for the Environment highlighted the benefits of a new focus on innovation and the development of human capital.[1] The Commissioner told his audience that electricity development is now at a fork in the road. Large-scale investments in transmission, generation, and fuel supply for generation will be confirmed or rejected within a year. We note that major roading infrastructure investments are equally imminent.

This framework outlines the territory that could be opened up by following the less-travelled paths.

International objectives	From an international energy perspective, the world wants only two things from New Zealand. We must take our share of global action to reduce our greenhouse gas emissions, and we must keep three months' stored oil in case of major supply constraints.
reduce GHG emissions	Reducing GHG emissions has economic value to New Zealand. This value is positive or negative (a benefit or a cost) depending on whether our Kyoto account is in credit or deficit. Value is created through well-verified actions to reduce emissions. This value (carbon credits or similar) is now fully tradable internationally. New Zealand is heading for a deficit in our Kyoto obligations, so the value is negative – it is a cost, or at least a liability to New Zealand.
3 months' oil stored	This requirement is imposed by the IEA (International Energy Agency) on all its member countries. The IEA also requires contingency planning to prepare for the event of oil shocks. Sanctions will be imposed if a major global security event occurs and New Zealand finds itself unable to respond.

National objectives	
Security of energy services:	Indications are that people care about security of energy supply much more than about price. Today security of electricity supply is in the news, but this applies more generally also. In the short term, most people will pay whatever price is required - to keep their cars on the road, to keep the lights on and to provide the necessaries for their jobs, their recreation, and their entertainment. Security is usually perceived as keeping up the supply of particular energy forms, such as oil or electricity. But what we really need to ensure is that the <u>service</u> is maintained - whether the ability to travel to the city or our outdoor recreation, or to keep the house warm and lit, and the electrical gadgets going. In the short term, this means maintaining the delivery of oil and

[1] "Future Currents: Electricity Scenarios for New Zealand 2005-2050". Parliamentary Commissioner for the Environment, July 2005.

	electricity, but in the long term many conventional sources will be run down, so maintaining the relevant services will require different strategies.
…oil	Three month's oil storage will help the world respond to oil market manipulation, or massive breakdown of production, refining or transport systems. But the protection relates to short-term events only. The more important security question nationally is to create a progressive transition towards a sustainable transport sector. Alternative liquid fuels will play a part, but are not the whole answer. In the longer term New Zealand's economic system can only be maintained if our urban form and communications technologies evolve to require less fossil fuels to transport goods and people. Better physical security for cyclists and walkers – including school children – will play a part.
…electricity	Security for electricity has different aspects, depending on the time-scale considered. Overloaded or broken networks will blackout electricity supply in an instant. Transpower's "n-1" security standard for Auckland is already breached on occasions when the Otahuhu B power station is off-line for maintenance. At such times, loss of any further major element of the system is likely to cause a blackout. Security of supply in dry years requires both generating capacity and stored fuel sufficient to meet a hydro deficit – typically running for a month or two at least. Whirinaki was built to provide the capacity, but the difficulty of transporting fuel to the station, and electricity away from it, makes it far from ideal. Electricity security also requires longer-term strategies. We need secure sources of fuel to run our thermal power stations, hence the extensive encouragement by Government of gas exploration. But liquefied natural gas is a questionable fallback strategy in view of rising world gas prices. To be secure against the increasing stringencies of climate change, a progressive transition towards renewable electricity sources will be needed. SEF welcomes input from its members as to what technologies are available to meet electricity shortages – whether instantaneous (transmission or power station failure), medium term (e.g. dry years) or long-term (transition to renewable-only electricity supply.
…heating fuels	Heating fuels can ultimately be replaced by biomass – woody fuels or fuels generated from waste materials. Further research and development is needed to reduce the costs of biomass burners, of handling and transporting woody biomass, of making near-smokeless fuels for household use, and of using lower-quality resources that do not have valuable alternative uses.
…and even many materials	Some materials are energy-intensive – aluminium requires electricity and a source of carbon, cement manufacture uses coal, urea fertiliser is made from natural gas, and plastics and resins today are derived from oil. Security in these cases requires either maintaining the energy required to manufacture

	them, or finding acceptable substitutes. For example, a plant to convert natural gas to urea was New Zealand's first Think Big petrochemical project. Dairying became very dependent on urea, and this (and also the clover weevil) suppressed the clover in pastures. Security is improved by restoring the pasture ecology so that clover again fixes nitrogen, so the farmer does not need to add nitrogen by way of urea. Energy is embodied in buildings, vehicles, power generation plant (nuclear, photovoltaic, hydro, etc) and chemicals (e.g. methanol). How much energy is embodied in each is a continuing and changing controversy – new technologies may be reducing embodied energy in some instances.
Environmental acceptability	
…NIMBY, …NIMTO, …BANANA	"Not In My Back Yard," "Not In My Term of Office", "Build Almost Nothing Anywhere Near Anybody – these local expressions of environmental concern are real and are proving very restrictive to future energy developments. The Waikato transmission lines are dramatic examples of all these, and wind farm development is also at risk. NIMBY concerns include direct health issues such as noise and electromagnetic radiation, and important amenity issues such as visual pollution, most important on urban skylines and in coastal areas protected under the National Coastal Policy of the RMA. The other acronymic "concerns" are rather more cynical but still very real.
…Biodiversity	Biodiversity is most obviously threatened by flooding ecologically valuable areas, also by reducing river flows and thus degrading in-stream values. The potential for New Zealand's wind turbines to affect bird life – especially migratory birds, is uncertain, though very tall turbines may be an advantage. The biggest threat to biodiversity is undoubtedly climate change, which will affect the habitat of many of New Zealand's unique species.
…Pollution	Pollution from vehicles, and from smoke emissions from domestic fires, has clear health effects. More research is needed on whether visible smoke is a good indicator of the health-damaging fine particles (invisible PM 2.5's and visible PM10's). Another example of pollution arising from the <u>use</u> of energy resources is indoor air pollution from unflued LPG heaters. Pollution from energy mining and transport includes leachates from coal mining (a serious concern now on the South Island West Coast?), the risk of spills from oil tankers, trucks and storage facilities, and liquid and vapour emissions from geothermal energy projects.
Social acceptance	
…convenience	Convenience is probably the most important element of social acceptance – after all the main services supplied by energy are those that provide

	convenience in our everyday lives. The convenience of cars obvious. It is reduced by the resulting traffic congestion, but for any single person the private convenience invariably outweighs the public impact. Electric lights, washing machines, home heating, communications and entertainment – these have replaced candles, the copper, open fires, and having to go out to gain contact with the world beyond our four walls. Something of course is lost, but that something, such as the ambience of open fires, can be recreated or replaced in other ways.
...price	Prices of energy commodities are important to social acceptability. In general rising energy prices benefit sustainability, as they reflect real environmental costs and rising costs of acquiring the primary resources. But low income consumers can seldom respond appropriately, so there is a real loss in consumer/ producer welfare, over and above the transfer of wealth from consumers to producers. Major energy users are also more likely to complain about high prices than to invest in equipment to reduce energy bills. Price structures are an important tool for electricity demand management. Retailers assert that domestic customers don't want to bother to respond to changes in cost with time of day or time of year. That may be true at present, but the option to reduce power bills through price responsive demand is not offered to those who would so choose. A major research and development effort is needed to realise its enormous potential to improve the sustainability of the electricity sector.
…fashion	Fashion is a surprising but very real element of social acceptance. SUVs are advertised for their "fun" value, but their extensive use in transporting children from home to school appears also to be based on fashion. Advertising is also widespread in the electricity sector, usually creating a "feel-good" impression rather than specifically promoting sales.

New Zealand position today

To devise a cost-effective strategy, New Zealand needs to recognise and build on its strengths, as well as to understand and correct its weaknesses. Thus it is useful to consider what features of the physical and built environment and the culture are good for sustainability in New Zealand, and what features are bad. Some features – such as our low population - have good and bad aspects.

Strengths	**Weaknesses**
Energy prices are reasonable – not stupidly cheap	Reluctance to deal with problems
Transport fuels are taxed	Panicked ad-hocery in policy, especially

Open NZ economy – open to technology change	electricity security actions
Enthusiastic adopters of new ideas	Infrastructure: inefficient buildings; 2M existing
Relatively wealthy, little real poverty	cars based on petrol/diesel
Well educated population	Governance: conflicting structures and capture …leading to ineffective, excessive expenditure
Generous and diverse resource base	
Produce our own food	Ignorant policy advice
No transport or inefficient manufacturing industries to protect	Capture by vested interests
	Lack of data
No nuclear or huge energy supply industries to protect	No need to do things well – can get by (this is true both physically and culturally)
Temperate climate	
Agriculture not highly susceptible to climate change	Perverse incentives for SOEs, other energy suppliers
Democratic system	
Parliamentary Commission for the Environment creates some accountability	Lost coordination of electricity supply
	Myopia
Things that have good and bad aspects	Must import liquid fuels
State ownership	Lack of contestability of: policy advice funding debate within and outside state sector
Low population	
Energy market systems	
Remaining known gas and oil fields are small (good because development unlikely to foster wasteful Think Big projects)	Dominance of process over purpose – fixation on process.
	RMA stalls good as well as ill-conceived schemes
Remaining coal reserves are large	
	Economy highly dependent on overseas trade and imported components

Suggested actions to support a sustainable energy strategy

New Zealand could survive on a 100% renewable energy system. However a too-rapid transition to 100% renewables would be unnecessarily costly to the economy, thus reducing the financial resources available to promote long-term solutions. For example, building infrastructure for highly efficient use of natural gas could promote a transition to the use of biogas. The focus in these suggested actions is a rational transition towards the final objective.

Assuming New Zealand continues to import oil, our economy must continue to be efficient to pay for it. If reducing use of imported oil is very costly to the economy, but imported oil prices continue to rise, there will be a progressive crossover toward substitution by domestic alternatives-a research task is to find the prospective pattern of that change.

New Zealand, with its open economy, can make good use of tradable carbon credits and clean development mechanisms, which capture international value from such development. The Kyoto Protocol invites analysis of the most cost-effective way that any country can reduce net emissions.

Finding cost-effective solutions requires an understanding of demand before discussing supply options. The transport sector can be treated separately from the stationary sector (buildings and industry), because the former relies almost entirely on liquid fuels, while the latter is based very largely on electricity, gas and solid fuels. Obvious crossovers include electric and hydrogen cars, and oil-fired power generation. Although these effects are minor at present, the dependence of the transport system on electricity is likely to rise. The effects of this need further investigation and modelling.

Problems in each sector are discussed, followed by potential actions. Areas are noted where data are scarce or other research is needed. We distinguish actions designed to yield short-term, medium-term and long-term outcomes. All types of action need to be begun or planned early, though some will take a long time to yield results – especially changes in urban form.

Some actions are national in scope, such as standards and labelling schemes for vehicles. Some are international, such as efficient light sources and universal power supplies. Others are or may be regional – some building standards will depend on climate differences between regions. Others are local, such as planning for cycling and walking routes within a city or town. Coordinating such actions can be valuable and reduce research and planning costs – but this is seldom easy.

Public policy needs to address ways to influence decisions by both consumers and suppliers. The former requires investment in human as well as financial capital, so that people are both willing and able to improve the way they use energy, and can understand the improved environmental outcomes. The latter requires improved incentives to align commercial goals with public-interest goals. Under today's electricity pricing and regulation, company profits rise when energy sales increase. And retail prices do not reflect impending shortages which actually create price spikes which further increase profits.

Actions proposed below need to be evaluated in terms of financial, environmental and social benefits, costs and risks.

Transport problems	Major problems in maintaining New Zealand's transport services include:
…Peak Oil	The global rate of drawdown of oil fields outweighs the discovery rate of recoverable reserves. Note that for gas, the decline of Maui is a local case of "peak gas", and both electricity prices and methanol production have been affected.
…Infrastructure	Oil refineries globally are operating close to capacity; oil tankers also. Infrastructure in NZ also includes the vehicles – the mean age of the passenger car fleet is around 11 years.
…Geopolitical issues	Middle East, Africa, and other oil-producing areas each have issues relating to military support, terrorism, corruption, and other issues;

…Future demand in developing countries	China and India, among other countries, are building massive highways in advance of expected demand from their rising middle classes. They will be serious competitors in a global oil market.
…Inelastic market	In New Zealand, demand for transport fuels is quite insensitive to price. In the short term people just pay, whatever the price.
…Data on transport end-use almost non-existent	Sustainability strategies are best based on a real understanding of the sector. The social dimension of transport will become evident by studying origin-destination surveys (if they exist) of transport planners. Ministry of Transport may have some data, regional and possibly city councils will also have data. Little if anything substantial has been published.
…emissions	Transport fuels give rise to very significant greenhouse, particulate, and other combustion pollutants.
…Unsustainable agendas of lobbyists	Much of the transport "debate" is fuelled by lobbying from sector interest groups such as the trucking lobby. Pressure for motorway expansion comes partly from real estate interests promoting the extension of suburbia, while passenger rail development is promoted by the owners of central city buildings. AA has now become somewhat more reasonable (?).
Actions for transport:	
Short term	
…fuel efficiency standards, MEPS, labelling schemes	There is a question whether NZ should develop its own standards, or use Japanese standards, since a very high proportion of our vehicles are Japanese. Modifying Japanese standards in a consistent way may be a useful approach. Labelling schemes may be a more acceptable "soft" alternative to mandatory standards in vehicle imports, but would have correspondingly "softer" outcomes.
…Hybrid vehicles	Some complex fuel-electric hybrid passenger vehicles are highly efficient in stop-start driving, but simpler hybrids are more cost-effective on the open road. How can they best be targeted to their best uses?
…Fuel taxes	Taxing fuel would be much more effective than taxing carbon emissions to achieve an objective of security against peak oil economic impacts. But fuel taxes are highly regressive, and their effectiveness means that transport businesses will seek exemptions. What is the best role for this?
…Encourage public transport	This policy has multiple objectives – reduce GHG emissions, reduce dependence on oil, reduce traffic congestion, provide access for people who cannot drive – children and the elderly. However fuel efficiency outcomes will not be simple where large buses are nearly empty, or

	"sorry not in service". An important research task is to find the fuel efficiency of alternative forms of public transport in specific districts. Shuttle services, collective taxis, company-run carpool schemes, internet-based carpooling, etc. may lead to the greatest fuel savings in many cases.
…Intelligent transport information	Some Auckland bus stops now tell you when your next bus is due. Putting such information on the internet would be a useful next step – presumably at lower cost. Just one idea would be a text-phone system – you text an abbreviated version of the query, "when does the next "81" bus reach Lambton Railway bus stop heading towards Eastbourne?", and get an automatic text reply.
…Address safety issues	Cycling and walking is suppressed at present by paranoia about physical safety – at times also because of pollution. Safety is an issue that must be addressed in the short term – walking school buses for example
Medium term	
…Cycling and walking	Cycling and walking for transport deserve a high priority in district and regional plans. Services such as bikes on buses and trains, or secure bicycle parking, are also relevant.
…Rail passenger and freight	Increased use of rail systems should be investigated. Rail freight is more efficient than road freight when the high tare weight of rail wagons is offset by high loading levels. Tare weight is much more significant with New Zealand's narrow-gauge rail than overseas. Light rail requires high passenger density, most likely to be found in Wellington's geographically constraint transport corridors. Electrification is attractive especially where load factors are high.
…biomass transport fuels	Revisit the potential for growing transport fuels, and also for deriving fuels from low-value products such as below-food-grade tallow, waste fish&chips oil etc.
…Electric vehicles	Improvements in batteries, or even supercapacitor storage, appear likely to make electric cars more economic soon. Niche opportunities for electric trolley and light rail transport are far more likely than widespread markets for fuel cell or hydrogen powered vehicles.
…CNG	As a bulk transport fuel, there may not be enough gas for widespread use of CNG; however in niche uses such as city council and other fleet vehicles this may add security in case of oil shortages. Conversion of relevant fleet vehicles to biogas is a possibility.
…social marketing campaigns	Over the medium to long term, social marketing campaigns against the wasteful use of fossil fuels can have a significant effect, judging from the experience of campaigns against drink-driving.

Long term	Reduce need for travel by, for example, making broadband easier and cheaper thus making it more practical for more people to work from home and to have video-conferencing instead of travelling to meetings Plan now for sustainable cities. Plan for rail travel and coastal shipping of heavy bulk commodities. Develop wind-assisted shipping.
Stationary Energy, general	
problems: …supply	The problems most commonly portrayed include security of supply of electricity, and a shortage of primary energy for electricity generation. Industrial and domestic users alike make much of recent increases in electricity and other fuel prices.
...decision making	A logjam in decision-making in the electricity sector has attracted much analysis, lobbying and media exposure. Much less reported is the clear bias in subsidies, electricity market rules, and political support in favour of large-scale development, against which many small-scale supply and efficiency projects can compete poorly if at all.
…ignorance, need for culture change	Even less recognised is the widespread ignorance of the potential for reducing energy bills and environmental impacts, and the culture change that will be needed to reverse that ignorance.
The House	Improving energy efficiency is much more cost-effective in new houses than in the retrofit programmes that are characteristic today. If we want to make a difference by the end of the century, we must start now.
…MEPS	Today’s new houses are not energy efficient; many houses are built on spec to cheapest first cost. Minimum Energy Performance Standards need to be improved so that houses built today will not be a block to a sustainable energy future. Standards, rather than being prescriptive, should specify required overall performance, acceptable solutions, and means of verification. Standards for appliances should be based on performance not technology; for example wood and coal stoves should not emit visible smoke. An energy consumption standard for the whole house would drive improved appliances. An effective enforcement regime is required to prevent abuses.
…HERS	A Home Energy Rating Scheme is important but not an easy matter. Home energy audits can have immediate benefits if sensitive to consumer’s actual situation, for example suggesting replacement of

	fridge and oven seals if the consumer can't afford new appliances.
…Building code	Today's building code has counterproductive aspects - prohibiting vapour barriers in walls, requiring insulation in floors to have so much ventilation they don't insulate effectively. Standards should prevent downlights from transferring heat from living areas into ceiling spaces. In general, building codes should maintain the good things we have, but increase the level of efficiency required.
…Bylaws	Some Councils have, or are considering, solar access bylaws; these are important to properly develop the potential of passive solar heat. Bylaws will differ regionally according to climate and other local issues – double glazing, permitted solid fuel appliances, etc. Residential High-Rise and retirement villages/ rest homes are an increasingly important sector. Consider requiring those in proximity to natural gas supply to connect with it (or explain why not).
…Retrofits	At present retrofit programmes are as poorly open to consumer choice as electricity supply. Consumers who wish to reduce power bills or reduce their environmental footprint have little independent information to support choices. Retrofit "schemes" are funded for objectives poorly related to individual consumer needs. Originally Government required a minimum Government input for each "kilowatt-hour saved"; now health benefits are accepted as a valid objective. But still only a small set of "technologies" is offered.
…Housepower and interval metering	A "Housepower" scheme would be governed by consumers for consumers; it would offer audits, appropriate retrofits, access to new electricity tariffs that reward price-responsive demand, and general advice appropriate to the cultural milieu of the consumer herself. The necessary interval metering could be synergistic with active management of distribution networks to reduce losses and accommodate intermittent renewables; trials of this are already underway.
…Water heating	Rather than require specific technology e.g. solar or heat pump, new houses should be subject to a performance standard – probably specifying a maximum energy consumption per house volume or area. Present support mechanisms distort the market severely – often subsidising finance companies not consumers. Support for replacing failed HWC's or fridges with efficient models may be justified especially for low income consumers
…Lighting	Lighting is an increasing part of household demand. Conventional downlights not only provide poor quality light resulting in high energy density lighting but also puncture the thermal envelope thus driving fuel use over and above their own requirements.
…Fuel poverty	Is a real issue but should not stand in way of energy price rises that reflect real costs. Subsidised household retrofits meet public as well as

	immediate consumer needs, as they are long-term solutions. The curtain bank in Christchurch is popular and effective. The energy market recognises that modest energy demand can be satisfied cheaply with the cost increasing as demand rises, but that is not reflected in consumer pricing where it may be fairer to charge a lower rate to consumers whose overall demand is equivalent to that provided by the lowest cost sources.
Commercial buildings	These are mainly built on spec. to very poor efficiency standards. A rating scheme would be useful – LEEP (Low Energy, Efficient Performance). Building management systems can give much improved performance.
…Schools	Schools are generally built to particularly poor energy efficiency standards. Both retrofits and Energy Action schemes within the curriculum can improve efficiency and raise awareness at the same time.
…Government Buildings	Government buildings could provide a market for many newer technologies such as solar water heat and pellet heaters.
Industry	Negotiated Greenhouse Agreements are improving.. Nevertheless these act to undercut the philosophy, effectiveness and equity of carbon taxes.
…Motors	Much of industrial energy goes into motors; improved enforcement of the present MEPS for motors and an extension of the range covered would eliminate some of the poor quality stock being purchased now. The whole motor-drive system needs to be tackled, not just the motors alone. Production and process engineers with a practical appreciation of energy management need to be trained.
…Electricity and fuel prices	Industrial demand is not generally very sensitive to price except for the largest users per dollar of product.
…Heating fuels	Much of the energy use in industry is for heat. Increased efficiency of boilers, and of systems of heat delivery (such as fixing leaking steam pipes) are needed. Use of waste materials for heat is now widespread but there is still room for improvement.
…Cogeneration	This is very widespread today – but poorly documented as to how much electricity and heat are produced. Electricity market rules for pricing connection and selling output have suppressed cogeneration in the past – what is the current state?
…SME incentives	Small and Medium Enterprises collectively use a lot of energy, but NGAs are offered to big, not small, enterprises. Energy efficiency initiatives have begun, but need much more development.
Regional economies	Much of the opportunity for industrial energy efficiency will come from integrating waste and water management with other business enterprise.

	Some of this will be within the water and waste management activities of regional government. Micro-hydro schemes are but one example. Regional energy planning would be of great benefit in recognising such opportunities.

Energy Supply

Today most effort, both publicly and privately funded, is being invested in large-scale development of energy resources. However a very large quantity and variety of energy resources can be found close to consumer premises. These are seldom developed because of lack of knowledge and understanding, lack of financial resources, and lack of vision.

As long as most development is undertaken by the major energy companies, it is the large-scale projects that will be pursued. These tap the environmental capital found in locations where natural features or geology have concentrated energy resources and made them accessible on a large scale. These natural features almost always have other ecological and/ or recreational and amenity values. In contrast, development of small-scale resources simply requires too much detailed local knowledge to be attractive to major energy companies.

A paradigm shift will be required to make effective use of the very large quantity and variety of distributed resources available. The basis for this shift needs to be a focus on developing this knowledge and understanding – on developing New Zealand's human capital - so that the fine detail in energy resource availability, generally amongst already-developed land or in productive industry, can be developed.

Energy networks: transport	Transport networks include all roads, from unsealed rural roads up to motorways, and also parking lots and parking buildings. These are major drivers of investment in road vehicles – or the public transport systems, walkways and cycleways that offer alternative services. The rail network, the port facilities and lighthouses that enable safe shipping services, and the extensive airport and air traffic management systems, round out New Zealand's very extensive infrastructure for transport. Inevitably decisions to upgrade any of these network elements create "winners and losers" and so are intensely controversial. Issues include traffic congestion, the weight and number of trucks on the roads creating pressure for further costly upgrades. One major influence on this debate is the realisation that oil price rises will not go away; therefore energy efficiency of transport services – very poorly understood today – needs careful revisiting using up to date information.
Energy networks: Stationary	Gas and electricity networks receive little attention until breakage or overcapacity reminds us that without them, energy commodities cannot reach the consumer. In New Zealand, almost half the retail cost of

	electricity supply to most consumers is attributable to capital and maintenance costs and losses on the transmission and distribution network. Almost all blackouts come from network failures.
Gas	Gas pipelines are a vital link in New Zealand's energy system. Though generally less subject to failure than electricity networks, they are more vulnerable to market power. This allows gas prices to rise higher than is efficient economically, which in turn may influence the choice of fuel for, or location of, new power stations.
Electricity transmission	Transmission lines are unique amongst electricity supply assets in their massive "economies of scale". The 400 kV "giant pylons" if built will be used for at least 40-60 years, and will be a major factor in deciding where new large power stations are built – and whether energy efficiency and distributed generation investments will make a good return.
…alternative to giant pylons	Alternatives to the 400 kV lines have been extensively debated recently. Undergrounding is very, very expensive – typically around 10 times the cost of overhead lines at lower voltages and more at high voltages. Direct current lines can carry much more current with lower losses, but conversion back to alternating current requires equipment costing around $500 million. The Hutt Valley (Haywards) conversion plant is planned to be replaced around 2010, and could in theory be rebuilt at Otahuhu. That would require new pylons between Hutt and Otahuhu – crossing a multitude of properties, though less intrusive. Transpower's original plans were to upgrade lines on the existing pylons to 330 kV. Delays in implementing this mean that the lines are now so loaded that none can be taken out of service for upgrading. If the Whirinaki gas turbine were moved to Auckand (not difficult), or Marsden B run as designed to be a backup plant using residual oil instead of being converted to coal, the 330 kV upgrade would be possible. But electricity suppliers argue strongly for the 400 kV upgrade to enable expanding electricity demand to be met.
…transmission planning drives other decisions	Transmission planning drives power planning, however strongly the electricity industry may deny it. For that reason, a majority of the consultation papers released by the Electricity Commission relate to transmission decision-making and pricing. Every single decision creates winners and losers; all market participants invest time and money defending their patches.
…"transmission alternatives"	"Transmission alternatives" include generators on the far side of bottlenecks (such as Otahuhu), and also investments to reduce electricity demand especially at peak times. Peak loads occur in winter, even in Auckland, so reducing electric space heating, and lighting loads are important alternatives.
…poor consultation	No small-scale energy service providers have been involved in the

	transmission debates; not surprisingly they consider that they are losers, every time. Any submissions on the various consultation documents they have made have made barely, or no, influence on the Commission's decisions.
Electricity distribution	
…Active management of the networks	Development of new technologies and management systems – called "active management of distribution grids" - could mitigate most of the problems of accommodating intermittent renewable energy sources. This would allow some types of appliances to switch on or off for the time required for more conventional generation to respond.
…Reduction of network losses	Active management of grids can also identify where losses are occurring, and could well pay for themselves by reducing losses. At present local network companies have no incentive to do so as they do not pay for the lost electricity. Losses are still usually quoted as around 6% for transmission and 6% for distribution networks. These are certainly under-estimates, as lines are being run harder and hotter, creating big losses.
…Large standby generators	Use of diesel (or even petrol) generators can have positive or negative implications in a transition to a more sustainable energy system. The most beneficial use is that of relatively large containerised generators that can be transported to a particular site in case of a network failure, thus reducing the duration of outages. Total use of diesel is small, and benefits to security of supply are large.
…peak-lopping generators	Generators can also be used to supplement conventional supply when demand is high and line voltage drops. This can defer network upgrades which were desirable to reduce overall losses. The desirability or otherwise of local generation for peak-lopping can only be determined from the specifics of each case.
…consumer-owned generators	Consumer-owned generators are reasonably widespread and probably increasing – as a response to network failures. They are often small, noisy and polluting. Performance standards for small standby generators would reduce the environmental impacts; but their use is seldom desirable.
Primary energy. Renewable	
Hydro **…micro & small**	The least controversy will be seen in micro-hydro developments on existing or new structures, such as drop-structures (which absorb energy in existing hydro and irrigation schemes), and through use of low-head turbines within rivers that do not significantly interfere with in-stream values. The total resource available may be relatively small, in comparison to conventional hydro. But the regional significance of micro-hydro could be high. For example, drop structures on irrigation schemes could generate up to 50 MW when most needed to support irrigation machinery.

…large scale	The total resource potential of undeveloped conventional hydro, such as Upper and Lower Clutha and the lower Waitaki, is large. But in the present environment of public controversy, any large-scale proposals on our remaining rivers are likely to fail - unless legal procedures reminiscent of the National Development Act of the 1980s are put in place. Also the costs of overcoming engineering problems such as those that helped to stymie Project Aqua are likely to raise large-hydro costs above those of many other alternatives for electricity generation.
Wind	The resource available in New Zealand for wind generation is extremely large. The total quantity of wind generation installed will depend more on amenity considerations and the issue of integrating the intermittent generation into the national grid, than on resource quantity. Dynamic, automatic demand response could be developed to absorb variations – but a lack of night-time load is increasingly discussed overseas. This would seem to create a remarkable opportunity for plug-in electric cars, which now use only about 3 kWh for a day's driving of 30 km.
…dispersed location reduces "correlation" problem	Most of the amenity issues, and much of the integration issue, would probably be mitigated if wind turbines were developed at the initiative of land-owners – especially on farms remote from urban areas or popular recreational localities. The potential for both economic development and security of supply may be particularly attractive for Maori communities north of Auckland. A widespread location of turbines would greatly reduce the potential problem in the Manawatu where already around 100 MW of generation is "correlated" and may vary between low and full production within 5 to 15 minutes.
…integration with the grid	Turbine designs that are mechanically rather than electronically synchronised with the power system are better able to ride-through faults, and in fact provide spinning reserve and other useful "ancillary services", in contrast to many of the existing wind turbines which require extra ancillary services to cover them. Performance standards and interconnection requirements for wind turbines are becoming common overseas.
Geothermal	Geothermal energy is so site-specific that little can be said other than that the resource is potentially large. At present it is most cost-effective to convert around 15% of the potentially available energy into electricity – this depends on the temperature of the geothermal fluid. Therefore very large amounts of low-grade heat remain unused.
…use of waste geothermal heat	One potential use for this is for drying wood residues (especially where geothermal energy is used in wood processing). This could significantly reduce the cost of manufacture of wood pellets or firelogs, the latter being particularly easy to transport and store for use in domestic heating, where the low moisture content can greatly reduce smoke emissions.

…geothermal as dry year reserve	Another way of adding value to geothermal fields that have been run down and are becoming less economic is to simply "mothball" them to let the geothermal heat build up again. They could then be run in dry years to enable the hydro resource to be conserved – when spot prices are high and the cost of re-opening the geothermal system can be justified.
Bioenergy:	Bioenergy resources include wood processing residues, now widely but not completely utilised by the industries themselves. These are being increasingly augmented by residues from forest landings, which could become more economic by adapting forest harvesting practices. More costly are short-rotation crops grown for fuel – but value can often be added by the crop taking up nutrients from sewage or dairy wastes, or by capturing high-value components such as eucalypt oils. Use of landfill gas for power generation is well developed; further advances may be possible in use of the associated waste heat. Ethanol and biodiesel can be made in small quantities from food processing wastes. More extensive renewable transport fuels will require substantial development, with careful analysis of net energy outputs and the effects of competing land uses.
Marine:	Marine energy has very large potential for New Zealand, and technology is developing rapidly. Both wave energy and tidal currents may become important distributed resources in the long and perhaps medium term. Scotland is a major source of research and development, with energy potentials similar to NZ.
Defining the role of fossil fuels	To create an affordable transition to a truly sustainable energy future, the best use of fossil fuels – even coal – needs to be described and debated.
…recycle profits	One principle could be that renewable energy should set the marginal cost of new energy supply, while intramarginal rents should be devoted to investment in the transition to sustainable energy development.
…need to mitigate effects of price rises	This would be certain to cause hardship to people on low incomes with little financial ability to either pay the higher prices or invest in means to reduce their energy bills. That link gives some justification to "subsidise" energy retrofits for low income consumers.
…but recognise that "bads" from fossil fuels are unpriced.	However a stronger case again is that the public benefit of reducing energy waste far exceeds the private benefit, and this will inevitably continue as long as the environmental "bads" of the supply and consumption of fossil fuels are unpriced.

Where to Next? What is Missing?

Barriers, indicators and monitoring path to sustainability, research needs.

This paper does not address these issues, which are in the nature of implementation rather than broad strategy. We recommend that a focussed workshop of sustainable energy people be held to address these specific issues.

For an example of work to come, a brief outline of barriers is given below. Barriers are discussed widely in the overseas literature, but are unique to each country, and are also unique for different ownership and regulatory regimes within countries.

Consumers have very little access to information that allows them to choose sustainable energy options appropriate to their specific needs. On the supply side there is far too much information – but of the wrong sort. Consultation documents on electricity have given rise to a new industry of analysis and commentary from the perspective of particular industry players.

Current official indicators do little to monitor New Zealand's progress toward a sustainable energy future. Publicly funded energy and emissions forecasting often carry assumptions that reflect business-as-usual policy choices.

Most research issues are also unique to New Zealand; they include

- investigation of demand patterns for transport and stationary energy,
- technology to monitor electricity networks to detect losses and incipient breakdowns,
- automatic response of household and other non-vital appliances to accommodate intermittent renewable energy supply,
- specific primary renewable technologies including geothermal and biomass conversion
- design of regulatory and pricing systems to level the playing field between small-scale energy supply/ services and large monopoly or oligopoly suppliers of energy commodities.

Where research issues are not unique to New Zealand, it will generally be preferable to monitor developments overseas and identify those of relevance. In some cases, a moderate amount of involvement will help to ensure a development is appropriate for New Zealand. In a similar vein, active participation by individuals from New Zealand in the development of common international energy efficiency standards is producing sets of requirements that are suitable for New Zealand conditions.

Barriers to better energy efficiency and supply

Consumer information	Information on home energy efficiency comes mainly from the electricity retailer-generators, whose incentive is to promote the efficient use of electricity rather than an appropriate balance between electricity, alternative fuels and conservation techniques. The availability of independent domestic sector energy efficiency information is extremely limited. Information on vehicle fuel efficiency is sporadic, and noted only by enthusiasts in the face of fashion promoted by advertising.

Information on energy supply and service opportunities	Arguably the most helpful information on sustainable energy resources would be gathered at the regional level. An agreed format would help such information to be aggregated for use nationally. Regional energy information could include assessment of the developed and potential primary resources, the opportunities for significant energy savings in buildings, industry, water supply and waste management etc. It should also include constraints in electricity transmission and conveyance of other energy commodities. Another whole section would be on regional transport data. A number of regional energy strategies, including that of Environment Canterbury, remark that information once available is now withheld for reasons of commercial secrecy, so that the whole exercise is becoming of dubious value
Pricing	Energy prices need to reflect costs much more closely. This would require much more use of meters that record every half hour. Research on consumer preferences, pilot trials and social marketing will be needed before advanced metering and tariffs are accepted. Any change in pricing creates a transfer of wealth, leading to much lobbying from interested parties. High electricity prices have become a serious problem for some low-income householders, and high oil prices are of increasing concern over the whole economy.
Split incentives	In home energy efficiency retrofits, the consumer gets benefit, but the landlord is unwilling to pay for the retrofit. More importantly, the public benefits of energy efficiency far outweigh the private benefits, once unpriced environmental effects are taken into account.
Perverse incentives	More sales and higher prices both mean more profits to the suppliers. Discussion of this effect is widespread in the U.S. and Europe, and many suggestions are made of regulatory mechanisms that are less perverse than the price caps used in New Zealand. Perversity extends to shortages, both of oil and electricity, which drive prices up dramatically, adding to company profits.
Crowd-out	Big projects reduce the need for the energy that small projects could provide.
Transaction costs	Much concern is expressed by major project proponents, especially about RMA procedures and the costs of interacting with the Electricity Commission. But such costs are far worse for small-scale energy service providers.
Institutional confusion	This is one of the most important barriers for energy efficiency. There are multiple regulatory and incentive systems. The Electricity Commission, Commerce Commission, MED, and EECA all have roles in regulation and/ or implementation of energy efficiency that are not clearly delineated.

Organisational inertia	The large energy supply companies have a strong interest in maintaining the system that they know – understandably so in view of the several enormous changes since corporatisation and deregulation that began in 1985. "Culture change" is only a part of this issue; the term makes too light of the very real difficulty of accommodating any further regulatory change. Yet the present regulatory structures are driving us further into patterns of unsustainable energy use and development.

Implementation

The working group recognised that planning for implementation will need to be done in the context of the framework, and thus should not be started prematurely. Each major area will need to be planned in detail, including identifying data needs, research requirements, technological development, skills development, production of guidelines or specifications, training of practitioners, development of infrastructure and identification of problems. A number of specialist sub-groups would probably need to be formed to address each individual area.

But the most important ingredient is a common will to face up to the forthcoming and inevitable changes to energy supply and use, and to use the challenges to improve the quality of life while maintaining our economic competitiveness.