

**PARLIAMENT
OF
SOUTH AUSTRALIA**

**ENVIRONMENT, RESOURCES AND
DEVELOPMENT COMMITTEE**

THIRTY-SEVENTH REPORT OF THE COMMITTEE

Mining Oil Shale at Leigh Creek

Tabled in the House of Assembly and ordered to be printed 16 November 1999

Third Session, Forty-Ninth Parliament

The Environment, Resources and Development Committee

The Environment, Resources and Development Committee (the Committee) was appointed pursuant to the *Parliamentary Committees Act 1991* (the Act) on 12th February 1992. Its members during the reporting period were:

Mr IH Venning, MP (Presiding Member)
Hon JSL Dawkins, MLC
Hon MJ Elliott, MLC
Ms SW Key, MP
Mrs KA Maywald, MP
Hon TG Roberts, MLC

Secretary to the Committee: Mr K Cudarans

Research Officer to the Committee: Ms HS Hill

Functions of the Committee

Pursuant to Section 9 of the Act the terms of reference for the Committee are:

- (a) to inquire into, consider and report on such matters as are referred to it under this Act:
 - (i) any matter concerned with the environment or how the quality of the environment might be protected or improved;
 - (ii) any matter concerned with the resources of the State or how they might be better conserved or utilised;
 - (iii) any matter concerned with planning, land use or transportation;
 - (iv) any matter concerned with the general development of the State.
- (b) to perform such other functions as are imposed on the Committee under this or any other Act or by resolution of both Houses.

The Inquiry

On Wednesday, 3 March 1999 the House of Assembly pursuant to section 12C and 16(1)(a) of the *Parliamentary Committees Act 1991*, passed the following resolution:

That the Eighty-Seventh Report of the Public Works Committee on the Leigh Creek Coal Dumping Bridge replacement be noted and its recommendations adopted.

The recommendations of the Public Works Committee in its report required that:

The House refer the Committee's concerns regarding possible adverse impacts of past and present coal mining operations on the health of workers and residents of Leigh Creek and environs to the Parliamentary Occupational Safety, Rehabilitation and Compensation Committee.

The House refer the matter of the possible commercial benefits and environmental impacts of mining or not mining oil shale at Leigh Creek to the Environment, Resources and Development Committee.

The Parliament requires that both Committees provide at least an interim report within three months of the receipt of the reference.

Presiding Member's Foreword

The Committee received this reference via the Public Works Committee as a result of an inquiry into the coal truck dumping bridge replacement at Leigh Creek coalfield. The Committee subsequently advertised this Inquiry and took evidence from eight witnesses, after receiving fourteen submissions.

Before taking evidence, the Committee was taken on a site visit of the coal mine. This visit, together with presentations from the coal field personnel, was extremely beneficial in facilitating an understanding of the coal mining operation and any potential oil shale deposits. The Committee appreciated the time and effort of the Flinders Power staff during this site visit.

I would like to thank all those who have contributed to this Inquiry including the Committee members and the staff.

I look forward to the Minister's response to this report.

Ivan Venning MP
Presiding Member
16 November 1999

COMMITTEE FINDINGS

The Committee finds that there is a large low grade oil shale deposit at Leigh Creek.

The Committee finds that this deposit has the potential for commercial realisation and should be taken into consideration when Flinders Power is to be leased.

The Committee finds that the future of mining the oil shale cannot be determined until the extent of the resource has been investigated. The opportunity should be made available for a mineral exploration company to investigate the resource and determine the quality and quantity of the oil shale. If it is determined that it is economical to mine the oil shale, then the investigating company should have the opportunity to take the project to full commercial production.

The Committee believes that if the oil shale industry was deemed to be economically and environmentally viable, several issues would need to be considered including:

- Whether the lessee of Flinders Power would get rights to the coal and the oil shale
- What sort of coal mining practices should be used to ensure that the oil shale could be mined in the future if it was not deemed viable at the present time
- The conditions under which concurrent mining of coal and oil shale could successfully occur.

The Committee is aware that an oil shale mine is being developed in Australia at Gladstone Queensland (The Stuart Project). The success of the mining process may provide important information to any developers in South Australia but the Committee notes that the Gladstone mine is situated in a very different environment and does not also contain coal.

The Committee recognises that the recovery of oil from shale is an energy intensive process and that there may be significant greenhouse implications.

COMMITTEE RECOMMENDATIONS

1. The Committee recommends that the commercial value of the oil shale deposit must be taken into account when considering the lease of Flinders Power and before a decision is made whether to include it as an asset covered by the lease.
2. The Committee recommends that the State Government conduct a commercial feasibility study to investigate issues including the following:
 - The conditions under which concurrent mining of coal and oil shale could successfully occur
 - The coal mining practices that should be used to ensure that the oil shale could be mined in the future if it was not deemed viable at the present time.
3. Should the feasibility study indicate the successful resolution of the above issues, then the Committee recommends that the way should be made clear for a mineral exploration company to further investigate the oil shale resource at Leigh Creek, with the possibility that it may take the project to full commercial production if the project is found to be economically and environmentally viable.
4. The Committee recommends that the energy needed to extract oil from shale must be determined, as it may have significant greenhouse implications. This would need to be considered as part of an Environmental Impact Assessment should there be a decision to mine oil shale.

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INTRODUCTION

Oil shale was identified at Leigh Creek near the end of the nineteenth century, but whether it represents a viable mining and extraction industry for South Australia is still unknown today. There have been some studies of the resource; however, a satisfactory and conclusive assessment has never been undertaken.

Oil shale mining has occurred in other States of Australia during times of world oil shortage, but the ready availability and low prices of vast world oil reserves made the industry redundant in the 1950s. Now, however, a pilot plant for an oil shale industry has just started in Gladstone, Queensland. The extraction process used in Queensland could possibly be adapted at Leigh Creek if the reserves of oil shale prove to be economically viable.

There are a number of factors to consider in deciding on the economic viability of the Leigh Creek oil shale including:

- The quality of the oil shale resource
- The amount of processing needed to turn it into a useable oil
- The ability to process the oil shale alongside the coal mining operation
- The existence of a company able to invest in the whole process
- The implications of the forthcoming lease of the mine
- The environmental impacts of such a venture.

This report examines these issues and suggests some future options.

THE LEIGH CREEK COAL FIELD

The mine is situated 550Km north of Adelaide and 250Km north of Port Augusta. The sub-bituminous, hard brown coal of Leigh Creek is located in five lobe shaped sedimentary basins formed during the late Triassic period. Mining is currently confined to Lobe B which is approximately 7.5x4.5x1Km in size. This is a very steeply dipping coal deposit with three coal bearing series – lower, main and upper. 70% of the coal mined at Leigh Creek comes from the main series and 30% from the upper series. The coal has a heat value of approximately 14 - 16GJ per tonne compared with that of a black coal which can have a heat value of approximately 26GJ per tonne. The Leigh Creek brown coal is currently mined exclusively for the Northern Power Station.

The coal is mined in an open cut mine. This necessitates the removal of the material on top of the coal (the overburden). Removal of this overburden accounts for the largest cost of mining the coal, and a strip ratio of ten parts overburden to one part coal is considered by Flinders Power personnel to be the extreme end of economic viability. There is approximately 500 million tonnes of coal in the mine; however, a large part of this coal is very high strip ratio material and, according to Mr S Caplygin, Chief Engineer, Mining Operations, Department of Primary Industries and Resources, is unlikely to be mined. Consequently, the coalmine has a predicted life of 20 years.

This could possibly change if it was proven that the overburden had some value and could be used. Within part of the overburden is the oil shale. Oil shale is a sedimentary rock comprised of about 50% clay, 25% water and 25% kerogen. Kerogen is fossilised algae which decomposes to give oil vapour when heated to 500°C. Much of the world's conventional oil is thought to have evolved from such deposits buried deep in the earth for millions of years. The Leigh Creek oil shale is classified as a Cannel Coal under the classification system used in Australia.

The oil shale occurs in the main series overburden which may be from 200m to 650m thick. This is between the main series coal seam and the upper series seam. It consists of dark grey carbonaceous mudstone interbedded with bands of siderite. The amount of organic matter within the mudstone varies vertically. There is no oil shale above the upper series but there may be some below the main and lower series. This possibility is supported by observations at the mine. Mr Watkins, Geologist and Secretary, Central Australian Oil Shale, said

'When they moved old waste dumps at Leigh Creek that were actually derived from that interval between the lower series coal and the main series coal, these waste dumps were totally burnt out. The material left in there was ceramic. That is indicative of last dump temperatures exceeding 1 000 degrees Centigrade. That would prompt one to think that the oil grades down there were better than most other parts around the mine. ... I have no doubts that there is oil shale there and it is probably good quality stuff, but it is below the planned mining in the next 20 years.' (Evidence, p38)

A small amount of the oil shale is used by Flinders Power to blend with the coal to get the right chemical composition for burning it in the Northern Power Station boilers. The rest is considered to be waste.

Current Management

Flinders Power currently has the legal right to mine the coal from Leigh Creek and it mines 2.8 million tonnes of coal per year for the Northern Power Station. Flinders

Power has 200 employees. In 1998, approximately 12 million cubic metres of overburden were removed. The mining method used is terrace mining and, in this process, to reduce costs, the unwanted overburden is dumped back into the pit left after the coal has been removed.

Mr Caplygin (PIRSA) wrote in the MESA Journal no. 1

'Terrace mining, in combination with numerous other performance improvement initiatives, has resulted in reduction of mining costs of ~32% ... The major reduction has been in the cost of overburden removal through a reduced haul cycle time, and rehabilitation costs have been greatly reduced. The level of coal output will be approximately the same as with previous methods. There are, however, some disadvantages with terrace mining – it is relatively complex in planning and scheduling of operations, and there is less flexibility with product blending and quality control.' (p19)

The CAOS submission 28/5/99 mentioned the following issues in relation to this method of mining.

'The mine will be backfilled progressively and will be completed around 20 years time. The coal and oil shale left after this time is effectively lost. The potential for in-pit fires from spontaneous combustion forcing a mine closure is a real threat in the next few years. Gas drainage from waste into the pit can be a serious environmental consideration.' (p11)

This method of mining the coal will be affected if the shale is taken for processing.

THE OIL SHALE DEPOSIT

Oil shale was first detected and noted at the Leigh Creek site in 1890 by government geologists. There have been several attempts to characterise the nature and extent of the oil shale deposit, beginning in 1986. Appendix 12 of the CAOS submission 28/5/99 – a minute (21/11/96) to The Minister For Mines and Energy from the Chief Executive Officer of the Department of Mines and Energy re Evaluation of the Leigh Creek Oil Shale outlines the different attempts at evaluation.

- **1986**

A sample of oil shale was tested and gave a result of 58 litres per tonne.

- **1987**

'In October 1987 an old core which ETSA drilled was sampled for oil yield and moisture by MESA [Department of Mines and Energy]. The results showed an average oil yield for the hole of 31.1 litres per tonne (dry basis) with one interval of less than 5 metres reaching 57 litres per tonne.' (CAOS submission, 28/5/99, Appendix 12, Minute to Minister for Mines and Energy re Evaluation of the Leigh Creek Oil Shale)

- **1989 CAOS Prefeasibility Study**

In 1989 it was decided that a better understanding of the oil shale resources was required and ETSA drilled eight fully cored holes positioned around the perimeter of Lobe B. These samples were not tested until 1993.

'CAOS carried out two prefeasibility studies on the project. In the second study in 1989, oil shale production from the mine was estimated to be 10 million tonnes per annum which would produce approximately 3 million tonnes of oil per annum. Mining reserves were estimated to

be a minimum of 200 million tonnes of oil shale above a cut-off of 50 litres per tonne.' (CAOS Submission 28/5/99, p3)

- **1992**

'In 1992 CAOS supported a study at the University of Adelaide's Chemical Engineering Department, where a comparison was made to establish the relationship between the heating value (specific heat) and oil content of oil shales.' (CAOS Submission 28/5/99, p2)

Mr Watkins (CAOS) said

'There was some correlation, although fairly crude, between heat value [of the oil shale] and oil yield. From that data [heat value] we managed to come up with an average across the mine of about 50 litres per tonne.' (Evidence, p33)

The CAOS submission continues

'This university study was used to produce a table of oil yields derived from these heat values. It showed oil yields of up to 122 litres per tonne could be expected at the western end of the mine.' (p18)

- **1993**

The cores drilled in 1989 were tested.

'The evaluation of the results of the analysis showed that a low grade oil shale resource existed at Leigh Creek. The average grade of the oil shale is 31 litres per tonne. Approximately 41% of the oil shale has an average grade of 25.5 litres per tonne, with another 3% of the material contained grades above 60 litre per tonne.' (CAOS submission, 28/5/99, Appendix 12, Minute to Minister for Mines and Energy re Evaluation of the Leigh Creek Oil Shale)

- **1996**

In 1996 another hole was drilled and tested. The CAOS submission 28/5/99, states

'When this core was analysed ... the oil yields were substantially higher than expected with many in excess of 80 litres per tonne at zero moisture. ... On closer inspection of these oil yields undertaken by Amdel in Adelaide, it is quite apparent some of the results are in error eg sample 65 had an oil yield of 11 litres per tonne at zero moisture, but a Gas+Loss of 15.2% which is totally unacceptable ... the implications being that substantial amounts of oil were lost during analysis. Additionally when assessing oil shale, there are two components of importance, oil yield and gas yield. [This core was not analysed for gas yield] This oversight is significant given that oil shale from Leigh Creek is considered to be quite gaseous and contain light fraction hydrocarbons; with every 1% by weight of gas produced equating to approximately 10 litres per tonne of oil. The gas also has a commercial value.' (p9)

Another comment taken from the CAOS submission 28/5/99 said

'Recent drilling by ETSA earlier this year (1996) intersected higher grades of oil shale up to 100 litres per tonne which has given rise to added enthusiasm about the possibility of retorting oil shale at Leigh Creek.' (Appendix 12, Minute to Minister for Mines and Energy re Evaluation of the Leigh Creek Oil Shale)

- **1997 Leigh Creek Oil Shale Conceptual Study** by MineConsult (Mine Management Consultants)

The Report states

'MineConsult Pty Ltd was commissioned by Mines and Energy, South Australia to briefly assess the viability of recovery and processing of the oil from the overburden shales at the Leigh Creek Coal Mine, South Australia. The oil shale deposit examined in this study lies within Lobe B above the Main Series coal seam of the mine.' (pi)

Mr Caplygin (PIRSA) said

'The scope of the MineConsult study was to collect relevant oil shale data, determine practical mining options, estimate the quantity and quality of oil shale, nominate a location for a possible plant, estimate the capital and operating costs and undertake some sensitivity analysis.' (Evidence, p15)

He continued

'The key assumption for the study was that the mine's geological interpretation is representative of the total resource to be mined in the area. One hole was drilled in each of these mining areas. ... Another assumption was that the AOSTRA process was capable of treating the oil shale. To my knowledge not a lot of work has been done in this area and that would certainly need to be undertaken. Next, the crude oil product requires no refinement. The study included no refining costs whatsoever. It is assumed that what you get out of AOSTRA has no nasty hydrocarbons or anything else – you go straight into fuel oil. Whether or not that assumption is true will have to be tested.' (Evidence, p15)

He added

'MineConsult issued a resource statement based on those earlier assumptions that that mining area had about 513 million tonnes of oil shale at a grade of about 40 litres per tonne.' (Evidence, p15)

He concluded

'The conclusion that we [PIRSA] drew from that study ... is that the project has low economic potential at current world oil prices and using current technology. ... PIRSA has no plans to continue to evaluate the Leigh Creek oil shale. ... at this stage we do not believe it has any economic potential.' (Evidence, p16)

The CAOS submission (28/5/99) casts doubt on the usefulness of the MineConsult study. It states

'The original concept [of the MineConsult study] was to assess the available data and decide what the next step was to be, as well as convincing the Minister it was a worthwhile project. ... The data MineConsult would have had to use in a prefeasibility study was derived from analysing very old drill core. ... it has been argued for years that any drill hole data gained from the analysis of old drill core was a waste of time and money, because of the loss of volatiles with time.' (p9)

Mr Watkins (CAOS) added

'The information on which it [MineConsult] based its work was obtained from the drill holes from 1988-89 drilling ... but they were analysed for oil five to six years later.' (Evidence, p33)

Potential size of the oil shale resource

There was conflicting evidence on the potential size of the oil shale deposit. Mr R Althoff, Chief Executive Officer, Flinders Power, said

'The potential oil shale resource is estimated at about 500 million tonnes, with an average grade of approximately 40 litres per tonne, ranging from 6 litres per tonne to 80 litres per tonne, and that variation is very much in that stratum ... which is parallel to the stratum of the coal seam. If only the higher grade bands are considered economic, the maximum oil shale tonnage is reduced to about 70 million tonnes at an average grade of approximately 50 litres per tonne.' (Evidence, p5)

The CAOS submission 28/5/99 states

'The total potential resource of oil shale within the Leigh Creek area is of the order of 10 billion tonnes putting this area in the potential world class category as far as oil shale resources are concerned. The final pit limits of the coalmine show that only a small proportion of the coal resource and the oil shale resource will be mined. Mining the oil shale could significantly extend the economic life of the mine. The extent of the coal resource is surpassed by many times by the oil shale resource. Whilst some work has been carried out on the deposit no comprehensive assessment of the resource has been undertaken by any party.' (p2)

THE PROPONENTS FOR MINING THE OIL SHALE

- **Central Australian Oil Shale Pty Ltd (CAOS)**

Central Australian Oil Shale Pty Ltd is a company that was formed in 1987 to develop the concept of pursuing the oil shale project at Leigh Creek.

- **Centrex Resources N.L.**

Centrex Resources is a small public unlisted exploration company that has had an interest in potential Leigh Creek oil shale since formation of the company in 1997. It has exploration leases on Eyre Peninsula and in an area which contains the Lock Coal deposit. The current objectives are to seek iron and other base metal deposits which might add value synergistically with the coal deposit.

METHODS FOR MINING THE OIL SHALE

- **The AOSTRA Taciuk Process (ATP)**

The AOSTRA Taciuk Retorting Process is supported by CAOS. It was developed by The Alberta Oil Sands and Research Authority (AOSTRA), UMATAC Industrial Processes and the Australian Group Southern Pacific Petroleum N.L. and Central Pacific Minerals N.L.

A large rotating kiln bakes the oil shale at about 500°C which causes the rock to give off oil vapour. This hydrocarbon vapour is then cooled to a liquid form that resembles conventional crude oil. Residual carbon in the shale is used to fuel the ATP and the processed shale is used to preheat the incoming shale before exiting the ATP and being returned as backfill to the mine. (The Stuart Project website 3/8/99, p2)

In the CAOS Prefeasibility Study it said

'The AOSTRA Taciuk processor consists of a 7.2m diameter horizontal rotating vessel 37m long which houses four compartments that preheat the dried shale, carry out oil shale pyrolysis, spent shale combustion and heat recovery from combusted shale.

The 4.5rpm processor is driven by a multiple tyre drive system. Retort temperature is approximately 500°C. The kerogen in the shale is pyrolysed to oil vapour and hydrocarbon gas. The superheated vapours pass through the cyclones to a primary and secondary fractionator where it is condensed into a shale distillate, shale naptha, condensed water and uncondensed hydrocarbon gas. Shale naptha is cooled prior to being hydrotreated and fractionated into a butane stream and a naptha stream.' (CAOS Prefeasibility Study Oct 1989, Section 9)

The CAOS submission states

'CAOS has had two separate testing efforts to date which indicate that the Taciuk Process can handle the Leigh Creek oil shale; however, its efficiency factor is less than 50%. The latest sample tested in October 1996, which was low grade 30 litres per tonne zero moisture, suggested that based upon this poor oil yield of 14 litres per tonne, that the Taciuk Process is not suitable and Uma Engineering indicated that if this sample was representative of the whole deposit then commercialisation appeared doubtful. ... One logical explanation was put forward, which can only be verified by many more such tests, indicated that the oil shale was tending to coke at normal retort temperatures ie a considerable proportion of the oil component was being burnt instead of being released. This theory fits in with earlier test work using microwaves which indicated that the Leigh Creek shale was very reactive and tended to produce light fraction hydrocarbons.' (CAOS submission 28/5/99, p11)

It continues

'The Taciuk Process which has been developed in Canada as a spin off from the tar sands industry has the advantage of being the latest technology and has been designed to cater for environmental concerns associated with the petroleum industry in general and more specifically the oil shale industry. ... The Taciuk Process can be used to treat Leigh Creek oil shale in an acceptable environmental fashion.' (p15)

However, Mr Watkins (CAOS) told the Committee

'We have virtually stuck to the system that the Stuart deposit [Qld] is adopting, that is the Taciuk process the Canadians developed ... we are a bit worried about the fact that the Taciuk process is carried out at a higher temperature at this stage, so we need to do a lot more work to verify that we could operate that process at a lower temperature and stop all this burning of the oil that is taking place through our testing so far.' (Evidence, p41)

- **Microwaves**

Centrex supports the use of a microwave process to extract the oil. Mr N Jackson, Director, Centrex Resources NL, said

'Work at Illawarra Technical Corporation showed that by using microwave processing a better quality oil was produced from the shale than by heating in a conventional kiln. They estimated at that time it was worth \$1.20 a barrel more than the standard light crude from the Middle East. The work showed that the radiation was efficiently absorbed above 300 degrees. That indicated it might need some other method up to the 300.' (Evidence, p21)

He continued

'The work done since that time has been mainly by a company in Canada, which has carried out extensive microwave on mineral, not particularly oil shale, but it has done some work on carboniferous materials and it has developed a microwave processing plant. A pilot scale

testing of the fluosolids technology has been done. Instead of a rotating kiln you fluidise the powdered minerals in a furnace that has been developed for burning coal ... It shows that it is a good method for burning coal so we think there is a high possibility that it would be a good process for the oil shale.' (Evidence, p21)

He added

'At Wollongong, they extracted the oil and there was a great deal of residual carbon left in the waste after burning it. ... we are looking to multiple fluosolid furnaces, one to extract oil and one to burn residual carbon which would supply a lot of the energy we need.' (Evidence, p24)

The CAOS submission comments on the use of microwaves. It states

'Microwave retorting produces a lighter oil than that obtained by conventional (Fischer assay) heating. ... Because microwave energy penetrates into the centre of relatively large lumps of shale some grinding costs could be saved as it is not necessary to grind the shale into such fine particles as for example in fluidised bed processing. Economic benefits are also associated with reduced residence time, and selective heating of the shale minerals, and kerogen.' (Bradhurst and Worner, CAOS submission 28/5/99, Appendix 19)

The Centrex submission states

'Some preliminary tests on shale from Queensland indicated that there could be advantages using microwave heating to expel the oil from shale. ... Results from shale from Leigh Creek assayed at 87.8 litres/tonne. Oil produced from microwave heating compared with a conventional kiln yielded a lighter oil, with most of the product in the C6 to C8 range, compared with the Fischer assay (comparable to kiln heating) yielding a heavier product from C8 to C17 range.' (p2-3)

A problem with microwave use can be the formation of hot spots around minerals in the shale. If there is inadequate mixing to reduce the heat, these hot spots will deteriorate the oil. Another potential problem with microwaves is the need for cheap power.

The waste product from either process is a light coloured powder with a greater volume than the extracted material. It consists of clay, silica and sand.

THE ECONOMICS OF MINING THE OIL SHALE

There are many factors determining the economic feasibility of mining the oil shale at Leigh Creek.

The Flinders Power submission (June 1999) adheres to the belief that because of its low grade energy, oil shale is not competitive as an energy source. It states

'Oil shale is probably the most widely distributed and the largest of the world's fossil fuel reserves. Yet despite this, recovery of energy from oil shale is only undertaken in a few overseas locations with no commercial operations in Australia apart from a pilot plant project in Queensland. The main reason is that it is a relatively low grade energy source which, except for specific circumstances, cannot compete with traditional relatively cheap natural gas, oil and coal. As with any other mineral processing development, commercial exploitation is contingent on a number of factors including quantity and grade of oil shale, mining cost, the associated infrastructure requirements and expected sale price.' (p1)

Flinders Power is concerned about the changes to its current coal mining process that oil shale mining would necessitate, and the additional costs that would result. In one submission it states

'If parallel mining was implemented, delivery of shale to a processing plant would incur significant additional haulage costs compared with our existing in-pit dumping operations. If the majority of overburden were processed for oil recovery, then the spent shale may be required to be hauled down into the pit to reduce the dump height in order to manage the dump stability and eliminate excessive creation of dust. Increased haulage requirements would necessitate the purchase of additional trucks and increase operating costs. ...

If the oil shale operation is limited to using the high grade overburden then this material would need to be mined selectively. Flinders Power has already reviewed this approach as part of our spontaneous combustion management strategy and discarded it because of the substantial increase in operating costs. ...' (Submission 17/9/99, p1)

The submission continues

'In 1997, the Department of Mines and Energy Resources (MESA) in conjunction with Optima Energy engaged an external consultant to undertake a conceptual study to estimate the cost of producing oil from the Leigh Creek overburden. ... The shale to be sourced from the Main Series mining area has been estimated at 513 million tonnes, with an average grade of 40 litres per tonne. In an international context, this grade is well below that of any current or projected commercial oil shale development. ...

Mining cost was estimated at \$2.35/tonne with majority of the costs \$1.10/tonne and \$0.95/tonne attributable to shale haulage and stockpile management respectively. Processing costs ranged between \$2.65/tonne and \$7.13/tonne reflecting different scales of operations and sources of data. The total operating costs varied between \$22 and \$42 per barrel.

After accounting for capital expenditure and assuming a modest 15% return on capital, the required break even minimum sale price was between \$28 and \$44 per barrel.

The report concluded that "only for the most optimistic scenario, that which includes the lowest processing costs and a high sale price of \$35/barrel, is a positive result consistently returned." In addition, the study has identified a number of operational and environmental issues that need to be resolved prior to establishing project viability.

We believe that the costs of the most optimistic scenario are considerably understated. ...

The results from this preliminary study indicated that oil extraction from the Leigh Creek shale deposit is not commercially viable at this point in time. Higher revenue streams or changes in extraction technology would be required to achieve reasonable returns on investment.' (p7)

Flinders Power used the following table in their submission (p3) to indicate different qualities of oil shale around the world.

Glen Davis Australia	Estonia	Green River USA	Alberta Oil Sands	Stuart Qld	Irati Brazil	Leigh Creek
450 l/t	200 l/t	200 l/t	100 l/t	95 l/t	80 l/t	40 l/t
Mined out	operating	Not operating	operating	Pilot scale operation	operating	-

Mr M Rajkowski, Mine Development Manager, Flinders Power, said

'The reason why there is not much of an advantage by having the operation in place as it is for the purpose of processing oil shale is that the processing plant would have to be stationary – it would have to be located somewhere. The deposit is quite large and, at the end of the day, you will find that your hauling distances are quite significant. You are talking about a 6 kilometre long deposit: so, whichever way you look at it, you have 1½ kilometres haulage distance, on average. That is the absolute minimum, and it is quite significant in terms of dollars ...' (Evidence, p11)

Mr Althoff (Flinders Power) added

'There is quite a large increase in overburden removal cost if you have to have any sort of elevation, because the trucks go at a fraction of the speed than they do on the flat.' (Evidence, p11)

Mr J Fargher, Manager, Mineral Resource Development, Department of Primary Industries and Resources, said

'It [the oil shale] is a resource but it is very likely to be marginal at best at current oil prices. ... oil price is a pretty fickle thing. ... You must remember it is not oil that is actually in the shale, it is kerogen that needs to be heat-treated in the process to become the useable hydrocarbon. I believe it would require refinery modifications ... That would probably be an additional cost and would make it a less attractive product than oil pumped from the ground from oil bearing reservoirs.' (Evidence, p17)

He continued

'The United States figures I see suggest that 40 litres per tonne would be the very bottom cut-off point. ... the better grades can range up to 200 and more, but typically in the US they have vast reserves, counted in trillions of tonnes, of grades getting up to about 150 litres per tonne. These are not being exploited at the moment.' (Evidence, p17)

CAOS believes the oil shale mining project is viable. The CAOS Prefeasibility Study (1989) states

'The initial cost for a demonstration plant has been estimated as A\$118 million and the total capital cost for the project is estimated to be \$303 million with an operating cost of \$24/barrel. These costs include a 20% contingency allowance reflecting the conceptual nature of the project.

Using unescalated costs, assuming equity funding and a discount rate of 10% real, an indicative price of oil per barrel at an oil shale grade of 50 litres per tonne is A\$37 or US\$27 – US\$30 per barrel, which indicates the medium term viability of the project.' [p5]

The CAOS submission, 28/5/99, Appendix 9, includes a speech presented at the 100th Annual Meeting of the Canadian Institute of Mining, Metallurgy and Petroleum by the Managing Director of Suncor Energy Australia Pty Ltd and General Manager of The Stuart Project. He is speaking about the Queensland pilot project at Gladstone. He states

'Stage 1 is targeted to achieve a cash operating cost of \$A19-20/barrel and earn a return equal to its cost of capital. ... Stage 2 will benefit from better economies of scale and its anticipated integration with Stage 1. We expect to achieve a lower cash operating cost, approximately \$A15/barrel. ... Stage 3 will be a fully commercial plant, consisting of multiple ATP units ... Stage 3 is designed to achieve a cash operating cost on the order of \$A11/barrel.'

CAOS also believes that recovery of the gas associated with the oil shale is important for the viability of the mine.

'1% gas is equivalent to 10 litres per tonne of oil – gas yields would have a significant effect on the economics of the project.' (CAOS submission 28/5/99, Appendix 11 – letter from CAOS to Director of Minerals, MESA)

However, Mr Jackson (Centrex) was not as positive about the viability of the oil shale project. He said

'I agree with the evidence submitted by Flinders Power and the PIRSA personnel that, at best, the economics of working that shale appear to be borderline with the known technology.' (Evidence, p20)

He added

'You would not want to build a plant on today's spike in the prices of oil. Our view is it has to be a new process which dramatically cuts costs.' (Evidence, p23)

Mr Jackson also believes that the retorted oil will need further treatment before it can be used. This would add to the cost of the oil. Mr Jackson said

'The work done on the oil produced at Wollongong from Leigh Creek did show that some processing was needed. We think the oil is much too valuable to simply burn, so we would be looking at adding further value to the oil in a new high tech product which is used in diesel fuels for transport.' (Evidence, p21)

The Flinders Power submission (17/9/99) concludes

'To date, no proposals have been put forward which demonstrate the economic viability of Leigh Creek oil shale utilisation.' (pii)

It also states

'CAOS have submitted to the Government, two very simple studies on the retorting of Leigh Creek oil shale. The last study in May 1993, suggested that utilisation of oil shale for the extraction of oil and related petroleum products was possible, however the indicative selling price per barrel of oil was significantly above current world oil prices.' (p8)

ENVIRONMENTAL EFFECTS OF OIL SHALE

There are already environmental effects from the oil shale as it is currently mined as part of the coal overburden. There are approximately 500 million tonnes of oil shale waste left to decompose around the mine. This mining and subsequent exposure to the open air results in its oxidation. This oxidation has the following results.

- **Spontaneous combustion of the oil shale**

Currently, the mined oil shale is used to refill the pit when the coal has been removed. During the oxidation process heating occurs, and if the heat cannot dissipate, then a fire can occur. This can result in a large amount of smoke and particles in the air in the pit.

The CAOS submission (28/5/99) said

'The most serious flaw with the terrace mining method is with the potential to totally shut down the mine by having an uncontrollable in-pit fire within this waste oil shale. Currently the mine is operating in what is considered the lower grade oil shale region of the resource i.e. grades of around 35-50 litres per tonne being common. However, as mining proceeds west, grades exceeding 100 litres per tonne become quite common and with such grades the potential for spontaneous combustion becomes extremely serious.' (p14)

Hollingsworth (1992) wrote

'Some empirical evidence indicates that shale with a petroleum content of 60 litres/tonne or more will support combustion.' (CAOS submission, 28/5/99, Appendix 8, p3)

In a private submission, Mr B Benn also wrote of his observation of the prevalence of in-pit fires at Leigh Creek.

However, the Flinders Power submission states

'Terrace mining in the Main Series has been operational for approximately five years using the practices which were developed from the investigation [of Professor Glasser] without any fires occurring in the in-pit dumps.

As part of the on-going management of the in-pit mine dumps, they are periodically monitored for heating using infra red surveys. These surveys have not shown any significant heating in the dumps to date.

Self heating and spontaneous combustion does occur from time to time in the older overburden ramps and surface dumps but these are controlled by dozing and covering with top soil.

Oil shale grades will improve for a time as mining proceeds but we do not expect that significant efforts will be required to prevent or control heating in the dumps. If excessive heating did occur in the waste dumps in the future, it can easily be controlled by moving the in-pit dump forward at a faster rate to leave the heating area well buried and without access to further oxygen.' (p9)

Mr C Steer, Health and Safety Manager, Optima Energy, told the Public Works Committee

'I have a fax from 1995 which indicates that there are about 80 fires a year. In 1996 there were 39 fires; in 1997, 29; and in 1998, 30. So, the incidence of fires has decreased. That is partly because of the work done in fire control.' (Public Works Report, Attachment 1, p7)

- **Conversion of oil shale into greenhouse gases**

The ongoing oxidation of the oil shale can result in the total conversion of the oil shale into gases that have an impact on global warming. The CAOS submission, 28/5/99 states

'In the long term all the organic carbon within the oil shale at Leigh Creek can be expected to eventually be transformed into carbon dioxide. It has been estimated the oil shale has an average organic carbon content of around 10%, therefore each year 20 million tonnes of oil shale has the potential to eventually add approximately 8 million tonnes of carbon dioxide to the environment.' (p14)

Yet, the Flinders Power submission states

'There is a small quantity of carbon dioxide which is released during low temperature oxidation of the oil shale, but this is insignificant.' (p9)

- **Inability to revegetate the mining waste**

The CAOS submission commented on the inability of revegetation projects to successfully cover the mining waste.

'The idea of topsoil covering waste dumps officially is for revegetation, but it will be readily noticed that revegetation is not very successful even after 20 years of trials.' (p15)

This is due to the ongoing presence of hydrocarbons and gases in the waste. However, Flinders Power wrote

'We do not believe that processing of the shale could have a positive impact on environmental or safety issues related to waste dumps. There is no evidence of significant volatile emissions from the shale and on-site testing has shown that the shale does not create any occupational hazards to personnel. Low oxygen atmosphere in the base of the mine is a minor issue. It only occurs under particular atmospheric conditions and is not a consequence of spontaneous combustion. A low cost solution to this issue is currently being implemented. The incidence of spontaneous combustion is low.' (Submission, 17/9/99, p1)

The possible environmental effects of mining the oil shale include:

- **The production of greenhouse gases**

Mr Jackson (Centrex) said

'The greenhouse consideration is one of the major factors raised in criticism of this industry. ... It is usually the fact that you need to use a fair bit of energy in order to get to the stage of extracting oil from known reservoirs.' (Evidence, p18)

Greenpeace wrote

'The major environmental impact of oil shale is through the greenhouse gas emissions released during its production and use. ... Developing new fossil fuel reserves, such as oil shale, is irresponsible because burning any more than just a quarter of already existing reserves will lead to dangerous levels of climate change. ... Industry and government money spent on the development of the oil shale industry diverts resources away from renewable energies. Based on figures from the annual reports of the companies developing the Stuart Project, oil shale produces 60% more carbon dioxide, the main greenhouse gas, than

conventional oil. This makes it the most greenhouse polluting of all fossil fuels.' (Submission, p1)

However, the Stuart Shale Oil Project website states

'Shale processing requires only a small amount of external energy because the heat required to release the oil is supplied by the combustion of the processed shale. This makes the oil-producing process energy self-sufficient and hence reduces overall energy demand significantly.' (p2)

The Executive Summary of the Draft Environmental Impact Statement for the Stuart Oil Shale Project Stage 2 [Queensland] states

'The Greenhouse gas emissions goal in a commercial plant (Stage 3) is net greenhouse gas emissions that are comparable to or less than the greenhouse gas emissions (on a per barrel basis) resulting from the production of conventional refined oil.' (p16)

This is the long term goal for the full commercial production of oil from shale and refers to the emission of sulphur dioxide and nitrogen dioxide from the oil shale processing plant.

- **Leaching of trace heavy metals from the discarded stockpiles into ground water**

There is a possibility of heavy metals being leached from the residue material left over from the oil shale retort process. Research has been undertaken in this area.

'Research at the University of Queensland has shown that leachate produced from production of oil shale, while saline in nature, does not contain environmentally significant levels of toxic inorganics.' (CAOS Prefeasibility Study Oct 1989, Section 11.1)

- **Air emissions from the processing plant**

The CAOS Prefeasibility Study states

'There are no unusual emissions from a shale oil plant and the plant will use conventional technology such as scrubbers for flue gases, precipitators for particles in the gas and flares to burn off unwanted byproducts similar to those used in the oil and gas industry.' (CAOS Prefeasibility Study Oct 1989, Section 11.2)

The CAOS submission (28/5/99) adds

'The Taciuk Plant meets their [USEPA] requirements in operation within metropolitan areas.' (p15)

The Stuart Shale Oil Project website states

'As a result of the combustion of processed oil shale and associated gases, the project will emit sulphur dioxide, oxides of nitrogen, some particulates and carbon dioxide that will be well within the Queensland regulatory standards.' (p2)

This would presumably remove contaminants including trace elements such as heavy metals and other gases which are volatilised during the process.

- **Retort water**

The retort water can be contaminated with a number of chemicals from the oil shale.

Flinders Power concluded

'We do not believe that processing of the oil shale could have a positive impact on environmental or safety issues related to waste dumps. ... Processing shale and the disposal of spent shale in the mine will introduce its own occupational and environmental implications. These would need to be properly understood and costed in any feasibility study related to the extraction of oil from the shale.' (Submission, 17/9/99, p1)

THE FUTURE

The first step needs to be a thorough evaluation of the oil shale resource. The Department of Primary Industries and Resources has indicated that it has no plans to pursue such an investigation. Flinders Power has also indicated that it is not intending to do an evaluation although it is undertaking discussions with interested parties. Central Australian Oil Shale (CAOS) has wanted to undertake a pilot study of the oil shale for many years. To raise adequate funding for the project, CAOS needs some guarantee that it will be able to proceed to full commercial production if the shale's economic viability is proven. This guarantee has not been given although over the years, CAOS has apparently received encouragement from employees of the State Government and politicians to pursue its venture.

Mr McDonald (CAOS) said

'From a non-technical point of view, one of the problems that CAOS had over the 12 year period since it wanted to do something with this resource was the interaction with various Government departments and politicians. I do not know whether you are aware of it, but the area of Leigh Creek has always been excised from the operation of the Mining Act so that any explorer or company wishing to undertake work there and get some sort of concession or tenement could not do that in the ordinary way. There was no security of title, so any commercial company wanting to resource this project needed some bankable security in a traditional way—an exploration licence or whatever—because you could not get this sort of licence in the area. Originally, we made submissions to the Government—John Bannon and Minister Payne—in relation to seeking something akin to an exploration licence. In other words, because the Mining Act did not apply there—and that may have been an anomaly—and because there was a mineral resource that should have otherwise been dealt with under the Mining Act, in a practical way the substance at that time was owned by the Crown, the Crown being represented by the Minister for Mines and Energy at the time.

Submissions were made to the Minister originally to get some sort of tenure over the resource to enable CAOS to continue work on it to develop it to a stage where it considered it would bring in other partners and perhaps develop the project further. Right throughout our submissions we have been saying that all CAOS ever wanted was something akin to an exploration licence over the resource to enable it to spend some money with some security of title so that it could develop the resource in the normal way that any other mining company might want to do in South Australia under the Mining Act. Our relationship with Government departments and politicians has wavered over the years. At some stages, they have let us right in, given us access to material and have allowed us to do tests; and at other times there have been closed doors. Ultimately, there was a fairly severely closed door in 1994 when the ETSA Act or one of the related Acts was amended to preclude the ownership of the shale being given to anyone other than Flinders Power. The Act now says that the carbonaceous mudstone, as Flinders Power calls it, is now the ownership of Flinders Power. So, any allocation of this mineral to the Mining Act and its being administered by the Mining Act is now precluded unless the legislation is

amended. The only way Centrex or any other company, for example, CAOS, can do any work is via negotiation with Flinders Power.' (Evidence, p37)

There is disagreement regarding the rights to the oil shale. The CAOS submission states

'Crown Law advised that any rights that CAOS had in relation to the oil shale granted by Minister Payne in 1987 have well and truly expired. Crown Law did comment that if MESA or ETSA actively encouraged CAOS to spend their money on the oil shale there may be an argument for some sort of defacto rights to CAOS. ... ETSA believe they have exclusive rights to all material at Leigh Creek and Crown Law has said there are arguments both ways about ETSA's rights to the oil shale.' (CAOS submission, 28/5/99, Appendix 12, minute to Minister for Mines and Energy re Evaluation of the Leigh Creek Oil Shale)

Statements by Mr D Watkins (CAOS) suggest that CAOS was encouraged to believe that it would be given preference in the exploration of the Leigh Creek site for oil shale. (CAOS submission, 28/5/99, Appendix 13)

Mr Watkins (CAOS) said

'The simplest thing for us is to get an exploration licence so we come under the umbrella of Primary Industries, but at the same time there would have to be some agreement with Flinders Power as mine operators, so we do not impinge on anything they do. There is no doubt that at least a few million dollars is needed to be spent to properly assess the resource.' (Evidence, p42)

The CAOS submission states

'A comprehensive drilling program is required with accurate analyses using the fresh material so obtained. With accurate reliable drilling data the next step would be to undertake bench scale pilot plant testing using the Taciuk Process to gain process data which will make a feasibility study possible.' (CAOS submission 28/5/99, p23)

At the moment, it is legally impossible for CAOS to get an exploration licence. CAOS suggests that the following actions are necessary:

- The proclamation by the Governor dated 25 October 1984 and made pursuant to Section 8(1) of the Mining Act 1971 be revoked pursuant to section 8(2) of the said Act (this would have the effect of making the Leigh Creek coal field area subject to the normal operation of the mining ie a person could apply for an exploration licence over the whole or part of the area for designated minerals); and
- Suitable amendments be made to the Electricity Corporations Act 1994 (and any other relevant legislation) to ensure that the mining, ownership and sale of coal (as distinct from oil shale) remains with and vests in South Australian Generation Corporation (Flinders Power) and that South Australia Generation Corporation (Flinders Power) ceases to have any ownership rights to the oil shale. (Submission 18/8/99, p1-2)

An alternative for CAOS would be to enter into a business agreement with Flinders Power. However, as CAOS explains in their submission of 18/8/99,

'There can be no certainty of CAOS gaining any title to or right to exploit the deposits through this process, hence CAOS' ability to raise necessary funds for the project would necessarily be limited.' (p2)

Mr McDonald (CAOS) said

'In raising any money in the market, in a mining sense, you need some sort of tenure. You need a tenement to say you have got title to something. Noone can do it without that. That has always been our catchcry. It is always what we have been interested in, being given some sort of tenure with conditions on it. Conditions under an exploration licence require you to spend certain amounts of money each year, with all sorts of other environmental and rehabilitation conditions, and we have been asking for nothing more than that this system be applied to this resource at Leigh Creek. Without that, it is impossible to go to a third party and raise significant money.' (Evidence, p44)

Management Options if the Oil Shale is Utilised

If mining the oil shale proved to be a viable industry, there would need to be changes to the method of coal mining. This could result in two operators within the pit. The following issues would need to be considered:

The interaction of personnel

Type of mining

The siting of the spent shale deposit

The separation of the shale from the overburden

The haulage distances to the stationary oil shale processing plant would increase with time

The elevation of the overburden out of pit to take it to the processing plant

Double handling of the oil shale

Mr Caplygin (PIRSA) said

'If ever this oil shale were exploited the organisation would have to work very closely with Flinders Power not to disrupt its coal mining operations ... The [MineConsult] study indicates that the operation should utilise the AOSTRA process, which is a process with low capital and operating costs, and that there would have to be significant stockpile management in order to minimise its impact on the mining operations.' (Evidence, p15)

The Flinders Power submission (17/9/99) states

'A parallel coal and shale recovery operation at Leigh Creek is not expected to provide any significant financial, environmental or occupational health and safety improvements to the existing operation. ... The success of any future oil shale venture would be heavily reliant on the effective integration of the coal and oil shale production processes at the mine site. This will only be achieved if the combined operations comes under a single entity.' (p2)

Mr Jackson (Centrex) said

'We have had friendly discussions with Flinders Power and we both agree that mining could only take place under one management, but that a joint venture is possible if the oil shale could in fact be economically processed.' (Evidence, p21)

Mr Watkins (CAOS) said

'The whole time we have maintained it would be a joint relationship between the mine operator and us, and they would do the mining. ... Whatever work is done, instead of going back to the pit, the shale would go to the plant for processing, to stop any selective mining problem and to stop any conflict about which bits should go where – what should go back to the pit and elsewhere.' (Evidence, p41)

Submissions	Date
Miss FG Lesses	2/5/99
Centrex Resources N.L.	26/5/99
Central Australian Oil Shale Pty Ltd	22/3/99, 28/5/99, 18/8/99
Flinders Power	June 1999, 17/9/99
Mr Bruce Benn	15/7/99, 27/7/99, 1/8/99, 10/8/99, 14/8/99
PIRSA- MineConsult Report	28/5/99
Greenpeace	10/9/99

Witnesses	Organisation	Date
Mr S Caplygin	PIRSA	4/8/99
Mr J Fargher	PIRSA	4/8/99
Mr M Rajkowski	Flinders Power	4/8/99
Mr Althoff	Flinders Power	4/8/99
Mr D Watkins	CAOS	11/8/99
Mr M McDonald	CAOS	11/8/99
Mr N Jackson	Centrex	11/8/99

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MESA Journal 1 (March 1996) *Leigh Creek coal mine – State of the art* Serge Caplygin, Sean Brennan p17-19

Stuart Oil Shale Project Stage 2 *Executive Summary Draft Environmental Impact Statement* Sinclair Knight Merz (September 1999)

Stuart Shale Oil Project 12 August 1999 [On-line]
Available URL: <http://www.altgreen.com.au/qge/stuart.html>

The 87th Report of the Public Works Committee, Parliament of South Australia (1998) *Leigh Creek Coal Truck Dumping Bridge Replacement*

The 4th Report of the Statutory Authorities Review Committee, Parliament of South Australia (1995) *Review of The Electricity Trust of South Australia (Occupational Health & Safety Issues at Leigh Creek)* Interim Report

The Stuart Project (3 August 1999) [On-line]
Available URL: <http://www.suncor.ca/01about/news10-97.html>