Forces Shaping the 21st Century:

Resource Availability

Contents

This paper has been prepared for internal discussion as part of the START project. It reflects a range of views and it does not represent official positions of the organisations involved.

Key Messages

- The world's economy and human life are fundamentally and increasingly dependent on using all parts of the natural environment as resources, including non-renewable resources such as oil, for a wide range of interrelated uses.
- Demand for resources is rapidly increasing globally, along with population and economic growth, such that use of even some renewable resources (such as water) is outstripping their supply. The unsustainable use of resources is a key source of environmental degradation (reducing biodiversity and upsetting normal balances), and is a threat to humanity's future standard of living.
- As non-renewable resources become scarce, they also become more expensive, particularly as increased demand can require costly infrastructure investments. The price of some natural resources is subject to considerable fluctuation and has been rapidly increasing. This creates shocks which economies may not be able to respond to quickly. Recent oil price rises are a particular example.
- Populations around the world are unequally endowed with natural resources. Increasing demand for these resources therefore contributes to competition, which can be expressed in political instability, war and disparate outcomes for different groups of people.
- There is significant scope to manage human demand for natural resources and reduce waste without reducing living standards. Technology has and likely will enable populations to better access some resources and/or provide substitutes for them, and to radically enhance efficiencies in resource use (dematerialisation). A shift in mindset and change of behaviour can also help to manage some of these resources more effectively.
- New Zealand's economy, the way we travel, the efficiencies of our urban form, and our agricultural and manufacturing practices will be fundamentally affected by increasing oil prices and possible oil scarcity in the future. Our isolation, the importance of exports to our economy, and the bulkiness of them, makes us heavily reliant on oil. This exposes New Zealand to significant economic risk as oil prices increase. On the other hand, as world agricultural thresholds are reached with deforestation, desertification and erosion, the quality and relative abundance of New Zealand's natural resources (apart from oil) may give it a comparative advantage. It may be in a reasonable position economically if it can add more value to what it produces from these resources and then sells these around the world.
- New Zealand will require a long lead in time and substantial investment in infrastructure and research and development in order to diversify energy sources and reduce energy demand.
- Aucklanders are heavily reliant on oil-based transport, and our current urban form is both based on "cheap" oil and limits the ability to move to more sustainable transport options with oil price increases. However, our expected population growth provides an opportunity to make this urban form increasingly more amenable to passenger transport.
- Auckland's growth is contributing to increasing demand for other forms of energy, water and wastewater services. While water is relatively plentiful, this increasing demand is creating pressure to make a series of significant infrastructure investments with economic and environmental consequences.
- Careful management, future planning and using a variety of resources is essential to ensuring that New Zealand and the Auckland region become more resilient and sustainable in the 21st century.

1.0 Introduction

> Natural resources – fuels, materials, water and food commodities – form the basis of all human activity. They are the essential inputs to both subsistence economies and the most advanced technological societies. (Matthews and Hammond, 1999)

The world's economy and human life are fundamentally dependent on the natural environment to provide the resources and support systems that ensure our wellbeing (Millennium Ecosystem Assessment, 2005). The START project has looked at one part of this picture: resource availability. There are three key considerations for the Auckland region when it comes to resource availability: the existence of the resources we use to meet our needs, our ability to predictably obtain and efficiently utilise those resources, and the consequent effects of our resource use on the receiving environment.

'Natural resources' refer to renewable and non-renewable naturally occurring biological assets that have the potential to be used for economic production or consumption (Statistics NZ, 2006). They can be grouped into two broad categories: *renewable* and *non-renewable*. Renewable resources, such as trees, fish, oxygen, and fresh water, are continually replaced by nature. Non-renewable resources, such as oil, coal and gold, generally have much longer replenishment rates, and are used up faster than they can be replaced in nature.

Poorly managed renewable resources can also become non-renewable if they are allowed to be depleted to a point of collapse, for example, by reducing fish stock numbers to a point where there is no longer enough genetic diversity to ensure the long term survival of a particular species. Renewable resources need to be thought of as being renewable only when they are capable of being continually replaced by natural ecological cycles or through sound management practices. They should therefore only be considered renewable in certain circumstances, i.e. when they are managed within the laws of the balance of nature.

Humans have always used resources that are easily accessible and available to them. Stewardship of these resources has formed a strong part of our cultural storehouse of knowledge (e.g. in principles of kaitiakitanga, or agricultural practices such as knowing when to plant, when to harvest, rotation of crops).

Historically, there has often been a fine balance between the prosperity of populations and the resources available to them. Abundant resources have supported the development of the world's greatest civilizations. Conversely, exhaustion of resources has been demonstrated to be a key factor in societal upheaval and collapse (Diamond, 2005).

History shows that human populations tend to modify their behaviour when it becomes apparent that essential resources are becoming scarce or non-existent. When resources become depleted, we usually look for new resources as replacements. Where populations were small enough, depleted resource bases often had an opportunity to recover, or the community could relocate to areas where resources were again more plentiful. Some commentators suggest that the unprecedented size of today's population, combined with our advanced resource extraction capabilities, means that future resource shortages could lead to significant shocks on a global scale (Wright, 2005). The rise of the fossil fuel dependent economy over the past 100 years and the likelihood that the supply of this energy source could peak during the first half of this century indicates that we could be approaching such a transition time.

Even without significant shocks, the efforts required to meet the resource needs of a projected additional three billion people in the next 50 years will be immense. As the human population continues to grow, and developing economies continue to strengthen, developed nations, including New Zealand, will need to consider how they plan to manage the use of resources so that future generations of New Zealanders can meet their own resource needs (UNEP, 1999).

In examining the long-term sustainability of a region, resource availability requires detailed analysis and coordinated planning to improve resilience to a range of resource changes – the global state of some of these resources is identified in Appendix 1. For purposes of brevity, this paper has focused on two key resources for the sustainable future of the Auckland region: energy and water. This paper briefly outlines the historical trends in the use of these resources. It then outlines the key resource trends we are likely to face in the 21st century, the future implications of changes to resource availability, and our ability to respond to these changes. Finally the paper discusses some of the possible implications and opportunities for New Zealand and the Auckland region to become more resilient to changes in resource availability.

Issues around resources

A discussion of resource availability needs to take into account numerous factors, such as:

- renewability or non-renewability/exhaustibility of a resource
- whether a resource, or a certain level or purity of a resource, is necessary for survival or merely for maintenance of societal features
- quantity of resource available
- quality of resource available
- ownership of resource
- threats or risks to the resource
- substitutability of a resource
- the likelihood of changes to the resource and the effects of those changes, e.g. changes to supply, demand, price, non-availability
- the state of knowledge about a resource, coordination at national or regional levels to plan for resource availability
- distribution and use of the resource, including equity and cost and cost fluctuations
- regulation and legislation surrounding resource availability, development, use
- processing, transportation, infrastructural, legal, other transactional costs
- positive or negative impacts of the development, provision and use of a resource on the environment (including whether the impacts are irreversible) and on social and cultural values
- whether the environment, social and cultural impacts are internalised into pricing of a resource or are externalities
- the resilience and adaptation to a range of possible futures: including forecasting based on historical data; also scenarios based on discontinuous change, such as effects of natural disasters, new technologies, social and cultural shifts
- an understanding of trends in global and local values, perceptions and paradigms as these affect management of resource development and decisions relating to resource use.

2.0 Historical Patterns

To understand likely future patterns of resource availability it is important to understand what has happened in the past. Historical resource use and changes can suggest options for managing future changes, and help us to adapt to potential future changes.

Resource availability has always affected the shape and potential of communities. In relatively recent history, the Industrial Revolution wrought a huge transformation in the scale, diversity and accessibility of resources available – enabling development to occur at an accelerated pace, and our quality of life to increase. People living in developed nations have become accustomed to an abundance of cheap and readily available resources.

Today, almost two thirds of the resources supporting life on earth are being degraded by human pressure (Millennium Ecosystem Assessment, 2005). The major cause of the continued deterioration of the global environment and resource availability is the unsustainable pattern of production and consumption by a large human population. This unsustainable pattern is particularly evident in developed nations (UN, 1992).

The total volume of natural resources required annually per capita in highly industrialised economies is in the range of 45 – 85 metric tons (WRI, 2006). However, this consumption is far from efficient: 30 tons of non-renewable resources are invested in every ton of goods produced in modern economies (Factor 10 Institute, 2004).

At the same time, many people living in developing nations have very limited access to resources, and few alternatives to depleting the natural resources in their immediate environment for their survival. Resource scarcity and environmental deterioration will further impact on living standards and prospects for economic improvement among these peoples. There are also significant additional resource availability impacts due to the fast developing economies and energy and resource needs of China, India and parts of South America (UNEP, 1999).

A rapidly changing landscape

'Over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history, largely to meet rapidly growing demands for food, fresh water, timber, fiber, and fuel. This has resulted in a substantial and largely irreversible loss in the diversity of life on Earth.

'The changes that have been made to ecosystems have contributed to substantial net gains in human well-being and economic development, but these gains have been achieved at growing costs in the form of the degradation of many ecosystem services, increased risks of nonlinear changes, and the exacerbation of poverty for some groups of people. These problems, unless addressed, will substantially diminish the benefits that future generations obtain from ecosystems.'

- 'More land was converted to cropland in the 30 years after 1950 than in the 150 years between 1700 and 1850. Cultivated systems (areas where at least 30% of the landscape is in croplands, shifting cultivation, confined livestock production, or freshwater aquaculture) now cover one quarter of Earth's terrestrial surface. Areas of rapid change in forest land cover and land degradation are shown in the second figure.
- 'Approximately 20% of the world's coral reefs were lost and an additional 20% degraded in the last several decades of the twentieth century, and approximately 35% of mangrove area was lost during this time (in countries for which sufficient data exist, which encompass about half of the area of mangroves).
- 'The amount of water impounded behind dams quadrupled since 1960, and three to six times as much water is held in reservoirs as in natural rivers. Water withdrawals from rivers and lakes doubled since 1960; most water use (70% worldwide) is for agriculture.'

Source: Millennium Ecosystem Assessment, 2005

2.1 Historical Global Trends

Energy

Humans have used wood as the main form of energy for heat, light, cooking and small scale commercial processes for most of history. Other forms of energy have been used where available, such as the sun, wind, water, hot springs and animals (including humans). It was not until the Industrial Revolution in the 18th century that most modern forms of energy were being discovered and used on a large scale.

Commercial extraction of oil began in the mid 19th century and by the 1890s, mass production of automobiles created increasing demands for gasoline. The use of coal also dramatically increased during this period for industrial processes, as it was cheaper and more readily available than other traditional forms of energy (US Department of Energy, 2006). The demand for petroleum products continued to rise over the 19th and 20th centuries as industrialised economies grew.

Post World War II saw a shift in energy consumption. As a result of greater energy demands and consumption, old wartime technologies were developed to service civilian needs such as nuclear power (US Department of Energy, 2006). Post-war rebuilding and population increases also drove nations from rationing fuel to exploration and production of oil fields to meet the demands of growing numbers of vehicles and economies (Ministry of Economic Development, 2004).

Production and consumption of petroleum products continued unchecked for many years until the oil shocks of the 1970's. Political tensions between developed nations and oil producing nations led to a global shortage of fuel (Ministry of Economic Development, 2004). This global shortage changed the way people thought about and used energy. The shortage of fuel prompted many developed nations to rethink their energy consumption and to look to alternative forms of fuel (Union of Concerned Scientists, 2006, Ministry of Economic Development, 2004 and US Department of Energy, 2006).

The 1980's saw a period of relatively cheap fuel, but the policies and programmes put in place after the oil shocks ensured that fuel was used more efficiently. However, despite the introduced efficiencies, economies of developed nations continued to grow and with them the demand for fuel (Union of Concerned Scientists, 2006, Ministry of Economic Development, 2004 and US Department of Energy, 2006).

The 1980's and 1990's saw the rise of a new series of concerns about energy consumption. Scientific discoveries and confirmation of a hole in the ozone layer over the Antarctic and global climatic changes were being linked to our energy consumption (Ministry of Economic Development, 2004). The public became more concerned about the current and future environmental impacts of their energy use and prompted their governments to take action. As a result the 1990's saw many climate change agreements being developed and signed by concerned nations (Ministry of Economic Development, 2004). Please refer to the Climate Change Forces paper for more details on the environmental impacts of energy consumption.

Water

Little is known about historical water usage quantities and patterns. However, through historical studies of ancient and modern settlements much has been learnt about our need for and dependence on freshwater. Historically, human populations have hunted or settled near key water sources. When there is a drought period, archaeological evidence has shown that these settlements either moved to another water body or manipulated a water body to service their needs. Studies have also shown evidence of how societies have mitigated negative impacts on water bodies (Diamond J, 1997).

The modern age of the potable water supply and distribution system arose as a result of large populations living in small land areas: urban environments. To prevent disease and illness in dense populations, water is treated, stored and distributed to a certain standard. In most modern cities the

availability and quality of water is very good. However as populations continue to grow, so does the demand for more water supply.

Clean freshwater is one of the key global resource availability issues faced today (World Health Organisation, 2006). When factoring increasing irrigation, industrial pollution, urban and rural runoff, and climate change the availability of freshwater has become scarce in many parts of the world. Many nations have taken radical action to safe guard existing freshwater supplies and gain access to other freshwater supplies (World Health Organisation, 2006).

2.2 Historical Trends in New Zealand and Auckland

Energy

Whilst the energy landscape of New Zealand has certainly changed over time, at least four trends for New Zealand and the Auckland region can be identified:

1. Supply choices have changed as new technologies have become available

New Zealand's first settlers were primarily reliant on wood (an abundant resource), with some use of geothermal for heat and cooking where it was locally available (Ministry of Economic Development, 2004). The arrival of European settlers brought new energy technologies, for example using oil and animal fat (candles) in households. Hydropower was also employed within the mining and timber industries (Ministry of Economic Development, 2004).

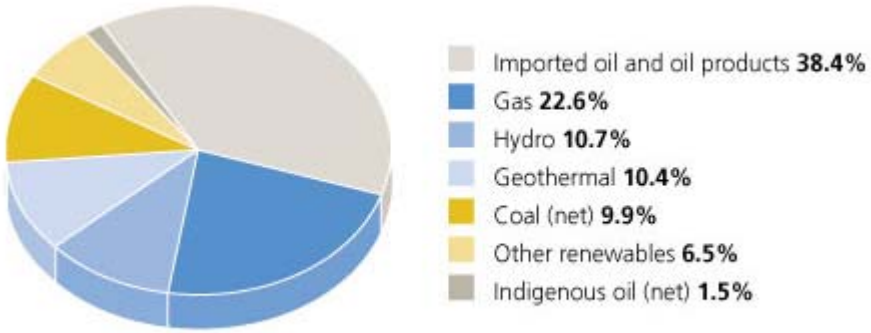
Mineral based products such as coal began taking over from wood as the main domestic and industrial fuel in the 1860's, and eventually became New Zealand's main source of industrial and domestic energy by the start of the 20th century. The first oil well was drilled in Taranaki in 1886, and by the 1920's oilfields were being developed for commercial purposes. The 1920's also saw a rapid increase in car ownership and the Marsden Point refinery was commissioned to process crude oil (Ministry of Economic Development, 2004).

Public electricity supply developed in the 1880s, with Reefton becoming the first town in New Zealand to switch on to the public electricity supply from the country's first hydroelectric plant in 1888. Electricity was mainly used for lighting purposes in New Zealand until the 1930's when it started being used for cooking and heating in homes. Between the 1930's and 1960's, large scale hydroelectric projects made electricity more available. Within a short few years, electricity eventually became the main form of household energy (Ministry of Economic Development, 2004).[1] New renewables generation (wind, solar, water, biofuels) began early development in the 1990s, most notably with large-scale application of wind generation. Currently, 70% of New Zealand's energy supply is from fossil fuels (see figure 1).

[1] Electricity is a "secondary" source of energy. It is produced from "primary" sources such as water, coal, gas, wind or oil. It is valued for the wide range of "tertiary" activities and services that it provides, from home heating and cooking to lighting of offices and powering computers, to inputting into industrial processes.

Figure 1. New Zealand's 2003 Total Primary Energy Supply (incl. international transport)

Source: NZBCSD, 2005.



2. Demand has continued to increase

New Zealander's energy demand has continued to increase as energy supplies have become more easily available. The following graphs (figures 2 to 4) illustrate the growth in demand, and where our energy is currently being consumed.

Figure 2. Changes in Energy Demand, Population and GDP 1970 – 2003

Source: NZBCSD, 2005.

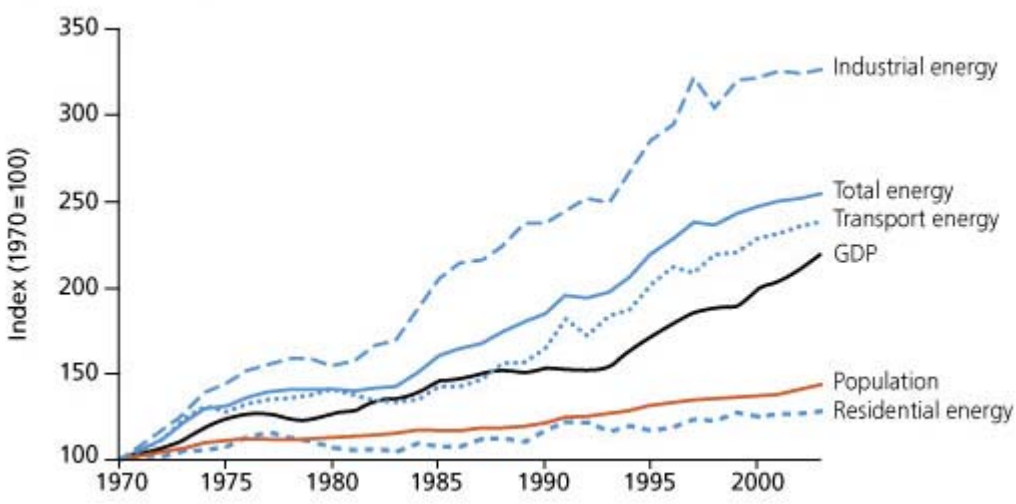


Figure 3. New Zealand's Energy Consumption by Sector

Source: Estimates from EECA's Energy End Use Database (http://www.eeca.govt.nz/enduse/index.aspx, accessed June 2006)

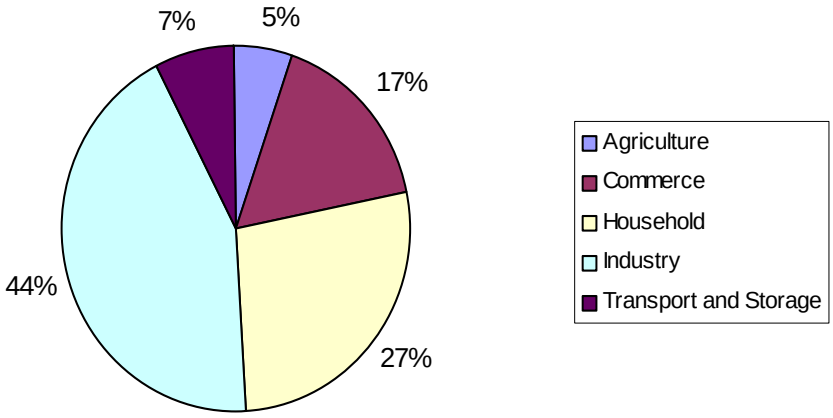
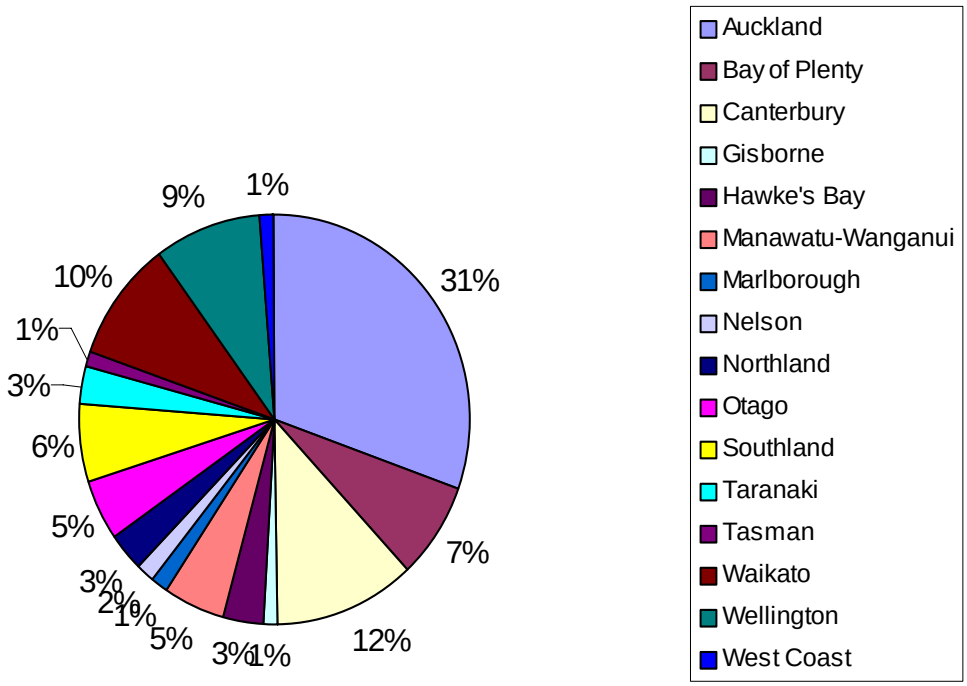


Figure 4. New Zealand's Energy Consumption by Region

Source: Estimates from EECA's Energy End Use Database (http://www.eeca.govt.nz/enduse/index.aspx, accessed June 2006)



Like all significant urban centres around the world, the Auckland region (and New Zealand) is dependent on vehicles for private, commercial and industrial use. Auckland has one of the highest vehicle ownerships in the world. There are 650,000 vehicles in the Auckland region travelling approximately 8 billion kilometres annually (ARC, 2005).

Nationally, over the past five years, oil consumption rose by nearly four percent per annum. Most of this growth was in the domestic transport sector. Domestic transport accounted for 84 percent of consumer energy use in 2004 and dominated total oil consumption (Ministry of Economic Development, 2005).

Since 1995, demand for oil has increased faster than New Zealand's ability to supply indigenous oil to the market. In 2004 80 percent of oil consumed in New Zealand was imported from overseas. In the year ended March 2005, New Zealand's self-sufficiency in oil production fell to 18 percent (Ministry of Economic Development, 2005). This dependence on foreign oil makes Auckland and New Zealand vulnerable to international political crisis. In response New Zealand holds 90 days' stock of oil against emergencies. Demand restraint plans have been developed and as IEA members we have the right to international support if oil availability is significantly reduced globally. However this does not shield NZ from a long term trend of rising oil prices, nor from a prolonged period of oil scarcity in which available oil for NZ import could not meet NZ's energy requirements.

3. Our energy supply systems have vulnerabilities

Security of supply is a significant concern for the Auckland region and for New Zealand. However – as history shows – it is not a new issue. New Zealand experienced its first serious petrol shortage during World War II. Fuel was rationed stringently until the 1950's. However, as the post-war economy began to grow, so did the demand for oil. The response by the government was to subsequently begin offshore oil explorations in the1960's and domestically produce fuel in the 1970's (Ministry of Economic Development, 2004).

A second series of fuel shortages was experienced in the 1970's as a result of the political situation in the Middle East. The oil shocks of the 1970's increased New Zealand's awareness of its dependence on foreign energy supplies and the vulnerability of that supply. The government responded to these growing public concerns by initiating a series of "Think Big" energy projects. These projects involved creating synthetic fuel plants, fertiliser plants, encouraging the use of liquid petroleum gas (LPG) and compressed natural gas (CNG) in the vehicle fleet and using indigenous natural gas from the Maui field in Taranaki (Ministry of Economic Development, 2004).

A severe drought in the South Island in 1992, and another dry period between 2001 and 2003 compelled nationwide electricity savings campaigns. Vulnerabilities in our current electricity supply were also evident when, in 1998, a high voltage underground cable failed, causing blackouts in the Auckland central business district for several weeks (Ministry of Economic Development, 2004). Although only lasting a matter of hours, the recent power outage on 12 June 2006 once again highlighted the vulnerability of the electricity supply to the Auckland region. Electricity supply was cut to much of Auckland and Manukau on 12 June 2006 due to an earthwire snapping in high winds at the Otahuhu substation. The early estimated cost to the Auckland economy was $50 to $70 million with the city experiencing traffic problems, hospital closures and business and home power failure (Radio NZ news, 12 June 2006).

4. Environmental impacts of energy choices are important considerations

Environmental and social concerns have an influence on energy decisions. In the last decades, many major energy projects – including proposals for new hydro, coal powered and wind generation – have been met with vocal opposition from environmental and agricultural interests. The air quality impacts

of open fires (for domestic heating) have led to new standards being put in place, including bans on open fires in places such as Christchurch. Increasing attention is also turning to the inadequacy of home heating, with its consequent effects on health.

Climate change emerged in the 1990s as a global environmental problem and New Zealand signed several climate change agreements including the Kyoto Protocol (Ministry of Economic Development, 2004).

Water

Freshwater is fundamental to the New Zealand way of life. Rivers, lakes, streams, wetlands and groundwater systems are among New Zealand's most valued natural assets for aesthetics, recreation, and the economic and cultural activities they support (Ministry for the Environment, 2006a and 2006b). New Zealanders value high quality of freshwater resources; however, due to changing land and water use patterns, the quality of water is declining (Ministry for the Environment, 2006b).

As a country, New Zealand is not short of water, yet demands on freshwater in some regions for farming, hydroelectricity, industry, recreation, tourism and more, are increasing and in many cases are exceeding water availability beyond what is sustainable (Ministry for the Environment, 2006a and 2006b). Recent drought periods in some areas in New Zealand and water allocation issues have shown us that we have taken our abundance of freshwater for granted (Ministry for the Environment, 2006a).

Potable water

Aucklanders are relatively efficient water users – consuming less per capita than people in Melbourne, Sydney or Christchurch. There is still, however, scope for improved efficiency. In the aftermath of the drought of 1993-1994, gross water consumption dropped to 270 litres per person per day. This has since crept up to around 300 litres per person per day (Watercare, 2004).

Even with our relatively efficient per capita consumption, overall water demand in the Auckland region continues to grow, due to population growth. Total annual demand has grown from 112 million cubic metres in 1994, to 124.5 million cubic metres in 2003 (Watercare, 2004). Efficiencies in per capita use would help to offset this growth in overall demand, and reduce the need for further infrastructure development.

Auckland is the only region in New Zealand that sources its potable water from another region, that is water extracted from the Waikato River. The Waikato River has a larger catchment area than the dams in Auckland, however this exposes the region to a degree of vulnerability in terms of both availability and cost.

As noted, the expected increased population in the region will have a parallel rise in demand for domestic water. It is more difficult to predict the commercial demand given that there will be changes in industry trends. There will also be changes in agricultural and horticultural demand driven by both climate change and changing land use patterns. The implications of this require further research and understanding. Nevertheless, meeting demand in some areas is likely to be difficult, especially given that there are already parts of the region where aquifers and streams are fully allocated (ARC, 2006).

Water Quality

The quality of the water bodies in Auckland is a significant issue. Much of the land in Auckland has been reshaped with natural water systems diverted or piped. With more urban areas, there are more impermeable surfaces (such as roads and roofs). The impacts of these surfaces are most evident during heavy storm events, when large quantities of water flush pollutants and dust off impermeable surfaces into urban water bodies (ARC, 2006). These pollutants and dust significantly degrade the

water quality of urban streams and lakes, affecting aquatic life. This water eventually drains into coastal areas and significantly impacts the quality of the coastal environment (Auckland Regional Council, 2006). Addressing stormwater quality issues is estimated to cost the region several billion dollars over the next 20 years (ARC, 2004).

3.0 Key Issues for the 21st Century

It is well understood that if current resources are not managed appropriately, there will be effects on our prosperity and basic standards of living. Continued dependence on non-renewable resources such as oil will increase society and economy's exposure to external shocks, such as sudden, large price rises, or simple non-availability (JDCC, 2006).

Resilience to shocks can be greatly improved by managing supply and demand for resources. This could be done by producing some resources domestically, by diversifying the demand for resources and by reducing inefficient use of resources. National and international studies have highlighted that now more than ever society needs change so as to operate within the boundaries of the natural function of the planet (Millennium Ecosystem Assessment, 2005).

There are three key considerations for the Auckland region when it comes to resource availability: the existence of the resources we use to meet our needs, our ability to predictably obtain and efficiently utilise those resources, and the consequent effects of our resource use on the receiving environment.

Applying these considerations to energy and water, several issues arise, including:

- Increasing demand and potential declines in supply, and the ability to pay for consequent changes in infrastructure (e.g. increasing supply capacity or shifting to other systems).
- Geopolitical risks (especially for energy).
- Continuing, and potentially compounding, social and environmental consequences of current practices.
- Opportunities for diversification of supply and improvement in demand efficiencies.
- The need to define transition paths and prepare early to move to more sustainable and resilient systems.

3.1 Global Key Issues

Energy

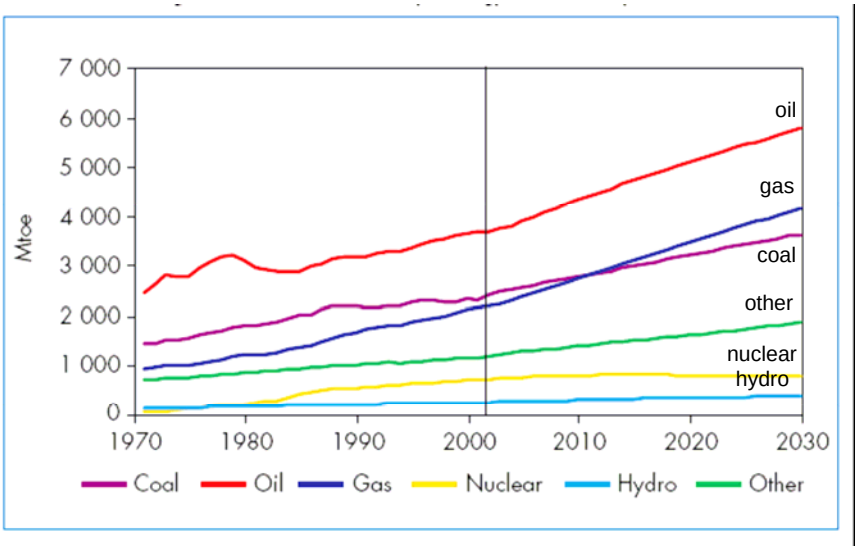
Energy demand globally is at a record high and there are no signs of it slowing down (Simmons, 2006). It is predicted that the world will need 60 percent more energy by 2030 than in 2002, and it is expected that, in the absence of developed alternatives, fossil fuels will have to meet most of this need (International Energy Agency, 2004, see figure 5 below). The United States and emerging Asian economies – notably, China – are expected to lead the increase in demand for world oil supplies, keeping pressure on prices through 2030 (US Department of Energy, 2006). Even if oil production continues to increase, it is unlikely to keep up with the demand.

Oil production is expected to peak in the first half of this century (MED, 2004). Most of the oil extracted today originates from easily accessible and economical oil fields. Exploration of new oil reserves has slowed down due to the feasibility, economics and accessibility of new fields (in deep oceans or on inhospitable land).

There are, of course, other energy options – for example accelerating research and development of renewables technologies, or using new technologies to extract previously uneconomical oil sources, such as oil sands. However, Hirsch (2005) warns that aggressive action is required now to secure adequate energy supplies in the future. 'Waiting until world oil production peaks before taking crash

programme action leaves the world with a significant fuel deficit for more than two decades' which would result in problems 'unlike any faced by modern industrial society.'

Figure 5: World Primary Energy Demand by Fuel. Source: International Energy Agency, 2004.



Whilst the issue of energy availability due to geological constraints and need for new investments has become a significant concern globally, so has the issue of energy security. Security of supply is a key concern for the future, due to the challenges of rising demand and declining oil supplies, and the potential of unpredicted shocks, for example from geopolitical upheavals, or more extreme weather events. Political instability in key oil producing nations threatens access to affordable energy and heightens worries about the reliability and cost of petroleum supplies. It is likely that conflicts of the future will be based or exacerbated by scarce energy resources (JDCC, 2006). (See box discussion of the Geopolitics of Resources, below).

The rapidly rising price of crude oil – from below US$25 per barrel in September 2003 to a level in June 2006 around US$70 – could have significant impacts on our energy future. Much of the energy forecasting that has been undertaken based on assumptions of lower energy costs. The IEA's 2004 World Energy Outlook report recognised future trends in oil prices as 'a major source of uncertainty'. Yet their modelling of a 'high price scenario' was set at US$35 per barrel (in year-2000 dollars). Even at this rate, global oil demand was predicted to drop around 15%. Should prices remain as high as US$70 per barrel, there are likely to be major divergences from modelled futures.

Finally there is continued debate over the environmental and human health impacts of energy production, distribution and use. Impacts such as air and water pollution, land contamination, radical alteration of the landscape, destruction of wildlife habitat, noise pollution and climate change continue to raise concerns for communities and governments alike (BBC, 2006). There will be significant climate impacts if non-renewable sources continue to be the main form of energy moving into the future (see the Forces of Change: Climate Change and Natural Hazards paper).

It is expected that new sources of energy and technologies will lead to fundamental changes in the way people use energy. Some technologies may mitigate the impacts on the environment; enable people to use less energy, or alternative forms of energy, while others will encourage more energy use (Parliamentary Commissioner for the Environment, 2005). Some technologies may become more acceptable or continue to be unacceptable (e.g. nuclear energy).

Water

As the world population expands from six billion now to an estimated nine billion in 2050, access to readily available drinking water is set to become more competitive. 470 million people currently live in water-stressed countries. This is projected to climb to three billion people by 2025 (UNEP, 2003).

Over the past 70 years water use worldwide has grown six-fold in total as the result of urban development, industrial development and increased use for irrigation. If consumption per person remains steady, by 2025 population growth could see us using 70 percent of the total water available for use. If per capita consumption everywhere reached the level of the developed nations then by 2025 we could be using 90 percent of all available aquifer and surface water (UNEP, 2003).

Competition for increasingly scarce water increases the likelihood of international conflict (both economic and military) over water quality and diversion schemes. More than 200 river systems cross national boundaries. Thirteen major rivers and lakes are shared by 100 countries (UNDP, 2003). There may be also a rise in intra-country conflict (as is apparent in the Canterbury Region in New Zealand), however these conflicts are more likely to be resolvable through domestic mechanisms such as the allocation of tradable water rights.

Geopolitics of Resources

Geopolitics is about the strategic importance of geographic regions and locations. Countries or groups of countries are usually important in geopolitical terms either for their location relative to other countries or for the economic resources they contain. Given this focus on economic resources it is perhaps unsurprising that geopolitics is also about war and international diplomacy.

While many wars have been fought for ideological, ethnic or religious reasons, underlying these causes are often disputes over resources and in particular access to natural resources. For example the 1993 genocides of Rwanda and Burundi are seen as being only nominally about ethnicity (Hutu v's Tutsi) and more about overpopulation, poverty and rivalry over access to land (Diamond, 2005).

Three principle resources are at the centre of political and military disputes: oil, water and land. Some futurists are predicting that there will be increasing disputes over water on account of three factors:

- Population and economic growth pressures and their impacts both on demand for fresh water and on water pollution.
- Degradation of natural resources which have in turn either reduced the availability of water (eg deforestation eutrophication) or placed pressure on local water supplies by shifting production patterns (desertification and salinization).
- Climate change, the greater variability of weather patterns and more extreme weather events

In the geopolitical context New Zealand could well feel the indirect consequences of water scarcity in Australia through a shift of water intensive production (eg dairying) from Australia to New Zealand, and increasing disputes between competing users of local water resources. As demand for water increases in New Zealand, the question of ownership of property rights will come more into focus which will in itself present a number of political issues particularly around the growing assertion by Maori that the property rights belong to them and not the Crown.

There is huge potential for political instability around the access to and ownership of oil resources. In particular there is the potential for major reorganisation of the world order as demand for oil from industrialising nations such as India and China begins to compete with developed nations such as United States, Japan and the European Union. The beginnings of this reorganisation may already be apparent with the growing instability within the Middle East which accounts for about two thirds of the known oil reserves in the world.

As oil become relatively more expensive, the rise in the importance of gas as a fuel is likely. Such a shift provides the means for Russia (which, along with Iran, owns half the world's gas reserves) to increase its influence both within Europe and North East Asia where it is easily able to supply gas. North Sea gas may also become a source of geopolitical tension within the European Union as its concentration of ownership between United Kingdom and Norway may focus attention on the extent of redistributional policies across the Union.

3.2 Key Issues for the 21st Century: New Zealand and Auckland

Energy

Local and global demand for energy is expected to continue to increase over time, putting pressure on national energy supplies. This will in turn put pressure on consumers – the New Zealand media is already reporting the struggle for some businesses and households to cope with recent rises at the petrol pump.

Due to the dispersed geography of the Auckland region and its limited public transport, Auckland is vulnerable to rising oil prices and decreased oil availability. However, our expected population growth provides an opportunity to make this urban form increasingly more amenable to passenger transport.

> Innovations and uptake of cleaner and more sustainable energy sources would help reduce supply constraints and mitigate the effects of climate change. Together with technology that promotes greater energy efficiency and efforts to reduce unnecessary energy consumption, these developments may provide us with a range of new ways to manage the issues. (Ministry of Economic Development, 2005). However NZ will require a long lead in time and substantial infrastructural and research and development investment in order to diversify energy sources and constrain energy demand.

As well as the global pressures on oil supply, there are also some challenges for electricity supply. The Electricity Commission's 20-year predictions range from 59% increases to 125% increases in demand (see Table A). Both the Electricity Commission and Transpower predict a higher rate of growth in peak demand in the Auckland region, suggesting the transmission network will not meet demand by 2010. Vector considers the threat to Auckland's security of supply may occur as early as 2007 (East Harbour Management Services, 2005). Maintaining reliability of the grid is recognised as a key input to economic viability.

In its Annual Planning Report 2006, Transpower identifies a range of potential transmission failures and proposes upgrade projects to manage them. The failures all relate to known capacity limitations in the transmission network. They do not include managing network vulnerabilities due to unforeseen equipment failure such as occurred on 12 June 2006.

Transpower's analysis indicates the transmission lines into Auckland will require reinforcement to retain reliability of supply between 2007 and 2013 and has submitted several upgrade proposals to the Electricity Commission to improve transmission capacity, including thermal upgrades to the existing lines and a proposal to construct an additional 400 kV line from Whakamaru to Otahuhu. Other upgrades to the transmission network will also be required further south in the grid backbone to ensure supply.

Possibilities and plans for large new generation facilities in or near the Auckland region include an 18 MW wind farm on the Awhitu Peninsula near the Auckland region's south western border (resource consents approved); another Otahuhu gas station of 400 MW capacity (resource consent approved but subject to long-term gas availability); investigation into a 386 MW gas-fired power station near Helensville and Silverdale and into a 200 MW open cycle gas turbine. Gas power stations may be dependent on imported gas and new gas line infrastructure (East Harbour Management Services, 2005).

Table A: Predictions for Growth in NZ Electricity Consumption

Gwh	Low	Mean	High
2005	36,892	37,371	37,792
2015	44,386	47,097	49,825

Increase from 2005	20.3%	26%	31.8%
2025	58,555	71,564	84,871
Increase from 2005	58.8%	91.5%	124.6%

Source: Electricity Commission Statement of Opportunities 2005 (Reported in East Harbour Management Services, 2005).

Issues and opportunities affecting electricity availability in the Auckland region

East Harbour Management Services (2005) identified a range of issues affecting electricity availability for the Auckland region:

- increases in demand and increases in summer peak profiles from changing use
- security of supply is peak demand constrained rather than energy constrained and is dependent on reliability of key features of the transmission network
- appropriate levels of security of supply and the cost of maintaining that level – currently the national security level is n-1, i.e. there is adequate back-up to cover at least one major contingent event. An increase to n-2 (adequate back-up to cover two contingent events) would be more costly
- fragmented overall energy market across electricity, gas and petroleum leads to difficulties for coordinated decision-making across supply, transmission and energy end-use management, which incorporate economic, social, cultural and environmental factors. For example, the range of future electricity supply scenarios developed by the Electricity Commission does not include the scenario of widespread small scale generation, such as widespread use of solar panels in urban areas for local use. This option may have large regional energy supply benefits reducing dependence on core elements of a bulk transmission network from large suppliers.
- lack of information and incentives available to the public and industry to take advantage of better energy choices, especially for small and medium-sized businesses, including lack of information on the time-of-use of energy (e.g. encouragement of time of use metering to lower usage during peak load times on non-critical tasks).
- air quality constraints on new generation within Auckland producing emissions.
- complexities in infrastructure consenting across multiple council boundaries.
- opportunity to provide better regional leadership and regional energy planning and activity implementation.
- opportunity to better influence energy efficiency of the built environment.
- opportunity to coordinate better regional information about how and where energy is used to support decisions.
- construction of new large scale electricity generators within or north of the region.
- greater use of a wider range of tools by the network providers to manage peak demand, e.g. via ripple control, distributed generation and demand trading.
- better contingency planning to mitigate effects of supply failure, including coordination between councils, suppliers and network providers to direct use of mobile generating plants, temporary transmission lines, or energy use reduction campaigns.
- opportunity to link energy planning with economic development planning.
- opportunity to focus on regional energy issues through creation of a cross-agency regional energy forum.

Water and water management

As a country, New Zealand is not short of water. On average less than three percent of New Zealand's available fresh water resource is used by farming, industry and towns. According to the Organisation for Economic Co-operation and Development (the OECD), that gives us the second lowest rate in the world (Ministry for the Environment, 2006b). Of what we use, 15 percent of fresh water use goes into public water supplies and seven percent is used by industry. However, demands on freshwater in some regions for farming, hydroelectricity, industry, recreation and tourism are increasing and in many cases are exceeding water availability beyond what is sustainable (Ministry for the Environment, 2006b). New Zealanders value the high quality of freshwater resources; however, due to changing land and water use patterns, the quality of water is declining (Ministry for the Environment, 2006a). It is possible that we have taken our abundance of freshwater for granted.

Abundance of water in the Auckland region is not expected to decline as in some parts of New Zealand and the rest of the world. However Auckland is one of the fastest growing regions in New Zealand and the need to facilitate this growing population is expected to place pressures on the water supply and quality. Careful and ongoing management of water resources is required to ensure that water availability and quality meets the needs and expectations of the population.

Surface water in the Auckland region is composed of rivers, streams, small lakes, dammed water and wetlands, (ARC, 2006). It is generally agreed that Auckland will not suffer extreme water shortages as in other parts of the country and overseas, however, as the Auckland region grows a lack in careful management of our water may lead to reduced water availability and quality. Potential changes in climate may also have an impact on the amount of water available.

Auckland currently has an abundant supply of water that can be treated to potable standards. Auckland's drinking water infrastructure is currently in good shape and there is capacity for the short to medium-term. However demands for water are increasing especially in the rural areas of Auckland (ARC, 2006).

Wastewater

Auckland's wastewater network (the pipes) is of mixed quality. Overflows to sea outfalls in some areas especially after heavy storm events are of significant concern to water quality of swimming beaches and harbours.

Wastewater treatment (through the Mangere plant) is generally environmentally sound but the treatment process is energy intensive. Additional capacity will be needed in the future, but at the moment the concerns about transmission are greater.

Stormwater

The Auckland stormwater network is incomplete in some areas and insufficient in others. One of the major problems with Auckland's stormwater system is the combined stormwater/ wastewater sewer systems. During heavy storm events, the water from these sewers has significant undesirable impacts on harbours and beaches.

There are significant concerns about outfalls into the harbour and the resulting impact on water quality. Plans to address stormwater problems have been recommended. The financial cost to maintain stormwater systems and mitigate the impacts of stormwater on the environment is potentially very significant.

The uses of stormwater retention systems such as wetlands and permeable surfaces in car parks and off major roadway sections have become common practice. It has also become common practice to include stormwater retention systems in some industrial sites as part of resource consent requirements.

4.0 Possibilities and Provocations for a Future Auckland

4.1 Effects on the region's Environment, Economy and Society

The following section raises a range of potential impacts and implications for Auckland's future resource availability. Not all of these changes are negative; in fact Auckland may have a number of potential opportunities.

We have several features that could make our responses different from other parts of the globe, including our geographic isolation (both a potential opportunity and a threat), our worldviews and cultural approaches to resources (see Appendix 2 for a discussion of Maori World View Around Resources), and our regulatory environment (see Appendix 3 for a discussion of Managing Resources).

Environmental Impacts

- Use of resources will continue to have impacts on receiving environments – population and economic growth and other forces are likely to exacerbate the extent of these impacts (for example, on harbour water quality, air quality, and quantities of waste to landfill).
- If Auckland moved towards greater energy efficiency and decreased reliance on fossil fuels, it could reduce the load it places on the environment substantially over time.

Economic Impact

- Changing comparative resource costs are likely to drive the types of hard infrastructure the Auckland region chooses to invest in (for both transport and urban water management). For example, rising oil prices may make other transport forms more economic and/or alter transport choices. Electronic communication may become a more attractive substitute for transport.
- The cost and availability of resources is likely to change consumption patterns and practices into the future.
- Auckland's dependence on imported resources (such as oil), makes it vulnerable to external shocks arising from sudden, large price rises, or simple non-availability.
- The increasing cost of resources will place a drag on some parts of the Auckland economy, affecting prosperity in those sectors. The flexibility to move towards new and other economic activities (e.g. more knowledge intensive) will be an important determinant of economic prosperity. That said Auckland's economy is likely to remain dependent on being able to ship bulk goods large distances well into the conceivable future.
- The economics of self-sufficiency may improve as gains from trade are eroded by increasing prices for imported resources and heightened risks associated with import dependence.
- Any transition to a new method for powering Auckland's economy is going to take time to implement and will require a step transition. There is a greater likelihood of reducing the step between existing and new technologies if risks associated with the changes are at least partly pre-empted. Auckland's decision to move towards a more compact urban form with a number of nodes is an example of an urban form with a higher degree of resilience and sustainability. Building on that concept over the coming century will remain important work for the region.

Social and cultural impact

- Higher resource costs will make all goods more expensive, potentially reducing standards of living and possibly even placing some more basic goods out of reach for lower income groups.
- The region's dispersed settlement form may compound these impacts, particularly for those living in outer suburbs.

- There may also be cultural shifts in how we value increasingly scarce resources. For example, commuters' attitudes to public transport may become more positive when fuel costs make private transport less viable.

4.2 Potential Opportunities

- Auckland's comparative abundance of clean drinking water, provided that the resource is managed appropriately, may attract migrants (from water poor regions) or may offer opportunities for Auckland industries.
- Auckland's resilience to shocks could be greatly improved by managing demand for externally sourced resources, by producing some resources domestically, and by diversifying Auckland's demand for resources. Resilience could be a useful policy goal because the better we cope; the more attractive it will be for migrants with key skills to relocate here.
- The degree to which Auckland effectively markets resource availability would be an advantage to attract skilled workers and international competitive firms.
- Resource shortages will drive innovation, with the potential for new technology and systems development. The Auckland region could take a lead in this innovation.

4.3 Some 'provocations' for debate

The following questions are posed with hope of sparking debate amongst the expert groups.

Oil and vehicle fuel

- What will be required to reduce NZ's and Auckland's dependency on imported oil. How long will these requirements take and therefore when do they need to start? Do we:
    - Invest in upgrading our PT system? Electrification of the local rail network, more dedicated bus lanes? Experiment using hybrid-electric buses on more routes? More park and ride facilities at train and bus stations?
    - Invest more research and development of bio-fuels? Or push dual-fuel systems in vehicles (similar to Australia)?
    - Explore the feasibility of getting businesses to use smaller, more economical vehicles in their fleet or partially replace their fleet with hybrid-electric vehicles?
    - Ask businesses to support working from home? Upgrading and increasing data transfer systems? Teleconferencing?
    - Ask businesses to re-examine the need to put all non essential services in the CBD? e.g. relocating data processors in banks from central locations to suburban locations – thus reducing employees' needs to travel to the city.
- Assuming oil prices continue to track upwards, what will happen to the Auckland region's suburbs? How will people adjust, and continue to meet their daily needs should travel costs become prohibitive, particularly in areas where local services are limited or unavailable?

Electricity

- What is the feasibility of developing renewable sources of energy in small cells to provide the energy needs of specific industrial sectors or CBD in Auckland e.g. wind, solar, wave/tidal rather than national grid?
- The Marsden B 300MW coal-fired thermal power station would only be able to meet the region's energy demands for so long (300MW is about 2 years annual growth for the nation.) Resource consent has been granted for only 25 years. What else needs to happen?
- Should we:

- Consider installing energy efficient and better designed lighting systems in built up areas, along roads and in public spaces?
- Promote or subsidise insulation in homes to reduce heating requirements?

Water

- Auckland's population is rapidly growing. How will we meet increasing urban water demands, rural water demands and industrial/commercial water needs.
- Local climate change will make for more droughts – we may need to look at new sources or water saving systems.

Local climate change and the impacts of sea level rises on sewage systems.

5.0 Our Ability to Respond

The availability of the resources that we rely on will continue to fluctuate, based on a number of environmental, economic and geopolitical factors. Compounding this, there is clear evidence that we cannot continue to take the services of our ecosystem for granted. The rapid and extensive change of the last fifty years cannot be continued indefinitely. There is a need to move to more sustainable methods of resource use, providing the level of services necessary to sustain human life without the accompanying environmental degradation that we currently generate.

The Millennium Ecosystem Assessment (2005) warns that the level of changes required "will have to be substantial when compared to the actions currently taken." It suggests that opportunities for change lie in:

- Institutions and governance – changing frameworks to more effectively manage resources
- Economics and incentives – employing instruments to regulate the use of goods and services (e.g. market signals, eliminating unsustainable subsidies)
- Social and behavioural actions – education and empowerment of stakeholders.
- Technological actions – development and diffusion of technologies
- Information based actions – improving the knowledge on which we make our decisions.

One of the main challenges for building in resilience to our resource demands is the need to cope with uncertainty. The difficulties of prediction can undermine the assumptions that models rely on. There is also a need for better analysis of alternatives (e.g. cost-benefit, performance over time, factoring in environmental and social costs).

Auckland's ability to respond to changes in resource availability will be predicated on:

- Sourcing good information on which to make decisions.
- Identifying opportunities for diversification of supply and improvement in demand efficiencies.
- Defining transition paths to more sustainable options, and preparing early to move to more sustainable and resilient systems.
- Finding opportunities to capitalise on change.

Sources and References

ARC. 2004. *Auckland Regional Stormwater Action Plan: a co-ordinated approach to regional stormwater management and the deliver of improved stormwater quality outcomes.* Auckland: Auckland Regional Council.

ARC. 2006a. *Air Quality Information*. Auckland Regional Council website. Available www.arc.govt.nz, accessed May 2006.

ARC. 2006b. *Water Quality Information*. Auckland Regional Council website. Available www.arc.govt.nz, accessed May 2006.

BBC. 2006. *Planet Under Pressure*. British Broadcasting Corporation website. Available www.bbc.co.uk. Accessed May 2006.

Diamond, J. 1997. *Guns, Germs and Steel : the Fates of Human Societies*. London: Jonathan Cape.

Diamond, J. 2005. *Collapse: How Societies Choose to Fail or Succeed.* New York: Penguin.

Dzioubinski, O. & Chipman, R. 1999. *Trends in Consumption and Production: Selected Minerals – Discussion Paper*. New York: United Nations Department of Economic and Social Affairs.

East Harbour Management Services. 2005. *Issues Paper for an ARC Role in Energy Management (report prepared for the Auckland Regional Council).*

Factor 10 Institute. 2006. Systemic Fiscal Reforms for a Future with Future Carnoules, source: http://www.factor10-institute.org/seitenges/Factor10.htm, accessed June, 2006.

Hirsch, R. 2005. *Peaking of World Oil Production: Impacts, Mitigation, and Risk Management (report prepared for US Department of Energy).*

International Energy Agency. 2004. *World Energy Outlook.* Paris: International Energy Agency. Available: www.netl.doe.gov/publications/others/pdf/Oil_Peaking_NETL.pdf. Accessed May 2006.

JDCC. 2006. *Strategic Trends (2nd edition).* Joint Doctrine and Concept Centre, Ministry of Defence, United Kingdom. Available: www.jdcc-strategictrends.org/index.asp. Accessed May 2006.

Matthews and Hammond. 1999. *Critical consumption trends and implications: Degrading Earth's ecosystems.* Washington, D.C.: World Resources Institute.

Ministry of Agriculture and Forestry. 2006. *LandCover Database*. Website, available www.maf.govt.nz. Accessed May 2006.

Ministry for the Environment. 2005. *Discussion document: Drinking water standards*. Wellington: Ministry for the Environment.

Ministry for the Environment. 2006a. *Freshwater for the future (information sheet).* Available www.mfe.govt.nz. Accessed May 2006.

Ministry for the Environment. 2006b. *Gentle Footsteps, Boots n All*. Wellington: Ministry for the Environment.

Ministry for the Environment. 2006c. *Air Quality Information.* Website, available www.mfe.govt.nz. Accessed May 2006.

Ministry of Economic Development. 2004. *Sustainable Energy: Creating a Sustainable Energy System for New Zealand - Discussion Paper*. Wellington: Ministry of Economic Development.

Ministry of Economic Development. 2005. *New Zealand Energy Data File*. Wellington: Ministry of Economic Development.

NZBCSD, 2005. *A sustainable energy future for NZ by 2050.* Auckland: NZ Business Council for Sustainable Development.

Northland Regional Council. September 2006. *Decision of Commissioners Report on Marsden B*. Whangarei: Northland Regional Council.

Parliamentary Commissioner for the Environment. *Future Currents, Electricity scenarios for New Zealand 2005 – 2050*. Wellington: Parliamentary Commissioner for the Environment.

The Press. 24 May 2006. *Remove the Taboo (opinion piece).* Christchurch.

Transpower. 2006. *Annual Planning Report 2006.* Available www.transpower.co.nz. Accessed June 2006.

UN. 1992. *Agenda 21.* New York: United Nations.

UNDP. 2003. *Water for People, Water for Life: The United Nations World Water Development Report.* New York: United Nations Development Programme.

UNEP. 1999. *Global Environmental Outlook GEO-2000*. Nairobi: United Nations Environment Programme.

UNEP, 2003. *Key Facts about Water*. United Nations Environment Programme website, available: www.unep.org/wed/2003/keyfacts.htm. Accessed June 2006.

Union of Concerned Scientists. Website, available: www.iucn.org. Accessed May 2006.

US Department of Energy. 2006. *Energy Information*. US Department of Energy Administration Website. Available www.doe.gov. Accessed May 2006.

Simmons, M. 2006. *Presentation to the NZ Petroleum Conference.* Simmons and Company International.

Statistics NZ, 2006. *Natural Resource Accounts.* Website, available: www.stats.govt.nz/analytical-reports/natural-resource-accounts/default.htm. Accessed June 2006.

WaterCare. Website, available: www.watercare.co.nz. Accessed May 2006.

World Health Organisation. Website, available: www.who.org. Accessed May 2006.

World Resources Institute. 2006. *EarthTrends: The Environmental Information Portal.* Source: http://earthtrends.wri.org. Washington DC: World Resources Institute

Development of this Paper

To date, a number of people have fed in to the development of this Forces working paper, including Dilini Hevapathirana and Mark Leggett, Ministry for the Environment; Simon North, Ministry of Economic Development; John Small, COVEC; Megan Howell, Alan Johnson, Jo Mackay, Claire Mortimer, Tanya Perrott and Kelsang Wangchuk, Auckland Regional Council.

Appendix One

Trends in the Human Use of Ecosystem Services and Enhancement or Degradation of the Service Around the Year 2000 - Provisioning services.

Source: Millennium Ecosystem Assessment, 2005.

Legend

↑ = Increasing (for Human Use column) or enhanced (for Enhanced or Degraded column)	↓ = Decreasing (for Human Use column) or degraded (for Enhanced or Degraded column)	+/- = Mixed (trend increases and decreases over past 50 years or some components/regions increase while others decrease

Service	Sub-category	Human Use (a)	Enhanced or Degraded (b)	Notes
Provisioning Services				
Food	Crops	↑	↑	Food provision has grown faster than overall population growth. Primary source of growth from increase in production per unit area but also significant expansion in cropland. Still persistent areas of low productivity and more rapid area expansion, e.g., sub-Saharan Africa and parts of Latin America.
	Livestock	↑	↑	Significant increase in area devoted to livestock in some regions, but major source of growth has been more-intensive, confined production of chicken, pigs, and cattle.
	Capture Fisheries	↓	↓	Marine fish harvest increased until the late 1980s and has been declining since then. Currently, one quarter of marine fish stocks are overexploited or significantly depleted. Freshwater capture fisheries have also declined. Human use of capture fisheries has declined because of the reduced supply, not because of reduced demand.
	Aqua-culture	↑	↑	Aquaculture has become a globally significant source of food in the last 50 years and, in 2000, contributed 27% of total fish production. Use of fish feed for carnivorous aquaculture species places an additional burden on capture fisheries.
	Wild plants and animal food products	**NA**	↓	Provision of these food sources is generally declining as natural habitats worldwide are under increasing pressure and as wild populations are exploited for food, particularly by the poor, at unsustainable levels.
Fiber	Timber	↑	+/-	Global timber production has increased by 60% in the last four decades. Plantations provide an increasing volume of harvested roundwood, amounting to 35% of the global harvest in 2000. Roughly 40% of forest area has been lost during the industrial era, and forests continue to be lost in many regions (thus the service is degraded in those regions), although forest is now recovering in some temperate countries and thus this service has been enhanced (from this lower baseline) in these regions in recent decades.
	Cotton, hemp, silk	+/-	+/-	Cotton and silk production have doubled and tripled respectively in the last four decades. Production of other agricultural fibers has declined.

	Wood fuel	+/-		Global consumption of fuelwood appears to have peaked in the 1990s and is now believed to be slowly declining but remains the dominant source of domestic fuel in some regions.
Genetic resources				Traditional crop breeding has relied on a relatively narrow range of germplasm for the major crop species, although molecular genetics and biotechnology provide new tools to quantify and expand genetic diversity in these crops. Use of genetic resources also is growing in connection with new industries based on biotechnology. Genetic resources have been lost through the loss of traditional cultivars of crop species (due in part to the adoption of modern farming practices and varieties) and through species extinctions.
Biochemicals, natural medicines, and pharmaceuticals				Demand for biochemicals and new pharmaceuticals is growing, but new synthetic technologies compete with natural products to meet the demand. For many other natural products (cosmetics, personal care, bioremediation, biomonitoring, ecological restoration), use is growing. Species extinction and overharvesting of medicinal plants is diminishing the availability of these resources.
Ornamental resources		**NA**	**NA**	
Freshwater				Human modification to ecosystems (e.g., reservoir creation) has stabilized a substantial fraction of continental river flow, making more fresh water available to people but in dry regions reducing river flows through open water evaporation and support to irrigation that also loses substantial quantities of water. Watershed management and vegetation changes have also had an impact on seasonal river flows. From 5% to possibly 25% of global freshwater use exceeds long-term accessible supplies and requires supplies either through engineered water transfers or overdraft of groundwater supplies. Between 15% and 35% of irrigation withdrawals exceed supply rates. Freshwater flowing in rivers also provides a service in the form of energy that is exploited through hydropower. The construction of dams has not changed the amount of energy, but it has made the energy more available to people. The installed hydroelectric capacity doubled between 1960 and 2000. Pollution and biodiversity loss are defining features of modern inland water systems in many populated parts of the world.

* = Low to medium certainty. All other trends are medium to high certainty.

NA = Not assessed within the MA. In some cases, the service was not addressed at all in the MA (such as ornamental resources), while in other cases the service was included but the information and data available did not allow an assessment of the pattern of human use of the service or the status of the service.

† = The categories of "Human Benefit" and "Enhanced or Degraded" do not apply for supporting services since, by definition, these services are not directly used by people. (Their costs or benefits would be double-counted if the indirect effects were included). Changes in supporting services influence the supply of provisioning, cultural, or regulating services that are then used by people and may be enhanced or degraded.

a For provisioning services, human use increases if the human consumption of the service increases (e.g., greater food consumption); for regulating and cultural services, human use increases if the number of people affected by the service increases. The time frame is in general the past 50 years, although if the trend has changed within that time frame the indicator shows the most recent trend.

b For provisioning services, we define enhancement to mean increased production of the service through changes in area over which the service is provided (e.g., spread of agriculture) or increased production per unit area. We judge the production to be degraded if the current use exceeds sustainable levels. For regulating and supporting services, enhancement refers to a change in the service that leads to greater benefits for people (e.g., the service of disease regulation could be improved by eradication of a vector known to transmit a disease to people). Degradation of a regulating and supporting services means a reduction in the benefits obtained from the service, either through a change in the service (e.g., *mangrove* loss reducing the storm protection benefits of an ecosystem) or through human pressures on the service exceeding its limits (e.g., excessive pollution exceeding the capability of ecosystems to maintain water quality). For cultural services, enhancement refers to a change in the ecosystem features that increase the cultural (recreational, aesthetic, spiritual, etc.) benefits provided by the ecosystem. The time frame is in general the past 50 years, although if the trend has changed within that time frame the indicator shows the most recent trend."

Appendix Two

Maori World View Around Resources

Maori views of resources extend from their cosmology or view of the supernatural. This view sees the natural and the supernatural worlds as being intimately intertwined through a complex genealogy or whakapapa which connects the supreme god *Io* and *Te Kore* or the nothingness which proceeded creation to the material world of the Earth, *Papatuanuku* and the sky *Ranginui e tu iho nei*. This whakapapa traces the emergence of Rangi's and Papa's children and their eventually successful efforts to separate their parents to create *Te Ao Marama* or the world of light. Subsequently, all things in nature, animate and inanimate are descended from the various gods including Rangi's and Papa's children the most noteworthy of whom, from a natural world perspective, are *Tane mahuta* (God of the forests) and *Tangaroa* (God of the Sea).

The whakapapa of all living things has a similarity to the taxonomy used by botanists and zoologists. For example in the Maori cosmology a number of similar species may share the same "parent gods" in much the same way as in Darwinian evolution where different species of the same genus are related as an evolutionary response to the need or value for specialisation. Similarly as in Darwinian evolution, humans are part of this overall whakapapa although in the Maori cosmology humans are descended from gods as they are in many other traditional and ancient cosmologies.

A key part of the Maori cosmology is mauri or life force or essence. Every living thing has *mauri* and it has been argued that even inanimate things like rocks have mauri as well. A basic ideal of the Maori world view is to safeguard the mauri of things either by *rähui* or prohibitions or through other practice or *kawa* which controls the way resources are used. This responsibility to protect the mauri of natural things is wrapped in the broader responsibility of *kaitiakitanga* or guardianship.

Kaitiakitanga goes to the core of Maori concepts of resource use and "ownership" of resources and relates both to *mana* or prestige and *tuku iho* or bequest. Ownership of resources such as land or access to fisheries or other renewable resources is not seen as absolute as with many western concepts of ownership. Rather such ownership is seen as a privileged responsibility where the group with access rights to the resource have a responsibility to safeguard the mauri of the resource and to pass it to future generation with this mauri intact.

Access to resources are gained through discovery, conquest or gift. Once this access is gained the resource holders have a regulated right to use the resource for their own material and spiritual needs but they also have an obligation to safeguard the resource for the use of their descendants. A group's or individual's mana is related to their access to resources and to the extent to which they exercise their kaitiakitanga or stewardship duties over this resource.

Resource use is regulated through kawa and *tikinga* or cultural values. These regulations are often quite specific and elaborate and tend to imbibe everyday material activities like work with a spiritual dimension. This is done through the dimension of *tapu* or sacredness. Many things are tapu in the traditional Maori world including tipuna or ancestors and the relationship between things. Consequently factors such as knowledge or *mätauranga,* resources or *toanga* and tikinga may be tapu and should be used with care and respect.

An example of this sacredness of resource use is the apparently simple act of weaving or *raranga* of flax or *harakeke*. In Maori cosmology Tane-mahuta not only clothed the earth with plants and trees but also breathed life into humans. Consequently plants such as harakeke and humans share the same genealogy or whakapapa. (much the same as Darwinian evolution suggests). Furthermore the art of weaving and in particular the patterns and techniques used and the things created have spiritual significant so that the practice of raranga is tapu. This sacredness means that practices such as the harvesting of harakeke and disposal of waste is very prescribed in part to preserve the mauri of harakeke and so sustain its continued use.

An interesting dilemma has emerged in the arena of the Waitangi Tribunal and iwi and hapü claims for resources which require modern and essentially non-Maori technologies to discover and exploit. Two

relevant Treaty claims are those of the hapü of Taranaki iwi, Ngati Ruahine, and Hawkes Bay iwi, Ngati Kahungunu, for petroleum (oil and natural gas) resources; and the claim by hapü of northern iwi Nga Puhi for the energy resources of the Ngawha geothermal field.

The Nga Puhi - Ngawha claim (Wai 304) was based on an alleged breach by the Crown in its Treaty obligations to the Nga Puhi hapu who occupied the locality around Ngawha in 1840 and who knew of and made use of the geothermal pools in the area prior to 1840. The alleged breach related to Government drilling for and tapping geothermal energy some distance from the Ngawha hot springs and to depths that Maori in 1840 could not have hoped to reach. The claimants' case was based on the argument that the resource being tapped by the Crown was the same resource as that of the hot springs and that exploitation of the deeper geothermal by drilled wells would diminish their use of and guardianship over this resource.

The Ngati Ruahine (Wai 796) and Ngati Kahungunu (Wai 852) hapü claims related specifically to the alleged confiscation of property rights to petroleum resources under Petroleum Act 1937. This Act effectively nationalised all oil and gas resources under private property including Maori owned land and land which had been subject to confiscation or questionable purchases. The basis of the claimants' argument was that in terms of customary law, Maori as part of the natural universe, have propriety rights in the resources of their universe, including the petroleum within their lands. *(Wai 796 p.5)*

In this case the Crown accepted that the claimants have a customary right to the petroleum under their land and that they had a right (at least to the time of the 1937 Act) to exploit this resource for commercial gain as would any other land owner. The Crown also acknowledged that this right existed regardless of Maori's inability to extract that resource in 1840. Furthermore the Tribunal itself referred to customary rights jurisprudence from British Columbia which did not limit customary rights associated with land ownership just to the traditional or customary activities of the indigenous people at the time of the treaty. In other words Maori have customary rights over resources which require modern technologies to utilise although these customary rights are limited to their ownership of the land on which access to the resource is required.

The application of customary law and associated rights of access to "modern resources" does not by itself answer the question of Maori views of the use of these resources. This question was tested by Mead (2003) where he considered the question of genetic cloning and the use of animal body parts in surgery on humans. Mead suggests that a number of ethical tests need to be considered in other to establish the cultural appropriateness of the use of such resources. These tests involve the application of aspects of tikinga to the ethical question at hand. These aspects include:

- the question of breach of tapu,
- the question of diminution of mauri,
- the acceptance importance of the issue (take),
- whether or not there is a similar precedence in whakapapa, and,
- the guidance offered by other aspects of tikinga such as maanakitanga and whanaungatanga.

Appendix Three

Managing Resources in New Zealand

The management of natural resources is coming to be seen as a critical role of the state and national governments in First World and many Third World nations. This resource management has tended to focus either on the rationing of scarce natural resources or reducing the environmental effects associated with the use and exploitation of resources. To date few if any resource management regimes have adequately addressed the problems of resource depletion and the incremental trading off of environment loss for economic gain.

New Zealand's resource management regime is largely based on the Resource Management Act 1991 although there are several of pieces of legislation such as the Fisheries Act and the Hazardous Substances & New Organisms Act which have tended to deal with specific types of resource. Most of the environmental legislation in New Zealand has a focus on sustainable management which is set down in Section 5 of the Resource Management Act to mean:

Managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural wellbeing and for their health and safety while -

> *a) sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and*
> *b) safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and*
> *c) avoiding, remedying, or mitigating any adverse effects of activities on the environment*

This definition has been problematic for a number of reasons including the lack of information around such ideas as environmental bottom lines which are critical to concepts of safeguarding the life-supporting capacity of ecosystems etc.

Some critics of the sustainable management approach to managing resources point to a lack of concern about the exploitation of non-renewable resources such as minerals and to the emphasis within the concept to seeing resources as existing generally for humans' use. Additional criticism is levelled at the ability to mitigate rather than avoid detrimental environmental effects with the result that resource use is often seen in piecemeal ways. As a consequence resource use is often traded off against environment quality on the basis that economic and environmental values are interchangeable.

The management of natural resources is likely to become more difficult as competition for resources becomes sharper and/or as environmental bottom lines become more apparent. Such developments will place the inevitable tradeoffs between environmental and economic values in sharp contrast and cause communities and societies to make painful choices around the virtues of consumption and conservation.