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IN-SITU GASIFICATION OF COAL FOR ELECTRICITY, SYNGAS AND SYNFUELS

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SUMMARY This paper outlines the development of a large scale, parallel borehole system for in-situ gasification of deeper coal. By use of modern deviated drilling techniques, operation of high pressure and engineering analysis the systems demonstrated on a small commercial scale in the U.S.S.R and by field trials elsewhere can be extended to yield high outputs of gas per borehole at attractive costs.

A cost analysis is presented for a demonstration plant for producing 60 MW of electricity from gas generated from deep coal at Leigh Creek, South Australia. Apparently raw gas can be made for about $1 per GJ and electricity for about 5c per KWH. A limited trial which would prove the underlying gasification concepts is also described. A successful demonstration of in-situ gasification with air would open the door to underground gasification with oxygen.

In-situ gasification of coal with oxygen promises to become the preferred source of syngas and synthetic liquid fuels when the shortage of oil recurrs.

1 INTRODUCTION

Australia is faced with declining self sufficiency in petroleum. Despite vigorous exploration, reserves have been falling and production is likely to halve before the mid 1990's. The recent fall in oil prices threatens to reduce exploration activity and aggravate the position. Thus we are faced with both declining security of supply and an increasing bill for imports.

It is important that local production of liquid fuel be increased. In-situ gasification of coal to produce synthesis gas for conversion to liquid fuels offers a low cost means to this end. It has the particular advantage of being applicable to deep and low grade coals, leaving the higher quality, more easily mined coals for other purposes including exports. Moreover it has lesser impact on land, air and water environments. In-situ gasification is also applicable to the generation of electricity.

To secure high outputs and low costs it is necessary to increase the scale and scope of the established technology. Pilot tests and some years' experience with a demonstration plant will necessarily precede full scale commercialization.

A pre-feasibility study[1] of a suitable demonstration plant has been funded by N.E.R.D.D.C. assisted by Electricity Trust of S.A. and the S.A. Department of Mines and Energy. The study indicated generation of 50 to 70 MW of electricity at Leigh Creek to be economically viable and is described later herein.

2 HISTORICAL DEVELOPMENT OF IN-SITU GASIFICATION

The concept of in-situ gasifications of coal developed in Russia[3], the U.K. and the U.S.A. late last century as a means to reduce the cost and the hazards of underground coal mining. The first major experiments were in the U.S.S.R. between the wars. Shortly after World War 2 tests were carried out in a number of countries but interest waned in the period when oil was cheap and since then most major trials have been in the U.S.A. and U.S.S.R.

The only commercial scale applications are in the U.S.S.R. where two small facilities, all air blown, produce gas for electricity generation, district heating and industrial purposes.

Trials using oxygen/steam have been carried out in the U.S.S.R, by Lawrence Livermore Laboratory, by Texas Utilities and most recently, between 1978 and 1982, by Gulf R&D[4] at Rawlins, Wyoming. These have demonstrated that oxygen-steam gasification is more efficient than air gasification and presents no particular problems. Building on this experience, the firm Energy International Inc. (who have inherited Gulf's expertise) is vigorously advancing a commercial facility[5] at Rawlins to convert over 1.5 m te p.a. of coal in-situ gasification with oxygen/steam to syngas and thence to transport fuels (using Fischer Tropsch synthesis) and synthetic natural gas.

A deep seam trial is also planned for France.

Two broad geometrical arrangements of inlet and outlet boreholes have been used to access coal. In one the holes are drilled vertically at a spacing of up to 25 meters and thus intersect a horizontal seam roughly at right angles. Each hole thus accesses only coal immediately below and drilling costs vary directly with depth and inversely with seam thickness.

In the second, boreholes are drilled within (or slightly below) the seam. Hitherto this has been possible only where the seam dips steeply permitting the drilling of straight holes within the coal from the surface (as at S.Abinsk in the U.S.S.R. and the trials at Rawlins) or where drilling is done from a drive (tunnel) within a horizontal seam as in trials at Newman Spinney[6] in the U.K.

Recent advances in deviated drilling now make it possible to drill from the surface into slightly sloping or horizontal seams and to continue drilling within the seam for perhaps a kilometre. In this way the volume of coal accessed per metre of hole may be increased many times, with a corresponding reduction in drilling cost per unit of coal gasified.

The use of coal at depth makes possible operation at pressure which further reduces costs. The use of long holes minimizes disturbance at the surface. A further advantage of this system is that boreholes are not liable to disruption by subsidence of the cover into the cavity created.

It is necessary at the outset of gasification to link the inlet and outlet holes and initiate the reaction. A major development of the Russians was the "reverse combustion linkage" which works well in low rank coals at distances to about 25 metres. Several other techniques are available.

Modern systems for in-situ gasification rely on in-seam boreholes to minimize costs and disturbance at the surface. Gasification with oxygen/steam (rather than air) is necessary if syngas is required.

3 AVAILABILITY OF SUITABLE COAL IN AUSTRALIA

N.E.R.D.D.C. sponsored a programme of work at the University of Newcastle[7] which included a survey of coal resources unsuited to mining by conventional means but suitable for in-situ gasification. Only considered were seams of minimum two metre thickness close to potential markets for gas for production of electricity or conversion to synfuels. Reserves identified included:

- about 600 million tonnes at Collie, W.A.

- about 2,000 million tonnes of high-ash coal, below seams currently being mined for power generation on the Central Coast of N.S.W.

- several hundred million tonnes of coal with high sulphur tops on the Greta-South Maitland field in N.S.W.

- large quantities in the Upper Hunter River area of N.S.W.

- about 100 million tonnes in the Moreton field in Queensland.

- about 250 million tonnes at Leigh Creek (S.A.) below the lowest open cut limit. While distant from markets this site offers particular advantages for an initial demonstration (seam nature and thickness, depth, infrastructure).

Some other resources with good market location will require development of gasification techniques and experience (e.g. the thick seams with high water make and low overburden in S.A. - Wakefield, Kingston etc.), also seams with massive igneous overburden (Fingal, Baccus Marsh).

Additionally, for the longer term, there are very large deposits of very deep coal in the Cooper Basin of S.A. and also undoubtedly in the Bowen Basin (Queensland) and the Sydney Basin.

It is concluded that Australia has very large reserves of coal suitable for in-situ gasification but unsuited to conventional mining. Moreover, most of this resource is at depths below 200 metres where the appropriate in-situ gasification technique is to use in-seam boreholes. Work at the University of Newcastle has been directed to understanding this system and developing reliable and cost effective layouts for it.

4 COST OF IN-SITU GASIFICATION

4.1 Comparisons

Where coal energy is required say for firing boilers in power plants, in-situ gasification performs the functions not only of mining but also of surface transport of coal, preparation of coal and disposal of ash, as indicated in Figure 1. Sulphur and dust are more easily removed from fuel gas than from stack gases. Boiler plant for gas is much less costly than for coal. Moreover the availability of energy as gas makes feasible the use of efficient, low capital cost combined cycle generation.

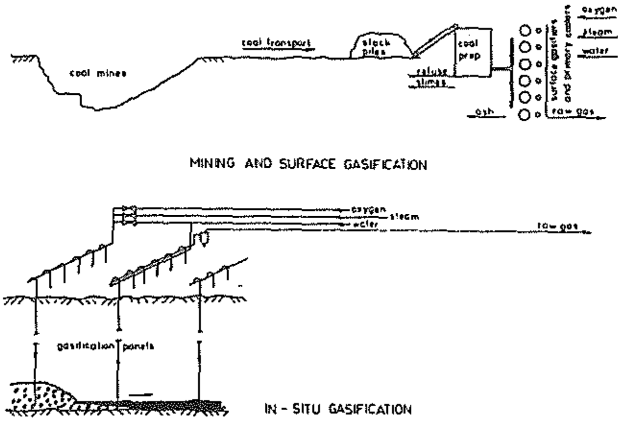

Fig. 1 IN-SITU GASIFICATION & MINING

Where the energy is required as syngas, in-situ gasification eliminates the dirty and unsightly surface gasifiers, coal handling and ash handling facilities which comprise 30% to 40% of the capital cost of conventional plant for producing syngas, with corresponding reduction in annual costs. An oxygen plant and gas cleaning, shift conversion and carbon dioxide removal facilities are needed whether gasification is carried out in surface facilities or underground.

In-situ gasification minimizes disruption of the environment by noise, dust, structures and transport systems. In some circumstances foul water may be disposed of into the reaction front. It has much less impact on the land-surface than open-cut mining particularly where the in-seam borehole system is used. Subsidence effects are similar to those of longwall mining.

It is apparent from the above that to get valid cost comparisons it is necessary to consider the coal winning - coal using system as a whole.

4.2 The Cost Structure Of In-Situ Gasification

The costs involved in in-situ gasification include:

- drilling and preparing boreholes. This increases with the depth of seam. The cost per unit of energy delivered is inversely proportional to the quantity of coal accessed per borehole (i.e. to seam thickness multiplied by length of borehole within the seam multiplied by width of panel gasified per hole). For thick seams at modest depths (200 metres) borehole costs below $0.2 per GJ are readily achievable. For deep coal long boreholes at wide spacings offer economic benefit.

surface piping and control equipment. Costs are generally less than the above. Unit costs fall as output per borehole increases as well as with quantity of coal accessed.

provision and compression of the blast. For the low pressure air blown systems used in the U.S.S.R. from 2 to 4 bars pressure was required and no pressure energy was recoverable. Compression of air absorbed up to 15% of the mechanical energy produced and was a major cost item. With gasification at higher pressures, pressure energy is recoverable from the increased volume of product gas.

gas cooling and cleaning is a substantial cost item. For syngas the equipment required is similar to that needed for surface gasification. In the U.S.S.R. water washing in a simple packed tower was used to clean gas generated by air blowing prior to combustion. (but see Section 6.4).

5 A MODERN IN-SEAM BOREHOLE SYSTEM

It appears from the above that to achieve low costs it is desirable to operate at pressure and to access as much coal as possible per metre of borehole, i.e. to use wide spacing and long in-coal lengths of borehole. The programme carried out for N.E.R.D.D.C. at the University of Newcastle investigated the scope and limitations of these variables.

5.2 Borehole Length

There is considerable experience in Australia of the rapidly developing technology of deviated drilling. It is certainly feasible to drill from the surface for a kilometre or more and to deviate to follow a coal seam. The drilling of hundreds of metres within a coal seam is certainly possible at reasonable cost and there is a reasonable basis for estimating costs. Drilling down dip is less arduous than drilling horizontally.

5.3 Lateral Spacing Of Boreholes

The only experience with in-situ gasification using multiple boreholes has been in the small commercial operation in steeply dipping coal at S.Abinsk in the U.S.S.R and one trial in a thin (0.8 meter), horizontal seam at Newman Spinney in the U.K. in 1959. Both were in hard coal.

Russian experience established a limit of 20 to 25 metres for the reverse combustion linkage method. This spacing was largely used at S.Abinsk but was successfully extended to 40 metres in thick (up to 9 metre) seams. The trial in the United Kingdom burned out the full width of its 23 metre spacing.

To optomize system design a method is needed to determine what maximum lateral borehole spcing may be used for a given mass flow of gas and borehole length. No such model has been available, either theoretical or empirical. The current objective of the University of Newcastle programme is to develop such a model.

5.4 The Newcastle Computational Model[8]

The model uses a simple "ideal" system of a cavity with smooth sides tapering towards the exit borehole as indicated in Figure 2. Inputs are coal properties (composition, heat content), water leakage, system width, roof break width, blast properties, and flow rate. Adjustable parameters for packed bed flow, apparent reactivity and ash blanketing were used to test sensitivity. They will enable the model to be adjusted for a particular seam from the results of a limited field test so that reliable extrapolation may be made to a larger commercial system. The programme computes the development with time and distance of cavity shape, gas analysis, and thermal efficiency.

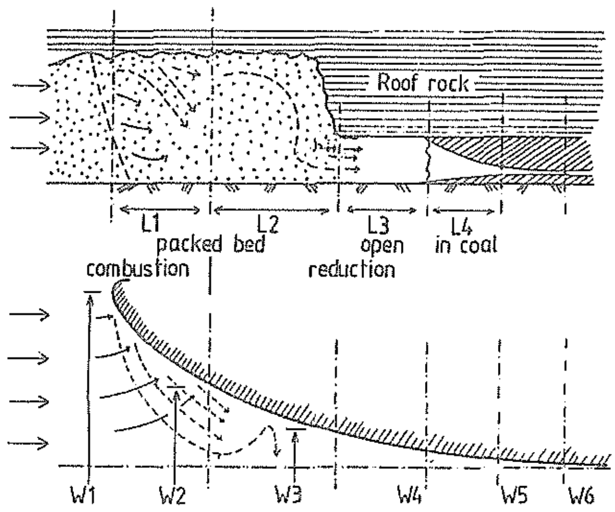

Fig. 2 REACTION FRONT

It is assumed that the panel of coal gasified is wide enough to ensure complete collapse of the roof (as in longwall mining) since otherwise the void space leads to instability in operation, particularly in deep coal.

Incoming air or oxygen/steam permeates from upstream, through the zone of broken rock, to the reaction front.

Exit boreholes are parallel and within the seam.

Within the model one parameter reflects the flow characteristics within the fallen roof zone. With adjustment only to this parameter the model predicted very closely the gas analysis, exit temperature, and the shape of the burned-out cavity both in laboratory tests at the University of Newcastle and the tests at Newman Spinney.

Some further elaboration is required to correctly reflect the effect of water flow.

Results so far establish that the model can be used with confidence to extrapolate the results of field trials and commercial experience. It will also indicate the key observations required in future

5.5 Computed Relationships (Mass Flow, Width, Length)

Firstly, the model produces results in agreement with U.S.S.R generalizations:

performance (thermal efficiency, gas specific energy) fall off rapidly with seam thicknesses below than 2 metres.

performance increases slightly with gas mass flow rate above a certain minimum rate (without limit if the borehole is long enough).

the effect of water ingress is great.

Secondly, new results, subject to development, indicate that:

performance is not very sensitve to the width of the system, reactivity of the coal or accumulation of ash provided that system length is great enough.

the active borehole length required is proportional to the mass flow of oxygen per metre of seam thickness for any particular coal. (For the pilot trial proposed in Section 8 this indicates an active zone about 20 metres long which should be adequately observable in the 60 metre length proposed).

increase in system pressure improves performance and reduces the length required.

oxygen/steam or oxygen/water gasification requires less length than air and gives slightly higher thermal efficiency.

5.6 Integrity Of Inlet and Outlet Boreholes

It is imerative that the inlet and outlet boreholes are not damaged during the life of a panel by subsidence over the burned out area. This is best achieved by locating the inlet boreholes within the seam between the outlet holes. This has added advantages of making for a compact surface layout and of distributing the oxidant uniformly to the reaction front.

One potential problem with this arrangement is to prevent the reaction front burning back along the inlet holes. Lawrence Livermore Laboratories have developed the "Crip" system for controlling burn-back. Here the inlet holes are cased with a light steel liner which is cut off (using a retractable lance) from time to time as the reaction front advances. Alternatively, work at the University of Newcastle has shown by laboratory trials and also computer studies that burn-back can be controlled by injecting a small quantity of liquid water with the inlet oxidant. This invention[9] has been patented.

6 PROPOSED TRIAL AT LEIGH CREEK

It will be necessary to get some years' experience with a system of substantial size before large scale, low cost gasification of deep coal could be undertaken with confidence.

It appeared this experience could most readily be obtained with an air-blown system applied to a readily accessed coal seam with gas being used to generate electricity for sale.

Shedden Pacific Pty. Ltd, in association with Prof. I. McC. Stewart and Golder & Associates Pty. Ltd, was commissioned by The Electricity Trust of S.A. and the S.A. Department of Menerals & Energy to carry out a pre feasibility study of such a system. The study was funded by N.E.R.D.D.C. and is described below.

6.1 Selection Of Site

The deeper coal below the ultimate depth (200 metres) of the Electricity Trust's open cut mine at Leigh Creek S.A. was selected for the study. The main seam here is 11 to 13 metres thick and it dips at 10° to 15° which would facilitate drilling. Considerable information is available on the nature of the deposit. About 250 million tonnes of coal at depth too great for recovery by opencast mining in the foreseeable future is available.

Infrastructure is available. There is a substantial local electricity load and a high voltage connection to the S.A. grid. A satisfactory trial here would also open the door to development of the larger but more difficult S.A. deposits.

6.2 General Specification Of Demonstration Plant

It was agreed with the South Australian Authorities that:

a gas turbine powered electricity generating plant should be used so as to minimize usage of scarce water.

plant capacity should maximize economies of scale without exceeding capacity of the existing transmission system (ie 50 to 70 MW).

the system should be laid out for a commercial life of 25 years.

the area to be gasified should be laid out so as not to sterilize remaining coal or to interfere with existing or foreseeable future open cut mining operations.

Economic considerations dictated that the largest practicable standard equipment be used. Brown Boveri turbines of 35 MW nominal capacity were selected. Two such units would consume about 30 million tonnes of coal over a life of 25 years.

Dr.L.K. Walker of Golder & Associates was retained to evaluate the geology and hydrology of the area and define the area to be gasified. He has since undertaken some additional study and has reported[10] further on faulting, hydrology and roof conditions. While much closer examination will be necessary, this preliminary work indicates in-situ gasification at pressure to be feasible.

6.3 Detailed Design Of Gasification System

The number and spacing of holes assumed in the design is based largely on Russian experience but the geometric disposition of holes (parallel Production and Blast boreholes within the seam) is as shown in Figure 3.

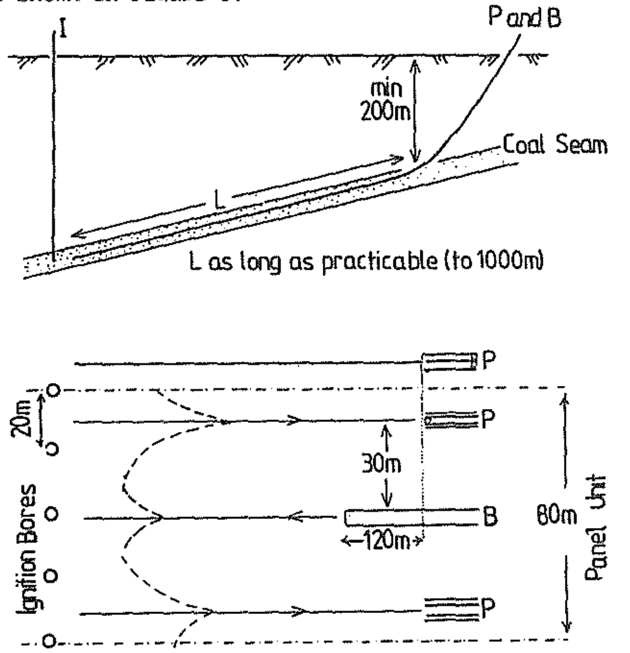

Fig. 3 PARALLEL BOREHOLE SYSTEM

The design output is taken to be 20 MW (thermal) per output (ie production) borehole. To achieve a total output of 60 MW (electrical) at least 12 holes are required to be in operation at all times, a number sufficient to ensure control of gas quality despite "lifecycle" and random variation between individual holes.

Acceptable pressure drops will be achieved using standard, 210 mm i.d. casing and one inlet (air) hole to serve each two outlet holes.

Subject to confirmation by preliminary trials, each pair of outlet holes will be parallel and 60 metres apart with the corresponding inlet hole between. Holes will extend 400 metres within the coal seam. Output holes will be cased and grouted to the point where they enter the coal seam, inlet holes will be cased and grouted for 120 metres into the coal. Each panel is expected to gasify a strip of coal 80 metres wide, 400 metres long and containing about 400,000 cubic metres.

Six panels will be in use at any time and roughly two panels will be retired and two commissioned each year. The first panels will be at depth 200 metres but depths down to 400 metres will be used later.

Ignition will be by the "reverse combustion linkage" method from vertical holes drilled from the surface close to the ends of the in-coal inlet and outlet holes.

The coal is sub-bituminous with about 31% moisture and 17% ash in situ. The dry, ash free composition (by weight) is:

C	O	H_2	S	CI
70%	24%	4%	0.9%	0.5%

Gas composition (v/v) is expected to be as follows:

CO_2	CO	H_2	CH_4 etc.	N_2	H_2S
15%	14%	15%	2%	54%	0.13%

The net specific energy of the gas should be about 980 kJ Kg^{-1} (dry) and its sodium chloride content should be less than 0.1% by weight.

Depending on the age of a panel gas exit temperature will be 300 to 600°C but will be cooled with a water spray to 300°C.

Operating pressure will be about 16 bar in the underground system and 12 bar at the turbine inlet in accordance with the specifications of the gas turbine sets selected. The gasification pressure, 16 bars, is amply safe for the minimum strata cover of 200 metres.

6.4 Detailed Design of Power Plant

The power plant comprises two standard gas turbine sets generating at 11,000 volts, three phases and 50 cycles with associated control and switch gear together with blast booster compressor and gas cleaning plant.

Standard gas turbine sets are designed for hydrocarbon fuels and their compressors provide too much air for the present service. Air compressed is used for three purposes. Part is used for combustion of the gas produced underground. Part is boosted from 12 bars to the 17 bars required for the underground system by a separate electrically driven compressor. The remainder is surplus and is exhausted through a let-down turbine which assists powering the booster compressor. For a larger commercial installation it may be feasible to simplify the system by using a custon-built compressor.

Two gas cleaning systems were investigated. As product gas is delivered from underground at about 300°C with 30% w/w of water vapour there is thermodynamic advantage in removing solids with high efficiency cyclones and delivering uncooled gas to the turbine combustion chamber. However, because of the high chloride content of the coal it is possible that the salt content of the cleaned gas will necessitate limiting the turbine inlet temperature. To be conservative it is assumed that turbine inlet temperature will be restricted to 800°C.

The use of water washing towers for removal of both solids and salt was also considered. The arrangement chosen was selected to minimise the loss of temperature and thus maximise thermodynamic efficiency. Although production of tar in in-situ gasification is expected to be low, liberal provision is made in the design for treating waste water.

Costs also included provision of transformers, switchgear and transmission lines for delivery of power to E.T.S.A.'s main switchyard at 132 kV.

7 ECONOMICS OF LEIGH CREEK

The system costed comprised:

two standard Brown Boveri gas turbine sets together with electricity generating control, and transmission facilities. Nominal capacity is 35 MW per unit but actual output is expected to be 30 MW and 24 MW with wet and dry gas cleaning respectively.

six (initial) gasification panels each 80 X 400 metres in size and served by a single, central in-seam air inlet borehole and two parallel outlet boreholes 30 metres distant on either side.

reticulation pipework and header delivering air to and gas from the panels.

off site facilities, buildings etc.

Capital costs, including all related expenditure up to and including commissioning were estimited to be as tabulated (in Australian money of mid 1983 value):

	CAPITAL COSTS $ millions	
GAS CLEANING SYSTEM	Wet	Dry
Underground	5.5	5.5
Reticulation	4.5	4.2
Gas Cleaning	9.3	1.1
Machinery, Electrics	25.0	23.9
Offsites, Buildings ect	16.1	16.1
Engineering, Admin, Licenses, Contingencies	30.3 to 39.3	24.9 to 48.0
TOTAL	90.7 to 99.7	75.7 to 98.8

Operating costs comprise, in roughly equal proportions, personnel costs, maintenance costs and the cost of adding new gasification panels as those in use are exhausted, as tabulated.

	OPERATING COSTS $ million pa	
GAS CLEANING SYSTEM	Wet	Dry
Gasification System	2.4	2.0
Maintenance	3.3	3.3
Personnel	2.6	2.3
All Other	0.4	0.4
TOTAL	8.7	8.0
ELECTRICITY COST c/KWH	4.4 to 4.7	4.7 to 5.4

The cost of electricity tabulated above is the "levelised cost" at 70% load factor computed over 25 years at a real discount rate of 5% pa.

Considering the small scale of the generating units the estimated cost of power produced is considered highly promising.

8 PROPOSAL FOR GASIFICATION TRIAL

While the outcome of the pre feasibility study is highly favourable, much further work is required before sanction of a $100 million demonstration plant could be contemplated.

Most important and urgent is a clear demonstration of the practicality of the intended gasification system. The Government of S.A., through S.E.N.R.A.C. has funded the definition and costing of a suitable trial. Its objectives are:

- to confirm information on the generally applicable aspects of the in-seam borehole system for in-situ gasification (accuracy and cost of drilling, pipe wear, borehole liner performance)

- to confirm that burn-back in the inlet boreholes can be suppressed by injecting liquid water in accordance with the patent of the Univeristy of Newcastle.

- to evaluate aspects specific to Leigh Creek coalfield, particularly gas composition including solids and salt loading and the performance of gas cleaning equipment, roof break and geological and hydrological conditions.

- to obtain design data for a commerical scale applications.

Subject to final design it is proposed that the trial be carried out in Lobe C, Leigh Creek, which is remote from existing and proposed workings. Parallel inlet and outlet boreholes would be 25 meters apart and 300 metres long of which 60 metres would lie within the seam. Air for gasification would be supplied at 1.25 kg s^{-1} and a pressure of 6 bars which is appropriate to the depth of coal. Gas made would be flared.

Under these conditions 7,000 to 10,000 tonnes of d.a.f. coal would be gasified in a year's run creating a cavity of area 1,000 to 1,500 square metres which is sufficient to evaluate roof fall and provide information on geological and hydrological conditions. If necessary the trial could be extended at the incremental cost of daily operations which is not large.

Such a trial could be completed in about three years and would cost about $3.7 millions (1985 money value) or perhaps $5 million in "money of the day". A similar trial in thicker and deeper coal in Lobe B, Leigh Creek might cost 30% more.

Information is required less urgently in other areas.

Detailed knowledge of the thickness, depth, and quality of coal and the prevalence, throw and location of faults is required before the area to be gasified can be selected or the panels laid out. Information in the mechanical characteristics of the roof rock is needed for modelling roof break. Information on the permeability and porosity of coal and the roof rock is needed to assess likely changes in the water table profile, the feasible range of operating pressures and the likelihood of leakage of gas to atmosphere.

Further investigation of gas turbines for use with gaseous fuels with low heat value and of "dirty" gaseous fuels is needed. The relative merits of gas turbines and steam turbines should also be further considered.

9 DEVELOPMENT PROGRAMME

The major use seen for in-situ gasification in Australia is for production of syngas and thence synthetic liquid transport fuels. It should be useful also for electricity in particular locations eg S.A. Vigorous development is necessary to ensure the technology will be available when needed, probably in the mid-1990s.

It is proposed that the trial outlined above be carried out as soon as practicable. Geological and hydrological evaluation of Lobe B and investigation of machinery options would proceed simultaneously so that on successful competion of the trial late in 1989 design and construction of a demostration electricity plant could commence. In this way some substantial scale practical experience of the technology could be available by 1994 or 1995 to provide a basis for oxygen gasification and production of syngas.

It is noted that the total cost of this programme (much of which would be recouped from the sale of electricity) is small relative to one year's expenditure by Australia on exploration for oil. However, in view of the shortage of domestic development funds it is proposed to invite overseas participation.

10 CONCLUSION

Each Australian state has large reserves of coal suitable for in-situ gasification but unsuited to conventional mining at acceptable cost.

Assuming the promise of in-situ gasification with oxygen/steam to be fulfilled as outlined herein it will be the cheapest source of syngas and "first cab off the rank" for production of synthetic transport fuels when this becomes necessary, in the 1990s.

In-situ gasification using air promises to be a cost effective source of electricity in the long term at a number of lcoations. Combined cycle (gas turbine plus steam turbine) plant would be used. This would provide large scale experience on which to base oxygen gasification for syngas and synfuel production.

An in-seam parallel borehole system formed by deviated drilling from the surface and operation under pressure is the future method. The system illustrated in this paper is in advance of anything yet developed overseas. It is supported by experience available to date.

The computational system analysis under development at the University of Newcastle will permit more precise extrapolation of design data from field tests and hasten commerical development.

The deep coal at Leigh Creek is suitable for, and would support a 300 MW commercial power plant.

A careful study of capital and operating costs indicates that a 60 MW demonstration plant would cost $75 to $100 millions, could produce power for 4.5 to 5.5c/KWH and be commerically viable.

A commercial scale pilot trial to prove the air gasification system proposed for the above plant would cost about $5 millions and could be completed in three years.

Several years' experience with a demonstration commerical scale facility using air for gasification is essential before proceeeding to a full scale syngas plant using oxygen. Early action will be needed if the tehcnology is to be available when needed, probably in the 1990s.

It is proposed that the gasification pilot trial be carried out and that the demonstration power plant be built on its successful completion. It is noted that the costs involved are small relative to current expenditure on exploration for oil. In view of the shortage of development funds in Australia it is proposed that an overseas partner be sought.

11 ACKNOWLEDGEMENTS

The work at the University of Newcastle and the pre-feasibility study were substantially funded by N.E.R.D.D.C. grants. Vauable information and field assistance were received from the Electricity Trust of S.A. and the S.A. Department of Minerals and Energy. The S.A. Government and the Department of Minerals and Energy through grants from S.E.N.R.A.C. enabled us to continue the geological and hydrological investigations necessary to confirm the technical feasibility of the project and to estimate the cost of the pilot field test which must precede commercial development. Finally we thank the University of Newcastle, Shedden Pacific Pty. Ltd. and Golder Associates Pty. Ltd. and our various colleagues for their contributions.

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