Relevance of the Liquid Fuels Trust Board work to present-day energy issues

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Abstract

The lignite resource in the southern part of the South Island is New Zealand's largest source of indigenous primary energy. The 10 deposits evaluated by the Liquid Fuels Trust Board (LFTB) have a total recoverable reserve of 6.2 billion tones equivalent to 74,000 PJ of energy or 20 times the original energy content of the Maui gas field. Updating the economics of the original LFTB studies indicates that lignite could be mined for between NZ$1.0 and 3.0/GJ. Its conversion to synthesis gas for production of petroleum products, chemical methanol, ammonia/urea fertilizer or electricity would be in the national benefit and likely to be commercially economic at today's product prices.

Keywords: *lignite, New Zealand, valuation, synthesis gas, gasoline, diesel, ammonia/urea, methanol, electricity.*

Introduction

The New Zealand Liquid Fuels Trust Board (LFTB) was established by Act of Parliament in 1978. It was charged with the task of reducing the country's dependence on imported transport fuels and was funded by a levy of 0.1 cent on each liter of petrol and diesel sold.

The LFTB focused its work on identification and evaluation of all practical options for producing transport fuels from indigenous resources. The mineral resources studied as possible candidates for transport fuel production included the South Island lignites, Huntly coal and Chatham Island peat. It is the first of these that is the subject of this paper.

It has long been known that there are numerous deposits of lignite in the southern part of the South Island. The extent of these became apparent largely as a result of the 1970's Coal Resources Survey with the result that 10 major deposits of lignite were identified. These were further defined by extensive LFTB field investigations during the early 1980's culminating in selection of a preferred deposit for development of a transport fuels production project.

The LFTB investigations sought to determine:

- the magnitude and characteristics of the lignite resource
- the technology available for its conversion to transport fuels
- the likely costs and economics involved.

The database developed is still, of course, valid today. Certainly there have been advances in some of the technologies involved but the individual lignite deposits are still in the same places and still have the same physicochemical characteristics. What has changed substantially are the costs and economics involved.

It is the purpose of this paper, therefore to indicate the likely value of the lignite resource in the current economic climate. The timing is particularly appropriate for two reasons:

- New Zealand is urgently in need of one or more major sources of energy to replace the now depleted Maui gas field
- At least two of the more attractive lignite deposits lie beneath land that is currently the subject of the High Country Land Tenure review – which could, potentially, result in their being sequestered forever from future development.

For these reasons alone it is essential that all present and potential stakeholders should be clearly aware of the likely value of the lignite resource – both for commercial development and to the nation. Crown Minerals division of the Ministry of Economic Development (MED) has, therefore, initiated an updated valuation of the lignite resource based on the extensive work done by the LFTB and this paper presents some of its findings.

Lignite resource proving

The LFTB focused its attention on 10 previously identified lignite deposits. It is well known, however, that lignite is distributed widely throughout the southern part of the South Island of New Zealand and there may well be many more significant deposits in addition to those identified herein. Several of these are already known.

Resource proving work included geological drilling, geotechnical investigations, mine planning studies and detailed lignite analysis and characterization. The outcome was to establish reasonable estimates of the amount of in-ground and technically recoverable lignite in each of the candidate deposits. The results are presented in Table 1 which shows that:

- there are at least 6.3 billion tones of technically recoverable lignite in these 10 deposits
- this equates to 74,000 PJ of recoverable energy :
  - Equivalent to 73 tcf of natural gas, or
  - about 20 times the original energy content of the Maui Gas field (3.438 tcf)
- the lignite can be mined with a moderate to high recovery rate,
- there is some regional variability in Specific Energy content but most values are within the top 25% of lignites worldwide.

Clearly, the South Island lignites are New Zealand's largest energy resource making this country one of the world's richer nations in terms of energy per capita. The question is, however: "Can the lignite be mined at a cost that makes its development commercially attractive?"

Table 1: Lignite quantities, energy contents and equivalents

Location / Deposit	In-ground lignite (million tonnes)	Technically recoverable reserve (million tonnes)	Recovery factor	Specific Energy (NCV) (MJ/kg)	Recoverable energy (PJ)	Natural gas equivalence (tcf)	Energy content wrt original Maui reserves
Central Otago							
Hawkdun	812	649	79.9%	11.04	7,165	6.60	1.9
Home Hills	346	246	71.1%	11.10	2,731	2.52	0.7
Roxburgh	245	132	53.9%	12.71	1,678	1.55	0.4
South Otago							
Benhar	n.a.	887	-	14.59	12,941	11.93	3.5
Eastern Southland							
Croydon	484	309	63.8%	14.04	4,338	4.00	1.2
Waimumu	286	217	75.9%	12.98	2,817	2.60	0.8
Mataura	2,940	1,808	61.5%	12.68	22,925	21.13	6.1
Southern Southland							
Morton Mains	1,226	507	41.4%	8.57	4,345	4.00	1.2
Waimatua	962	775	80.6%	9.72	7,533	6.94	2.0
Ashers-Waituna	1,357	746	55.0%	10.26	7,654	7.05	2.1
Totals	8,658	6,276	72.5%		74,127	68.32	19.9

Lignite mining costs

Mining studies commissioned by the LFTB (Otto Gold various) developed production costs for several different mining rates at each of the deposits. Bucket Wheel Excavator technology was employed.

The results have been placed on a common year basis (Q3 1982) and are presented in Table 2. These are undiscounted run of mine costs and do not include infrastructure, offsites, land acquisition, lignite royalties and levies.

To update these production costs to Q3 2005 NZ$ we have reworked the economics taking into account:

- inflation indices for costs incurred in NZ$, US$ and DM
- differences in currency exchange rates over the period
- advances in mining technology
- alternative mining technology options.

At one extreme the raw production costs listed in Table 2 could be multiplied by a factor of about 3 to bring them to Q3 2005 NZ$. This would result in lignite production costs of between NZ$1.5 and 3.0/GJ for the more attractive mining prospects.

Table 2: Indicative lignite production costs in undiscounted Q3 1982 NZ$ excluding: infrastructure, offsites, land acquisition, lignite royalty and levies.

Deposit	Mining rate (million tonnes/y)	Production cost NZ$/tonne	NZ$/GJ
Hawkdun	2.5	13.50	1.22
	9.5	7.00	0.63
	12.5	8.20	0.74
	15.0	9.00	0.82
Home Hills	5.0	10.90	0.98
	8.0	9.00	0.81
Roxburgh	2.5	19.90	1.57
	4.0	14.10	1.11
Benhar	9.1	7.10	0.49
Croydon	5.0	24.30	1.73
	9.0	17.70	1.26
Waimumu	2.5	24.00	1.85
	5.0	16.60	1.28
Mataura	10.0	13.00	1.03
	15.0	10.90	0.86
	20.0	10.10	0.80
Morton Mains	10.0	8.60	1.00
	15.0	7.70	0.90
Waimatua	10.0	7.20	0.74
	15.0	7.00	0.72
	20.0	6.50	0.67
Ashers-Waituna	10.0	6.60	0.64
	15.0	6.50	0.63
	20.0	6.60	0.64

More realistically, and using current lignite mining technology, a multiplier of between 1.5 and 2.0 should be applied. This would result in lignite production costs of between NZ$1.0 and 1.5/GJ for the more attractive mining prospects.

Including the costs of infrastructure, offsites, land acquisition, lignite royalties and levies could add another NZ$1.0 – 1.5/GJ for a total project cost.

However the mining economics are configured, the more attractive lignite mining prospects would have an associated production cost of less than NZ$3.0/GJ making lignite not only the largest but the cheapest source of energy currently available in New Zealand.

Conversion technology evaluation

It is of real importance to recognise that lignite should be regarded not simply as a source of primary energy but, rather, as a chemical feedstock.

Thus, lignite achieves its highest product and economic values if it is converted to synthesis gas that can then be used as the basic chemical building block and energy source to produce:

- petroleum fuels, via Fischer Tropsch synthesis
- chemical or fuel methanol
- ammonia/urea fertiliser
- electricity.

It can also be converted, by hydrogenation and liquefaction, to produce a syncrude that can be refined into petroleum products. Various other uses for synthesis gas are also available (Hooper, 2005).

In all of these applications the associated greenhouse gas emissions are very much less than those derived from direct combustion of lignite.

Based on current market values of the various products at a New Zealand port, or nearest market node, the undiscounted Gross Product Values (GPV) of each is listed in Table 3 for the Hawkdun lignite deposit if its total recoverable reserve of lignite (649 million tones) were to be converted.

The numbers in Table 3 are large and impressive but the question remains: “Can these products be produced at a cost that is commercially attractive?”

Table 3: Indicative gross product values, Hawkdun

Lignite development options	Primary conversion products	Product/ lignite ratio (t/t)	Product GPV (NZ$M)	Process GPV (NZ$M)
Gasification	Synthesis gas	10.862 (GJ nat.gas/t)	35,247	35,247
Fisher Tropsch synthesis	Gasoline Diesel	0.027 0.108	19,607 63,173	82,780
Liquefaction	Gasoline Diesel Avtur	0.082 0.079 0.030	59,295 46,051 14,711	120,057
Methanol synthesis	Methanol Sulphur	0.277	74,498	74,498
Ammonia/urea synthesis	Ammonia Urea	0.309 0.167	83,001 47,552	130,552
Electricity generation	Electricity	1,225 (kWh/t)	77,918	77,918

Lignite conversion costs

The LFTB commissioned a number of studies (LFTB various) designed to assess the contemporary status of the technology and to develop pre feasibility level project economics and product production costs. This work has been updated to a Q3 2005 basis using the same methodology as applied to lignite mining as explained in the previous section.

Based on the results of this work, and including some additional promising new technologies, Q3 2005 NZ$ economics (100% equity financing) have been developed for projects producing:

- synthesis gas, using High Temperature Winkler (HTW), Shell, Dow and HTL IDGCC gasification technologies
- gasoline and diesel blend stocks, lubricants and LPG using state-of-the-art Fischer Tropsch technology
- petroleum products using H Coal, I.G. Farben and Exxon Donor Solvent (EDS) technologies
- methanol, using conventional land based methanol production technology
- ammonia/Urea Fertiliser, using modern production technology
- electricity, using lignite derived synthesis gas as fuel for a CCGT plant.

Understandably the results of this work are quite commercially sensitive at this time but it is clear that, at current product prices and likely lignite feedstock transfer prices:

- all would meet national benefit criteria of a 10% IRR (excluding taxes, royalties, and levies),
- several are likely to meet commercial economic hurdle criteria.

Consequently, we believe that serious consideration should be given to the potential development of the South Island lignite resource.

Environmental and social factors

In addition to its technical and economic evaluations the LFTB also undertook extensive environmental and socio-economic studies of the likely consequences of a major lignite development at each of the 10 deposit sites. Indeed, more money and intensive research was applied in these areas than had ever been previously.

The results are summarized in several LFTB publications (LFTB various) and are detailed in the contractors' reports referenced therein. Specifically, these studies identified and evaluated the key environmental and sociological issues associated with development of each of the deposit sites. This information should provide an invaluable initial database for a potential developer.

Relevance to contemporary issues

Worldwide, we currently have a so-called energy crisis with international crude oil prices close to US$70/bbl. However, the reasons for the present high oil prices are quite different from those of the late 1970's and early 1980's.

The high prices during the 1970 -1980 period were supply side driven because OPEC had reduced the supply of crude to manage prices upward. As soon as this constraint was removed in January 1986, crude oil prices dropped back to a level determined by contemporary supply/ demand criteria.

Today, however, we have a demand side constraint determined primarily by rapidly increasing demand for crude oil and petroleum products in China and India and the continuing high demand in the United States. It is unlikely that these voracious appetites will be abated in the foreseeable

future so there are good reasons to expect that the current crude oil prices will remain and, probably, increase.

Meanwhile, there have been major advances in Fischer Tropsch (FT) technology for the conversion of natural gas and synthesis gas to gasoline, middle distillates and high valued lubricant products that are of higher quality, and more environmentally friendly, than their conventional counterparts derived from crude oil.

FT production from natural gas and synthesis gas is economic at today's crude oil parity prices. Furthermore, the FT technology available from suppliers such as Syntroleum, Halder Topsoe and Williams is economic at scales down to 10,000 bbl/day capacity thereby making it applicable to currently stranded natural gas and potential synthesis gas assets. There is currently an estimated 3,700 tcf of discovered natural gas worldwide that is stranded for want of markets. Much of this is potential feedstock, together with an even greater amount of potential synthesis gas, for FT production.

It is our contention that as the cost of FT technology comes down it will supply an increasing share of the petroleum products market over time and will help to maintain, or possibly reduce, the market price of these products.

In short, we will continue to retain a transport fuels economy based on the use of petroleum products but they will increasingly be derived from natural gas and synthesis gas rather than from conventional crude oil.

For New Zealand, the South Island lignites provide us with a potential source of synthesis gas that, together with ammonia/urea,methanol and electricity, could supply our national and export requirements for well into the next century.

In New Zealand, we are about to run out of Maui gas which has provided a significant part of our energy and chemical feedstock requirements for over 25 years. It is unusual for a country to have so much reliance on a single large energy resource and the imminent depletion of Maui has left us scrambling to find one or more replacements.

The resource proving and conversion process evaluation work done by the LFTB during the 1980's provides a sound initial database that can be used as a springboard for further investigations into development of the South Island lignite resource. Furthermore, the associated environmental and sociological studies indicate that development could proceed at several of the deposit sites in an acceptable manner – even given the high level of contemporary concerns about environmental conservation.

The South Island lignites are New Zealand's largest indigenous energy resource. This resource is likely to be our cheapest to produce. We need new sources of energy urgently so serious further consideration should be given to lignite development.

Discussion

An obvious question that arises from the foregoing analysis is: "If the South Island lignite resource is so good, why have we not pursued it before now?"

The answers would appear to be several fold:

- With the collapse of the international oil price in 1986 the need to increase our national self sufficiency in transport fuels literally stopped. So also did all further work on the lignite resource.
- At about this time a new Government and political paradigm made so-called "Think Big" projects politically unacceptable in the public mind. Lignite development would, obviously, be classified as such.

- The national increase in environmental awareness and conservation has created real uncertainties for a developer interested in lignite mining.
- There was, and still is, a public perception in New Zealand that coal is a four letter word and that the only way to use lignite was to burn it and produce large amounts of nasty black smoke.
- Our continuing, and satisfactory, reliance on Maui gas did not provide a market environment that encouraged commercial interests to pursue the energy potential of the lignite resource.

While several of these reasons are still in force, the fact remains that New Zealand needs energy urgently and both this fact and the longer term worldwide perspective make it imperative that we give serious regard to our largest energy resource.

Conclusions

The following conclusions can be drawn:

1. The work undertaken by the LFTB during the 1980's provides a sound database for future development of the South Island lignite resource.
2. The energy content of the currently identified lignite deposits is equivalent to about 5 times that of the original Maui gas field.
3. Given that only three of the ten lignite deposits are smaller than the original Maui gas field (and Mataura is 6 times larger) it would be necessary to develop only one of the lignite deposits to replace Maui.
4. Updating the costs and economics developed by the LFTB indicates that lignite could be mined at several of the identified deposits at production costs in the range NZ$1.0 – 3.0/GJ making it New Zealand's cheapest source of primary energy.
5. Conversion of lignite to synthesis gas and thence to petroleum products, fertilisers, chemicals or electricity would provide a very high Gross Product Value (GPV) at today's prices and would be to the national benefit economically.
6. There is an urgent need to give serious consideration to the potential development of lignite as New Zealand's largest, and potentially cheapest, primary energy resource.

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