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"Mining to Keep the Home Fires Burning."
- New Zealand's Energy in the 21st Century.

By
John P Ashby

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MINING TO
KEEP THE HOME FIRES BURNING

- New Zealand's Energy in the 21st Century

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ABSTRACT

As a result of cheap Maui gas and plentiful hydro-electricity, over the past few decades New Zealand has enjoyed some of the cheapest energy of any OECD country. The situation is changing; at best we are facing some radical changes in energy use, at worst we are facing a crisis resulting from the following:

Cause 1: Maui gas will be exhausted by 2012. Distorted pricing and supply contracts; - resulted in Huntly Power Station, a coal mine mouth generator running on 70% Maui gas until very recently!

Cause 2: Investment in new generating capacity (and transmission) is woefully inadequate; - as a result hydro lake levels are being continually pushed to the limits.

Cause 3: Distorted thinking is everywhere, for example; "We will find more cheap gas." "Gas is clean - coal is dirty." Hot air – “green alternatives such as wind generation will save us." "No Nuclear." The outcomes of the distorted thinking will be price increases, then shortages (there is nothing like "black-outs" to focus national thinking) and finally recession.

But what can NZ do? - Mine Coal. Coal jump-started the industrial revolution, it can provide the transition to post-gas and oil. NZ has the second highest reserves of coal per capita in the world, yet we use less that any other country with significant coal reserves. Our exports of our best coal have increased threefold, yet out own consumption has remained static at about 1-1.5 Mtpa for the last 30 years. Our coal is NZ owned and inexpensive relative to other energy sources, even allowing for infrastructure and environmental costs.

What can we do? We as mining professionals can promote informed responsible development and investment in the country's mining and energy business. We can galvanise public opinion on issues such as "unbundling" our entire energy chain from mine - to generator - through transmission, even if the nuclear issue has to wait! With oil above US$70/bbl substitution is feasible. - For individuals, there is always solar!

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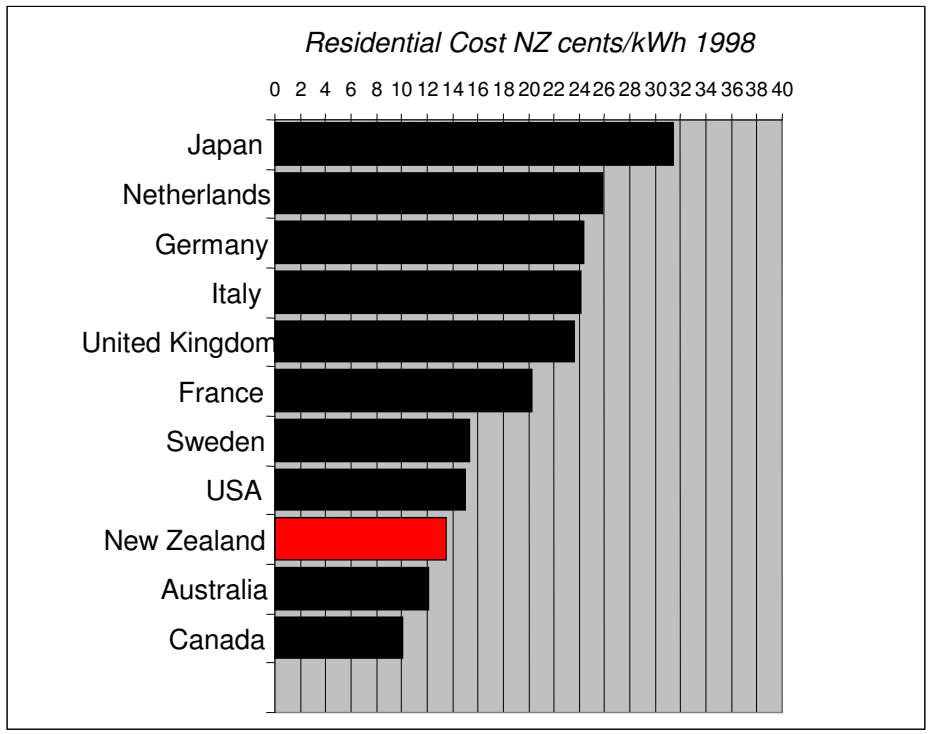
Preface

The quality of information on energy in New Zealand is sometimes questionable or non-existent. The Author has made every effort to base conclusions on current and accurate data.

New Zealand's Energy position in 2006 – a false sense of security

As a result of cheap gas from the Maui gas and plentiful hydro-electricity, New Zealand has enjoyed some of the cheapest electricity of any OECD country over the past few decades as illustrated by the following graph:



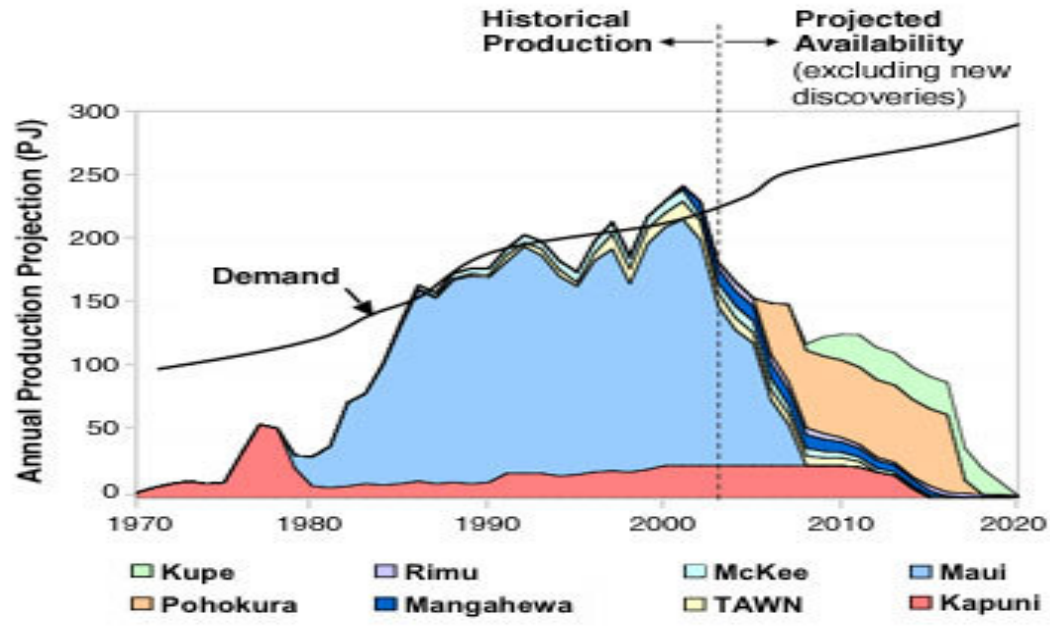
New Zealanders have been lulled into a false sense of security. The situation is changing; at best we are facing some radical changes in energy use, at worst we are facing a crisis by the end of this decade. This appalling situation results from various factors including the following:

- Fuel supply problems including the demise of Maui Gas
- Insufficient investment in new generation
- Distorted thinking

Cause 1: Fuel Supply Problems

Maui Gas

Maui gas will be exhausted between 2009-2012. Reliable reserve data is not published and even well informed wholesale consumers are guessing as to when the tap will be turned off. The following graph seems to sum up the situation fairly well:



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The Ministry of Economic Development suggests the gas available by 2015 will be less than half that required for electricity generation, even with Huntly Power Station running entirely on coal. But where did the gas go?

The problem started and ended with the Maui gas contract. It started with the Government committing to a take-or-pay contract for volumes which greatly exceeded New Zealand's foreseeable domestic demand. To avoid these penalties, demand was "created" in the form of a petrochemical industry. It is ending three decades later with severe withdrawal symptoms – weaning ourselves off cheap gas which has been force-fed into the economy.

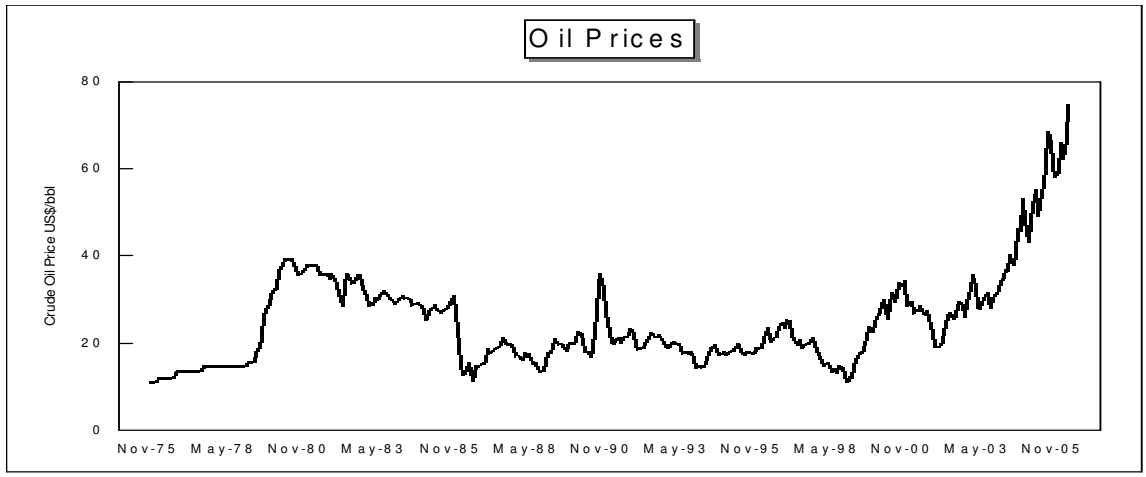
This distorted gas pricing and supply contracts resulted in the Huntly Power Station, a coal mine mouth generator, running on in excess of 68% Maui gas for two decades. In total it is estimated that 42% of Maui gas was used for electricity generation, much of it in older less efficient plant located away from the market.

A further 31% of Maui gas was used in to produce methanol until the Methanex plant was closed in 2005.

To date the search for replacement gas reserves has been disappointing.

Oil

Importation of oil used to be an option for power generation but with crude oil at $US70/bbl and beyond there are better options and many opportunities for substitution.



Coal

New Zealand has ample coal, more per capita than any country except Australia. We export coal in increasing quantities from the West Coast (3Mtpa) yet our domestic consumption mostly of North Island thermal coal has remained constant at about 1-1.5Mtpa for some decades. Ironically, we now import approximately 1.25Mtpa of Indonesian coal to keep Huntly power station running to capacity. This is a “Coals to Huntly” twist on the old country saying “Coals to Newcastle”.

New Zealand coal will be discussed later and the author will try to explain why it is so under-utilised.

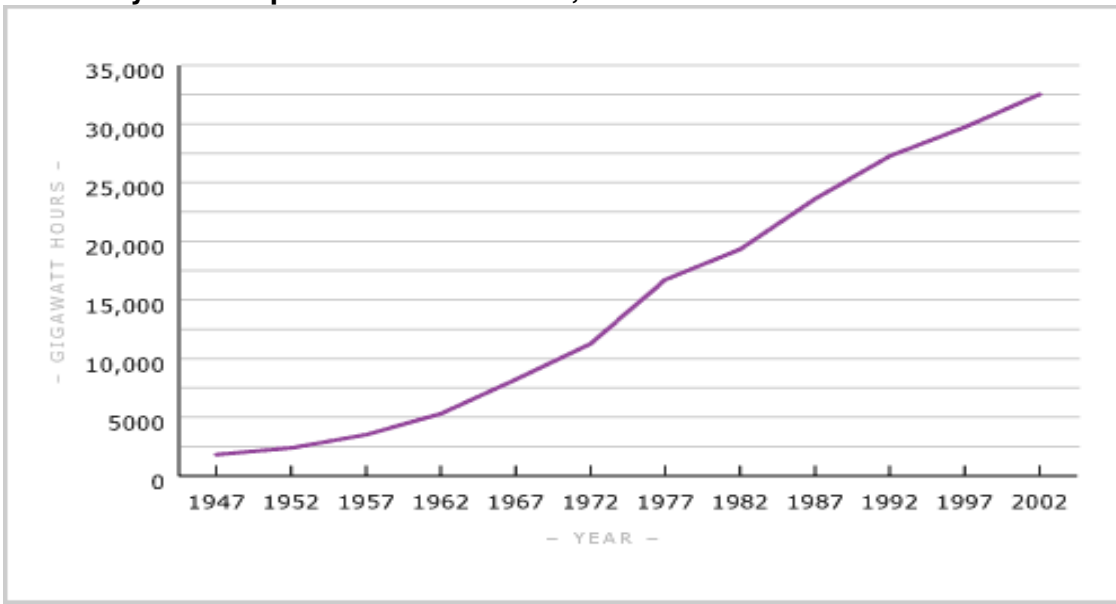
Cause 2: Insufficient Investment

Investment in new generating capacity (and transmission) has been woefully inadequate. One manifestation of this is that all generation capacity and hydro lake levels are being continually pushed to the limits, even in not particularly dry years, because of insufficient base load generation.

Since the electricity industry was restructured post 1987, investment in new generating capacity has been less than half of the growth in demand. We consume

about 10,000Kw (or 36GJ) per person with demand for new capacity increasing at about 150 Mw per year – equivalent to a new single set generator every 2 years.

Electricity consumption in New Zealand, 1947–2002



Source: New Zealand Official Yearbook, 1947–2002

Huntly Power station (1000Mw) was built through the early 1980's. It has old inflexible boilers, no secondary recovery and cooling provided by the Waikato River. New Zealand has become so dependent upon Huntly that it cannot afford to shut down even one of the four units for a boiler reline or upgrade. The new e3p (350Mwe) gas turbine unit being constructed at Huntly, of all places, might provide some relief – assuming that the gas supplies can be justified and sustained, and that there is sufficient transmission capacity to take the power to Auckland!

Electricity transmission systems in New Zealand, developed since the 1950's, have been neglected since 1980, despite a 50% growth in demand since then. The systems are antiquated and in serious threat of failure as illustrated by the failures of the Auckland supply in 1998 and 2006. The North Island is dependant upon the Direct Current link commissioned in 1965 to carry hydro South Island power across Cook Strait and is the only system of its type in the world that is still operational.

Cause 3: Distorted Thinking

Accurate facts on New Zealand's energy position are surprisingly difficult to come by, – for example try trolling the Web for "coal price" and the figures are "not available" or "confidential". The lack of reliable data on gas reserves was discussed above. Without solid facts, misinformation and distorted thinking follows especially when politics is involved.

Even following deregulation and privatisation, other than for petroleum and gas, the energy business in New Zealand is still monopolised by the Government. Coal mining, electricity generation and distribution are handled almost exclusively by State

Owned Enterprises (SOE's). It is perhaps ironic that, as a state monopoly the NZ Government managed to build world class infrastructure, yet the market model that replaced the old monopoly has failed to encourage investment. The Government has retained ownership through its shareholding but has neither retained responsibility for security of supply nor properly divested that responsibility to the SOE's.

While errors were made early on, even the much maligned "Think Big" policies of the 70's and 80's had many successes: The Government of the day encouraged extensive studies, for example the Coal Resources Survey and the Liquid Fuels Trust Board. Perhaps the most distorted thinking is that the current economic model built around SOE's and private enterprise would work in New Zealand's best interests without legislated performance requirements. The greatest single simple improvement would be to require all generators to guarantee supply either through their own resources or via back-up contracts.

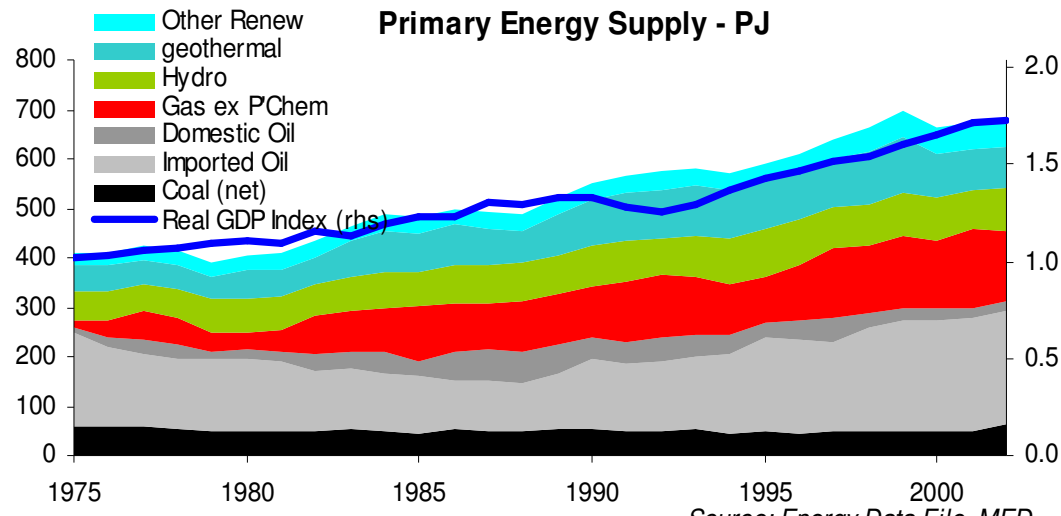
A non-partisan approach to energy development is urgently needed in Parliament.

Distorted thinking and misinformation is rife in the media and general population. New Zealanders need to be better informed. Examples of the distortions include "there is ample gas", "we will find more cheap gas", we will replace Maui gas with Liquefied Natural Gas (LNG)" -which is particularly curious because of the high cost when LNG is sourced on the spot market.

Then there are the green messages "wind generation will save us", "Gas is clean - coal is dirty", "No Nuclear." NIMBY – not in my back yard prevails when consenting new capacity and the Resource Management Act gets the blame. However, the balancing argument of the greater need of the Country or the Economy should carry more weight.

Outcome – the Crisis

The outcome of the situation will be price increases, then shortages and finally recession. Energy demand is inextricably linked to the economy as illustrated by the next figure:



Source: Energy Data File, MED

On the positive side there is nothing like electricity shortages (brown-outs and black-outs) to galvanise national thinking, Unfortunately new generating capacity takes considerable capital investment and time to bring on line and in the Author's opinion we scarcely have enough time. A severe downturn in the economy is the inevitable outcome unless dramatic action is taken.

What can New Zealand do?

NZ both the Government and the Population need to change:

- Ensure responsible exploitation of fuels especially indigenous fuels
- Encourage true competition and investment in energy
- Replace distorted thinking by research and education

Mining in the broad sense is at the centre of the solution and can make the difference and "keep the home fires burning".

Gas Utilisation

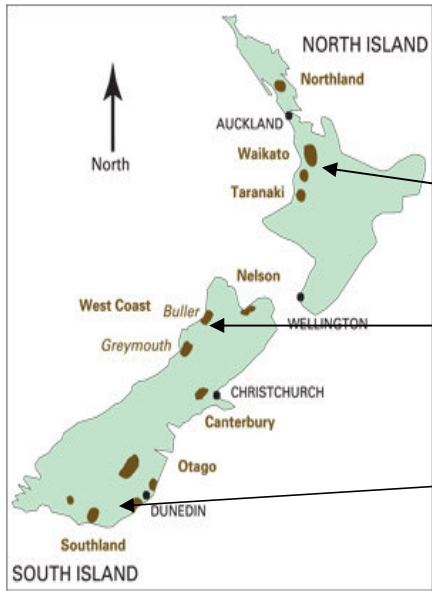
Our dwindling supplies of natural gas should be utilised wisely. Gas should be priced properly and utilised as a fuel that can be reticulated and used directly by the customer.

The efficiency of burning gas in old thermal coal station such as Huntly is no greater than when burning coal and the practice should be discontinued! The remaining natural gas should only be used for electricity generation when there is no alternative. If gas is to be used for electricity generation it should be done using efficient turbines with secondary recovery located close to the market to avoid transmission charges and line losses.

Coal Utilisation

New Zealand is blessed with vast coal resources as shown in the following figure. The coal is NZ owned and cheaper than other energy sources, even allowing for infrastructure and environmental costs.

New Zealand Coal Reserves

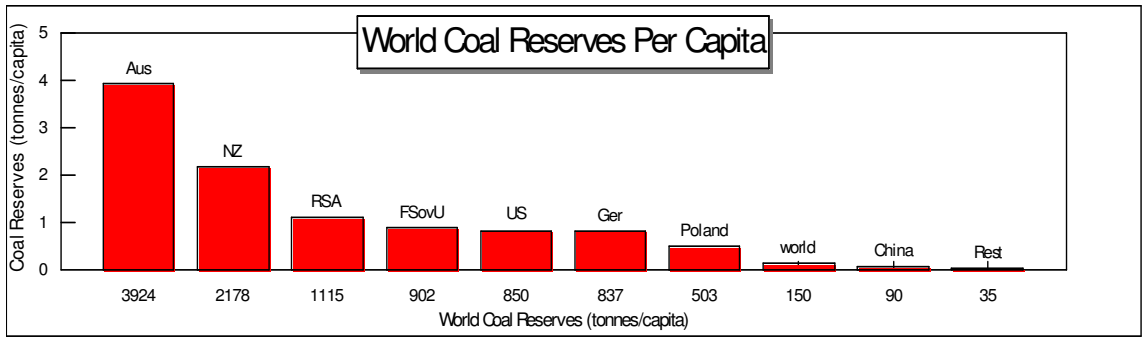


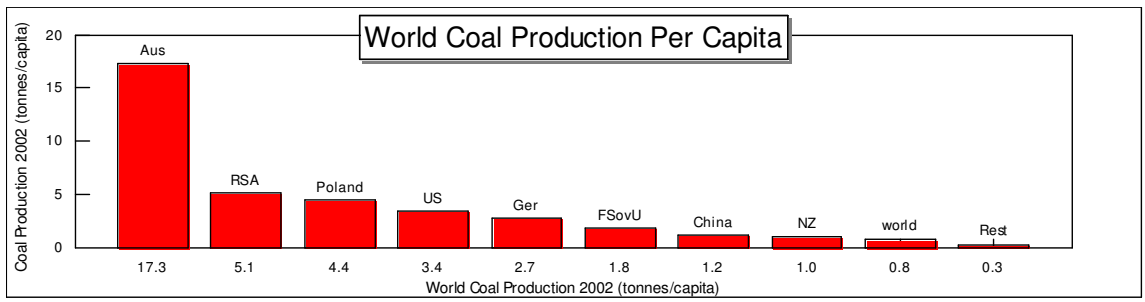
North Island sub-bituminous **870Mt (18,000PJ)**

W Coast Bituminous **340Mt (9,000PJ)**

. SI Lignite & Sub-Bituminous **7500Mt (110,000PJ)**

NZ has the second highest reserves of coal per capita in the world, yet we mine less that any other country with significant coal reserves as shown by the following graphs:





Cost of Coal Production

An indication of the cost of coal mining in the North Island was provided in a study for the Author conducted in 1988 for the Electricity Corporation of New Zealand (ECNZ). At that stage given the distorted pricing of gas, Maui Gas was priced at less than the cheapest coal. Coal could not compete and Huntly power station converted to Maui gas.

Those costs of mining coal have been escalated to present day dollars as shown in the following Table.

Estimated Cost of Mining North Island Thermal Coal

	Cost *NZ2006$
Rotowaro Callaghans OC	**3.7$/GJ**
Rotowaro Pukemiro OC	**3.9$/GJ**
Mokau OC	**4.3$/GJ ***
Maramarua OC	**4.5$/GJ**
Huntly West UG	**5.2$/GJ**
Ohinewai OC	**5.4$/GJ**
Maramarua UG	**5.8$/GJ**
Kawhia East UG	**5.9$/GJ**
Kawhia West UG	**6.3$/GJ**
Mokau UG	**7.0$/GJ**
Tihiroa UG	**7.1$/GJ**

Note * Estimated average discounted cost NZ$2006 of mining coal at a rate of 800,00tpa for at least 10 years, to mine gate after tax , excluding GST at a discount rate of 10%
OC- opencast UG – underground

Seventeen years on from that study, with the current New Zealand natural gas and coal prices at about $6.0/GJ, most of the North Island opencast and the cheaper underground coal would be competitive.

The current coal price of thermal coal on the Australian spot market is $US53/t. Shipped to New Zealand it is estimated that this coal could be landed and freighted to a generator for between 5.0-5.5$NZ/GJ. Thus as a source of energy North Island lower strip ratio opencast thermal coal should be able to compete with domestic gas and imported coal.

Coal and the Environment

But what about the environmental issues associated with burning coal? Coal, oil and natural gas are of course all fossil fuels. When fossil fuels are burnt they produce carbon dioxide ($C0_2$) which is widely implicated as a cause of Global Warming. Are these sufficient grounds to abandon coal?

Taxing $C0_2$ emissions as considered by the NZ Government under the Kyoto Protocol, was promoted as a solution to the environmental woes. However, the tax would not have encouraged what are really needed are responsible government policies, uniform treatment of all “polluters” and investment in new less polluting

plant. The policy was dropped in 2005 but not replaced by any alternative which has lead to even more uncertainty.

The following table shows that coal with its higher carbon content generates approximately twice as much CO_2 when burnt than natural gas and about 50% more than fuel oil. Nevertheless, the influence of the carbon tax of $NZ15/tonne CO_2 that had been proposed by the Government ranges from about $2/GJ of electricity generated by natural gas to $4.5/GJ for coal generated electricity is relatively insignificant compared to the cost of the fuel component.

Cost of Electricity Production from Fossil Fuels			
	Natural Gas	**Oil**	**Coal**
	hydrogen rich < > carbon rich		
Current NZ Fuel Price $NZ/GJ	$5	$20	$5.2
Efficiency of conversion to electricity	36%	39%	38%
Fuel Cost to generate 1GJ of electricity	$13.9	$51.3	$13.7
Fuel Cost to generate 1GJ of electricity	$13.9	$51.3	$13.7
Kg CO2 produced per GJ fuel	52	76	115
Kg CO2 produced per GJ of electricity	145	195	302
Proportion CO2 per GJ compared with natural gas	100%	120%	208%
Total cost per GJ of electricity $NZ/GJ	$16.08	$54.23	$18.23

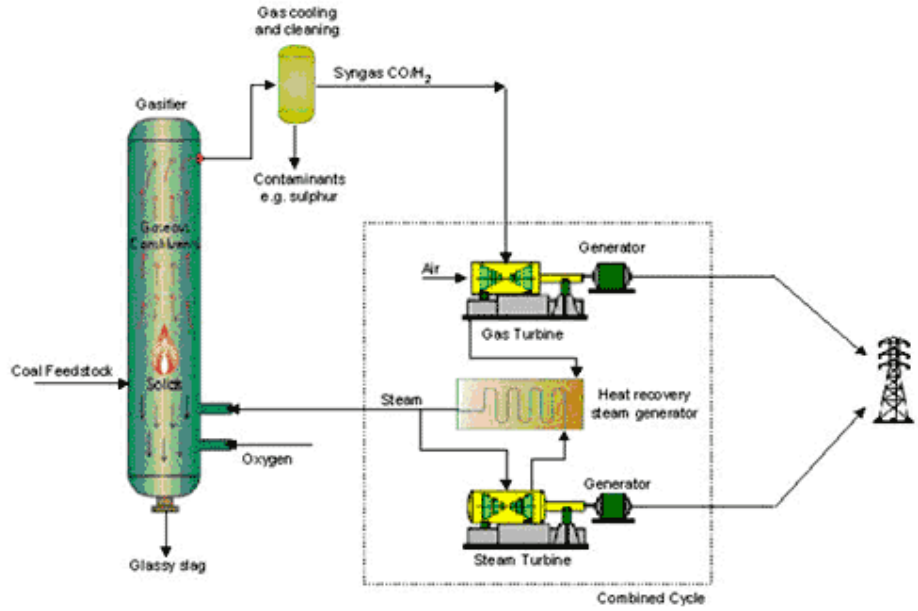
The use of coal should be based upon the availability of alternatives, the environmental effects and the effect on the economy of not using it. Give the gas situation, It follows from the above that even allowing for environmental effects by applying a carbon tax, domestic coal is a cost effective fuel for electricity generation.

Coal as a Fuel or as a Raw Material

Attention is being given in the technical literature and even the press to cleaner use of coal. Some improvements such as secondary heat recovery can be made incrementally by upgrading existing thermal power stations. However the real advances are in techniques such as Integrated Gasification Combined Cycle (IGCC) shown below. Typically these techniques involve converting coal to a gas, combustion of the gas to drive turbines directly, with use of remaining heat to drive low pressure or steam turbines.

Gasification of coal was developed during the industrial revolution it spurred a significant chemical industry and was well established by the beginning of the 20th Century. Cleaner natural gas, a by product of petroleum displaced smellier, less pure coal gas in most economies.

IGCC Process



Source Australian Black Coal Utilisation Research Limited 2002

To begin to understand the cleaner coal techniques it is better to think of coal as a raw material rather than just a fuel. The Author must confess to only reaching this conclusion during the writing of this paper – we can all suffer from distorted thinking! Clearly petroleum is a fuel as well as precursor in the petrochemical industry which was started with coal.

Petroleum is sent to plants called refineries – we should start thinking about refining coal. Burning coal and then cleaning up the pollutants, for example scrubbing nitrogen and sulphur oxides from the flue gas is commonly undertaken, but is akin to "closing the stable door".

A better approach is to send the coal to a plant where chemical reactions can be contained and controlled, for example:

C	+	H_2O	+	heat	=	CO	+	H_2
carbon	+	water	+	heat	=	carbon monoxide	+	hydrogen

The gaseous products can be used directly as fuels or for power generation or as precursors or reagents for further "petrochemical" processes. The South African oil from coal Sasol process starts in this way. Even the contaminants in coal such as sulphur can be used to produce valuable by-products rather than pollutants.

But what about that ubiquitous greenhouse gas, carbon dioxide? By containing potential pollutants in a closed plant it will be easier to manage them. For example it is easier to conceive of storage of carbon dioxide if it is a pipe rather than up the flue.

Alternative Energy Sources

What about alternative sources of electricity? –Surely wind is the answer particularly with the ample resources in places such as the Manawatu? A comparison of electricity generation costs for new plant including wind generators in the UK is shown in the following table. The main contributor to the high cost per unit is the high capital cost of wind farms and the fact that wind does not blow all the time. The table includes the cost of backup supplies when the wind is not blowing. Although claimed by some to be clean and green the environmental impacts, particularly the visual effect on our landscape is hardly minor. The potential of wind is also small compared to overall energy demand. As an alternative source of energy, wind just does not rate. In generating the following table a particularly high carbon tax was assumed by the Royal Academy for electricity generation using fossil fuels. (The effects of a more realistic carbon tax have been added to the table by the Author.)

2004 Cost of Generating UK Electricity from various fuels and new plant NZ¢/kWh

	Nuclear	**Gas** CCGT	**Coal** Pulverised	**Coal** Fluidised Bed	**Wind** Onshore	**Wind** Offshore
Basic Cost	6.6	6.3	7.1	7.4	10.6	15.7
With CO2 $315/t *	-	9.7	14.3	14.6	-	-
With CO2 $15/t (JPA)	-	6.4	7.5	7.8	-	-
With Back-up	-	-	-	-	15.4	20.6

Note NZ$=.35GBP,
* A very high CO2 tax had been assumed in original work
Source: The Costs of Generating Electricity, Royal Academy of Engineering, 2004

The previous table should not be left without commenting on nuclear power. According to the Royal Academy study generation costs of nuclear are lower than for fossil fuels and wind when all costs are considered. At the time the Author was working with the US Nuclear Regulatory Commission in 1980 there was a compelling and prophetic text, now out of print, by an unknown author entitled “The Dangers of Not Going Nuclear” which amongst other things identified the environmental issues of burning fossil fuels and the relative benefits of nuclear power generation. The text should be reprinted and be required reading for our parliamentarians and the general public. Although New Zealander’s stance on nuclear weaponry may be laudable, the inability to distinguish bombs from the peaceful application of nuclear energy for our country’s future is incredibly short-sighted.

Conclusions

Coal jump-started the industrial revolution, it can provide the cost effective transition to post-gas and post-oil in New Zealand. Rather than cleaner burning of coal in old furnaces or boilers, New Zealand should be investing in the newer techniques of processing or “refining” coal. The petroleum industry could most probably provide some leadership here. The techniques that start with gasification, result in more

efficient electricity generation, less pollution and a wide range of products including synthetic gas, oil and other petrochemicals.

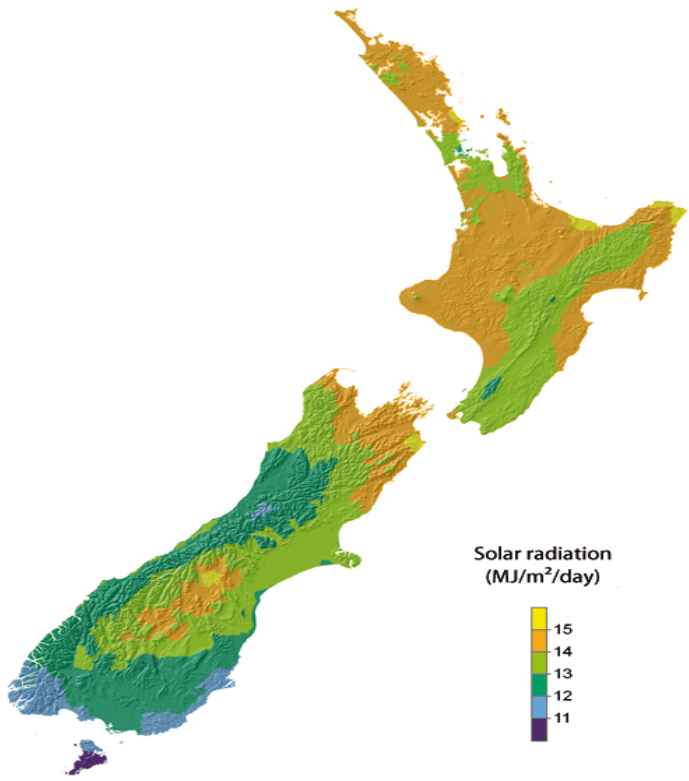
But what can We as Mining Professionals do?

We as mining professionals can promote informed responsible development and investment in the country's mining and energy business. We can galvanise public opinion on issues such as "unbundling" our entire energy chain from mine - to generator - through transmission, even if the nuclear issue has to wait!

But what can We as New Zealanders do?

We can become better informed and can lobby our politicians. We can manage our energy use, improve efficiencies and conserve. We can ensure that our homes and offices are fully insulated. Have we can install heat transfer systems and more efficient heating systems such as heat pumps.

There is always solar. Our energy end use in 2004 was 126 GJ per capita per year or 13MJ/m^2 per day. Referring to the solar radiation map that follows a 25m^2 collector operating at 100% efficiency would be required to satisfy our current demand. This is hardly practical but passive solar heating of well designed homes and installation solar hot water systems can help to alleviate the impending crisis.



Courtesy NIWA 1

Acknowledgements

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