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72194 Sustainable Development and New Zealand

Assignment 2

Energy production and consumption in New Zealand

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Introduction

This report discusses the trends in past and present energy production and consumption in New Zealand, focussing on the impacts on New Zealand's natural environment and the management responses designed to address them.

Background

The extraction of fossil fuels often have a negative impact on environment and society. Coal is used in New Zealand's industry sector, but most of the local coal production is exported. Local oil production only meets half of the growing demand for vehicle fuels, which are responsible for more than half of New Zealand's greenhouse gas emissions. Gas from the Māui field has long been a cheap source of energy but is now near depletion. New Zealand is rich in renewable energy resources and generation from hydro-electric schemes contributes most to total electricity generation. Geothermal energy, as it is utilised now, should not be considered a renewable form of energy due to unsustainable rates of extraction of hot fluids.

Discussion

Consumer energy demand is rising sharply and is increasingly met with fossil fuels, responsible for the continuing increase in greenhouse gas emissions. The Government's Energy Strategy is rather vague with regards to actions that would reduce New Zealand's greenhouse gas emissions. Attempts to achieve higher levels of energy efficiency are only of limited use as this doesn't necessarily reduce energy consumption. Financial barriers and environmental concerns have slowed down further development of renewable resources with the exception of wind power projects. Contradictory policy impulses also work against the goal towards achieving 90% of electricity generation from renewable energy resources.

Conclusions

Despite New Zealand's wealth of renewable resources, fossil fuels continue to satisfy most of the country's increasing appetite for energy. Generation from renewable energy is still at high rates, but in slow decline, in part because of the Government's hesitant and somewhat contradictory approach to reducing greenhouse gas emissions through an Emission Trading Scheme that tantamounts to subsidising emissions-intensive industries. Modifying the ETS to remove subsidies to polluters and providing positive financial incentives to invest in renewable energy projects could help New Zealand to achieve the ambitious goals of the Energy Strategy.

2 Introduction

This report discusses the trends in past and present energy production and consumption in New Zealand, focussing on the impacts on New Zealand's natural environment and the management responses designed to address them.

3 Background

In the following, I shall review the histories and trends in production and consumption of New Zealand's main sources of energy, namely fossil fuels such as coal, oil, and gas, and a range of energy sources that are traditionally categorised as renewable, including hydro power and geothermal.

3.1 Fossil fuels

3.1.1 Coal

Coal has been an important source of energy in New Zealand since the establishment of European settlements at the end of the 19th century (Ministry of Economic Development, 2011b). New Zealand's coal reserves—most of which are located on the west coast—are estimated to exceed 15 billion tonnes (Barry, Duff, & Macfarlane, 1994).

More than 70% of New Zealand's annual production of more than 5 million tonnes in 2011 were exported, a tremendous increase compared to 10% in 1990 (Elliot et al., 2011). Most of the remainder of the local coal production is used for electricity generation (about 4% of New Zealand's total consumer energy supply) and in industrial processes, including the production of steel and cement, as well as the processing of wood, dairy, and wool (Elliot et al., 2011).

Surface mining procedures to extract coal often result in severe degradation and destruction of ecosystems that exist at and around the mined site. Sites with coal deposits near the surface are stripped of all vegetation before the overburden is removed. Streams and rivers passing through the site are redirected, affecting aquatic and riparian communities directly and by altering the flow and sedimentation characteristics (Miller & Spoolman, 2009). In some mining methods ablated soil and rock is deposited as spoil banks which are exposed to erosion and recover only very slowly through primary succession. These deposits constitute a long-term source of water contamination as pyrites in the exposed waste piles oxidise, resulting in the production of metal-laden acid solutions that are flushed into streams by rainfall and snow melt (Gray, 1997).

Burning coal leaves behind toxic ash that has to be treated and deposited safely as it contains toxic trace elements, including arsenic, selenium, chromium, cadmium, and mercury,

that can leach from landfills and ash basins, pollute groundwater and surface waters, and become biologically magnified in food webs (Cherry & Guthrie, 1977; Wiener, Krabbenhoft, Heinz, & Scheuhammer, 2002; Singh & Kolay, 2009).

Coal mining not only impacts the natural environment, but also may have disruptive effects on society, as evidenced by the story of Rotowaro ("lake of coal"). Once a small village of 400 mine workers and their families (Cook, 2006), it is now the location of one of the most productive coal mines in the Waikato (Elliot et al., 2011). The township was evacuated in 1987 and eventually became part of an opencast mine to enable access to the coal beneath the village, leaving no trace of its former existence (Cook, 2006).

3.1.2 Oil and gas

All of New Zealand's productive oil and gas fields are located in the Taranaki Basin, a petroleum basin to the west coast of the North Island covering an area of about 330,000 square kilometres (Crown Minerals, Ministry of Economic Development, 2011). Since modern oil exploration started in the mid-1950s, more than 400 onshore and offshore wells have been drilled (Crown Minerals, Ministry of Economic Development, 2011). Despite increasing oil production volumes since the 1970s, New Zealand's domestic oil production satisfies only 51% of the local demand for petrol, diesel and other products derived from oil (Elliot et al., 2011). Most of the remaining 49% is imported from the Middle East and Asia (Elliot et al., 2011).

The use of petrol by the transport sector has dominated oil consumption since gathering oil consumption statistics in 1974 (Elliot et al., 2011). In 2010 the use of petrol and diesel made up 80% of total oil consumption (Elliot et al., 2011). Between 1985 and 2007 the demand for oil grew continuously by about 3% per year, though in recent years the trend has flattened (Elliot et al., 2011).

In 1969 the massive Māui gas field was discovered off the west coast in the Taranaki basin (Ministry of Economic Development, 2011c). Originally considered too big and expensive to exploit for New Zealand's electricity generation and industrial needs, the gas field was more intensively used when international oil prices soared in the 1970s (Gregg & Walrond, 2009). Until the 2000s, when the gas field began nearing depletion, Māui gas was increasingly used for electricity generation, contributing up to 30% to the total electricity supply (Gregg & Walrond, 2009). In 2004 only 16% of New Zealand's electricity was generated from natural gas as the Māui field further declined, but increased production from the Pohokura field has since buffered the total gas supply, such that in the following years electricity generation from natural gas again reached levels above 20% (Elliot et al., 2011; Ministry of Economic Development, 2011a).

According to the Ministry of Economic Development (2011d), the use of liquid fuels derived from oil is responsible for more than half of New Zealand's total greenhouse gas

emissions. The remainder is dominated by emissions from the combustion of gas and coal (Ministry of Economic Development, 2011d). The use of petrol and diesel affects local air quality, and run-off from roads may impair local water quality (Ministry for the Environment, 2008).

Climate change driven by an increase of greenhouse gases is a considerable threat to New Zealand's unique biota as projected sea level rise, ocean acidification, changes in rainfall patterns and frequency of droughts, and temperature shifts result in the loss of suitable habitat for many already endangered species (Lundquist, Ramsay, Bell, Swales, & Kerr, 2011).

3.2 Renewables

Utilisation of what are generally considered renewable sources of energy has a long tradition in New Zealand—for Maori who used hot springs for cooking, heating, and medical purposes, as well as for *pakeha*, who supported early gold mining operations with the energy from rivers and lakes (Stewart, 2009b; Kelly, 2011). The most important renewable energy sources in New Zealand are hydro power and geothermal energy. Although the potential capacity of renewable energy sources underwent development during recent decades, the contribution of renewable energy to overall electricity generation is declining. The proportion of electricity generated from renewables has fallen below 70% in the last decade, a level lower than that in previous decades since 1974 (IPENZ, 2010).

3.2.1 Hydro power

Hydro power was used to generate electricity for public use as early as 1888 when a hydro-electric unit supplied power to the electric public lighting in the gold mining town of Reefton (Kelly, 2011). The first hydroelectric power station built by the New Zealand government at Okere Falls in 1901 marked the beginning of an era of development of water power capacity (Martin, 1999). However, it took until 1930 before the percentage of electricity generated by coal-fired power plants and coal-gasification plants fell below that generated by hydro power stations (Martin, 1999). From the mid-1940s until the end of the 1980s, New Zealand's capacity for hydroelectricity was dramatically extended by roughly a factor of 10 (Kelly, 2011). By the 1950s, New Zealand's hydroelectricity capacity already exceeded 1000 MW; in 2010 hydro power contributed more than 56% to the total electricity generation with a total capacity of about 5000 MW (Elliot et al., 2011).

Hydro-electric power schemes rely on water storage, which is often realised by damming river channels. Dams interfere with the natural processes of the affected aquatic and riparian systems by altering flow rates, sedimentation, and flooding levels (Young, Smart, & Harding, 2004). Fluctuations in electricity demand can directly translate to fluctuations in downstream flow and affect upstream lake levels (Young et al., 2004). Changes in lake levels can increase shoreline erosion, leading to higher sediment loads which decreases the available light to

aquatic plant communities (Young et al., 2004). Dams significantly affect sediment transport by rivers, causing an increase in sediment load upstream while starving the downstream segments of sediment, allowing the water downstream to erode the river bed and banks, as can be observed at the exposed piles beneath the Claudelands Rail Bridge crossing the Waikato river (Young et al., 2004).

3.2.2 Geothermal energy

Straddled across the Pacific and Australian tectonic plates, New Zealand is located in a region of constant geological activity that endows the country with a wealth of geothermal resources. New Zealand's geothermal energy resources were first used for electricity generation in 1906, but it took more than half a century until commercial scale geothermal generation plants became operational (Kelly, 2011). It was not until the 1990s before the total capacity for generation from geothermal energy was significantly extended from the level of the 1950s, now reaching a little over 700 MW (Kelly, 2011).

Geothermal energy is used directly for heating or for tourism, and to generate electricity. In New Zealand, significant direct use of geothermal energy was limited to the Rotorua-Taupo region where the application of geothermal energy for industrial process heat dominated other direct uses (White, 2009). A much larger share of the geothermal production in New Zealand is used for generating electricity (Elliot et al., 2011). Generation from geothermal energy has been exceptionally productive in recent years (see figure 1) and accounted for almost 13% of New Zealand's net electricity production in 2010 compared to only about 7% in 2000 (Elliot et al., 2011).

Although geothermal energy is usually considered a renewable form of energy, it often is used in a manner that is not sustainable, as the rate of fluid extraction usually exceeds the replenishment rate (Kelly, 2011; MacKay, 2009). The extraction of water from underground can lead to subsidence, i.e. compression or sinking of the land as the rate of fluid withdrawal exceeds the natural inflow rate, adding to the maintenance costs of power stations and other buildings (Stewart, 2009a). Subsidence caused by excessive fluid withdrawal may also damage natural geothermal features. According to Stewart (2009a),

> the withdrawal of hot fluids from the underground reservoir [in the Wairākei geothermal field] began to cause long-term changes to the famous Geyser Valley, the nearby Waiora Valley, and the mighty Karapiti blowhole. …
>
> In Geyser Valley, one of the first features to vanish was the great Wairākei geyser, which used to play to a height of 42 metres. Subsequently, the famous Champagne Pool, a blue-tinted boiling spring, dwindled away to a faint wisp of steam.

According to (Ármannsson & Kristmannsdóttir, 1992), subsidence effects can be overcome by re-injecting spent fluids, though this is not always possible and may initiate earth-

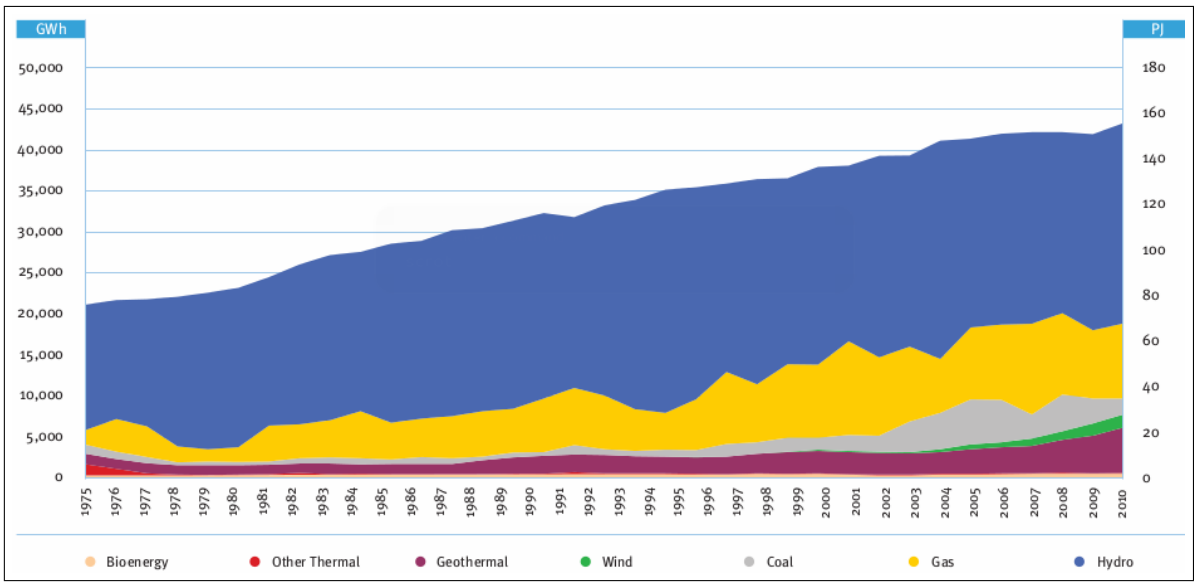

Figure 1: Relative contribution of different energy sources to total electricity generation in New Zealand from 1990 to 2010. Reproduced from: Elliot et al. (2011).

quakes. If waste water is released into rivers, lakes, or local ground water, it can seriously alter the affected aquatic system as the average water temperature is increased and—in case of untreated waste water—hazardous substances such as hydrogen sulphide, arsenic, and mercury accumulate in sediments and organisms (Ármannsson & Kristmannsdóttir, 1992). The release of spent water into waterways may make the water unsuitable for drinking or irrigation purposes (Stewart, 2009a).

3.3 Management response

New Zealand's reliance on fossil fuels, increasing population pressures, and the rise in greenhouse gas emissions are all issues in the Government's environment and energy policies. The *New Zealand Energy Strategy to 2050* and the *New Zealand Energy Efficiency and Conservation Stragey* in particular address these issues and attempt to reduce the impacts of energy production and consumption on public health and the natural environment, while also aiming to improve security of energy supply. In the following section I shall review the recent trends in consumption and production in the light of these strategies and related policies.

4 Discussion

4.1 The balance between fossil fuels and renewable energy

Although a considerable proportion of the total electricity generation is derived from renewable energy sources (see figure 1), the consumer energy demand is heavily dominated by oil and there has been no significant change in the ratio of fossil fuels (70%) to renewables

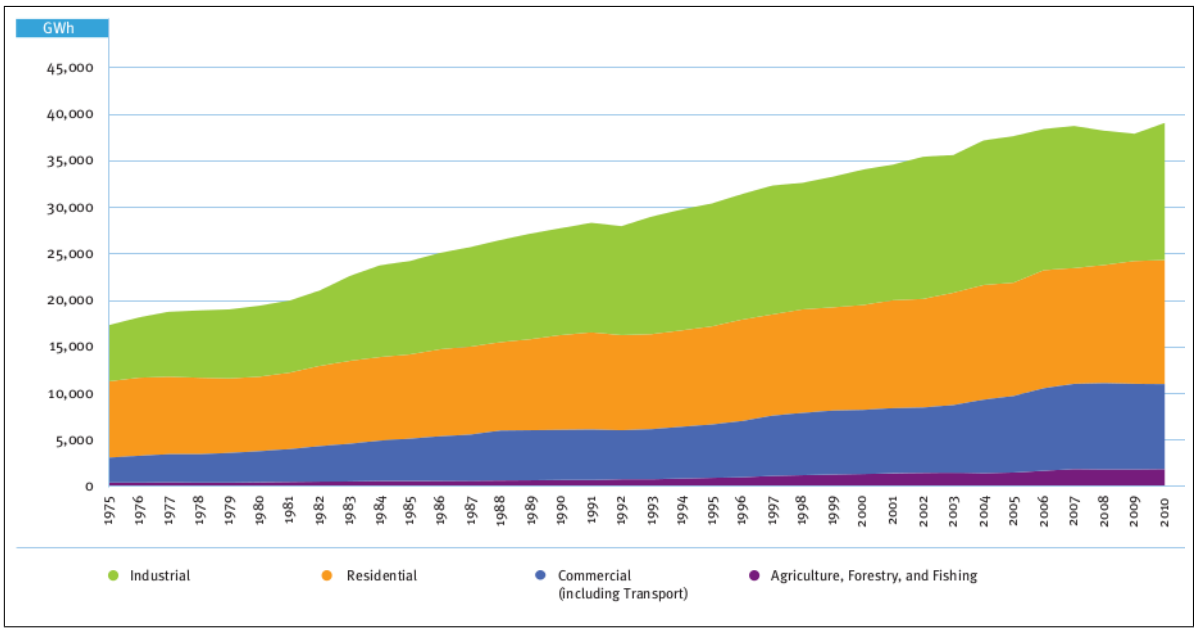

Figure 2: Electricity consumption by sector from 1975 to 2010. Reproduced from: Elliot et al. (2011).

(30%) in the total energy supply (Ministry for the Environment, 2009). By 2007 consumer energy demand had grown by 39% compared to 1990 levels (see figure 2); normalised by population the trend is unaltered (Ministry for the Environment, 2009). This increase in energy demand correlates with an increase of greenhouse gas emissions 39% higher compared to 1990, caused largely by the combustion of petrol and diesel (Ministry for the Environment, 2009).

The 2008 drought that reduced electricity generation from hydro power stations is also linked to the recent rise in greenhouse gas emission, as the drop in hydroelectricity was compensated for by increased generation from coal (Ministry for the Environment, 2009). The use of coal for electricity generation rose sharply during the late 1990s and is still above 1980 levels (Elliot et al., 2011).

In recent decades a trend can be observed that rising energy demand is increasingly met by fossil fuels. The report *Environment New Zealand 2007* attributes the overall increase in the demand for energy to a number of factors, including population growth, increasingly smaller households, and a marked increase in the number of vehicles (Ministry for the Environment, 2008). According to the Institution of Professional Engineers, "it is unlikely that any progress will be made towards achieving the Government's objective of reducing emissions", predicting a further 8% rise of greenhouse gas emissions by 2025 (IPENZ, 2010). Sadly, even the latest *New Zealand Energy Efficiency and Conservation Strategy* is rather vague about how greenhouse gas emissions and the strong dependency on oil are to be reduced. While many successful government projects have been developed to help businesses and households to improve their energy efficiency (Ministry for the Environment, 2008), the biggest consumer of oil and therefore primary emitter of greenhouse gases—the transport sector—seems to get little attention beyond the necessary but not sufficient pledge to improve the public trans-

portation infrastructure (see Ministry for the Environment, 2011).

The recent increase in the utilisation of fossil fuels is especially disappointing considering the goals that were declared in the *New Zealand Energy Strategy* in 2007. One of its targets is to achieve

> renewable electricity generation of 90% by 2025 (based on delivered electricity in an average hydrological year). (Ministry of Economic Development, 2007)

Observing the continuing slow decline of the proportion of renewable energy to national electricity generation since 1974 it seems rather unlikely that this goal can be met (IPENZ, 2010). Despite this slow downward trend, there has been an increase in the number of renewable energy projects in recent years, in particular wind power projects (IPENZ, 2010). According to the IPENZ (2010), however, this is not mainly because of government action, but a consequence of the end of cheap gas from the Māui field and higher energy prices that make renewable energy projects more viable.

Government action may also play against the achievement of the goals outlined in the New Zealand Energy Strategy; as the IPENZ (2010) criticises in their 2010 report, the Government repealed a moratorium on new fossil-fuelled generation plants in 2008 and amended the Climate Change Response Act to shift the obligations of the Act into the future, thereby attenuating the immediate need for emission reductions. According to Wright (2011), the allocation of free carbon credits to firms under the Emissions Trading Scheme actually subsidises polluting companies and removes the incentive for reducing emissions. He further states that

> in 2050 the New Zealand Government will still be paying for 55 percent of emissions from high emissions-intensive industries, and 37 percent from medium emissions-intensive industries. This is incompatible with the Government's target to reduce 1990 emissions by 50 percent by 2050.

The latest *New Zealand Energy Efficiency and Conservation Strategy* continues to stress the importance of the development of renewable energy resources, and renews the Government's commitment to "removing unnecessary regulatory barriers" (Ministry for the Environment, 2011). While the Strategy declares that investment in renewable energy is already being put at a financial advantage over fossil fuels by putting a price on carbon (through the New Zealand Emissions Trading Scheme), little else is being done to encourage the growth of the renewable energy sector (Kelly, 2011).

4.2 The future of renewable energy

Although hydro capacity has potential for growth in New Zealand, there are barriers to further development. Not only are the environmental costs for large scale hydro power stations prohibitive; developing hydro capacity is also much more expensive than developing other forms

of renewable energy (Kelly, 2011). Its dependence on water supply in storage lakes which is subject to seasonal swings also makes hydroelectricity a less desirable option compared to other methods of electricity generation.

The potential geothermal generation capacity in New Zealand is estimated to be far higher than today's installed capacity. The environmental impacts associated with the development of geothermal resources, however, are major barriers limiting further development, also because they generate conflict between the use of geothermal energy for tourism attractions and electricity generation (Kelly, 2011).

Despite its very short history in New Zealand, wind power becomes quickly more important in the generation of electricity. By 2005 wind power contributed more to total electricity generation than the burning of biomass (Elliot et al., 2011). Although further growth in generation from wind power is to be expected, it is unlikely that it will be enough to increase the proportion of electricity generation from renewables to the level that is targetted by the New Zealand Energy Strategy before 2025 (IPENZ, 2010).

5 Conclusions

Despite New Zealand's wealth of renewable resources, fossil fuels continue to satisfy most of the country's increasing appetite for energy. Generation from renewable energy is still at high rates, but in slow decline, in part because of the Government's hesitant and somewhat contradictory approach to reducing greenhouse gas emissions through an Emission Trading Scheme that tantamounts to subsidising emissions-intensive industries. Modifying the ETS to remove subsidies to polluters and providing positive financial incentives to invest in renewable energy projects could help New Zealand to achieve the ambitious goals of the Energy Strategy.

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