Brian Smeaton

The King is Dead. *Long Live the King!*

King Coal

- King Coal = deep mining, fuelling coal-burning power stations; formerly major employer, now in terminal decline
- Dates back to 17th century
- Helped fuel the expansion of steam
- In 1913, produced 43 Million tons, exported worldwide

King Coal

- Increased investment in the 50's and 60's, but competition growing from nuclear, oil and gas
- In 1984, employed 30,000 men at 14 pits, then the strike
- Provides 30% of Scotland's electricity / export of electricity
- Provided security and surety of energy supply
- Last deep mine inn Scotland, Longannet, closed this month
- 12? Deep mines left in UK

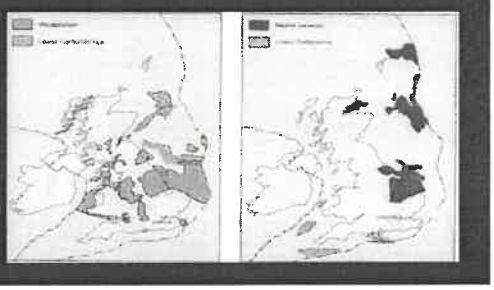
The King is dead because of:-

- Union/Government interaction; 1984 strike
- "Dash for Gas"
- Cost of mining British coal (increasingly difficult conditions, world pricing)
- Environmental Lobby
- "Dash for Renewables"
- Social considerations

The White Paper requires:-

- Diversity and security of supply
- Low net carbon emissions – coal for CO_2 sequestration
- 20 % renewables by 2020
- Innovation
- Energy-driven foreign policy

UK Coal Resources

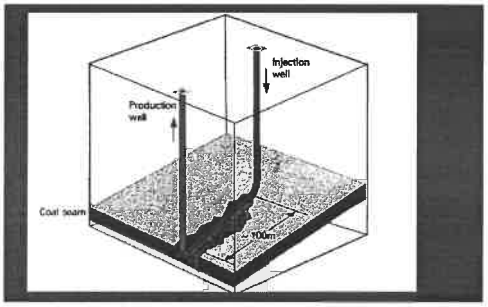


Long Live the King!

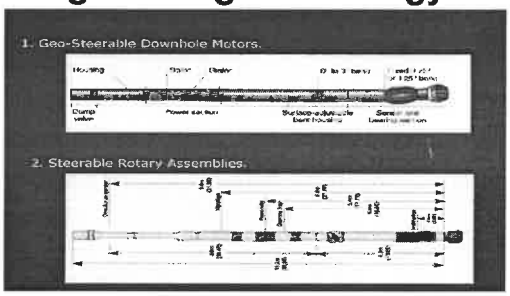
- ***In situ* gasification *(not recognised?)***
- **CO_2 sequestration + CH_4 production *(CO_2 sequestration recognised)***

Consider *in-situ* gasification

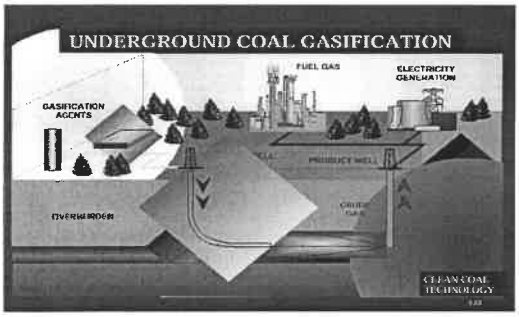
In Situ Gasification



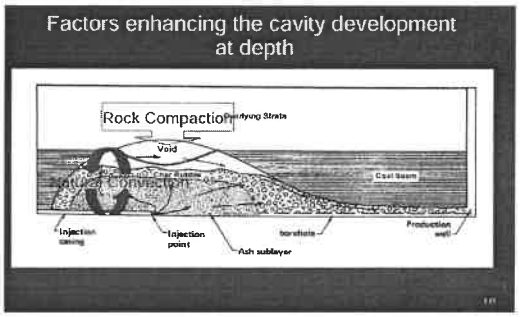
Uses petroleum engineering technology



In Situ Gasification



Process-Related Challenges



Is this being treated seriously?

Yes, successful pilot-scale trial in Spain, DTI a partner

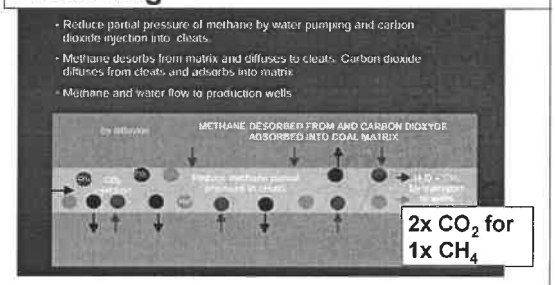
"The feasibility of the underground coal gasification at the intermediate European depth (580m) has been demonstrated"

Will it be tried in the UK?

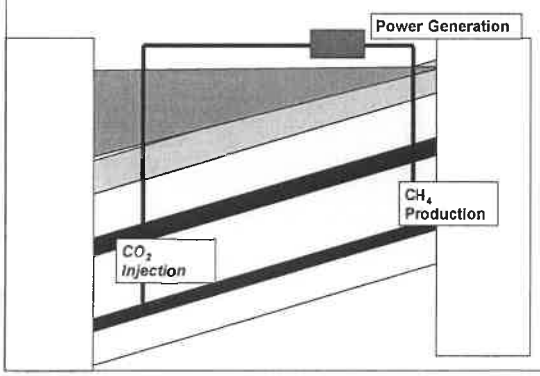
- The DTI (the Coal Authority) is attempting to do this
- Planning permission refused for first site (Silverdale)
- Prime sites have been identified in Scotland

Consider CO_2 sequestration

CO_2 Sequestration (injection), Producing Methane



CO_2 Sequestration

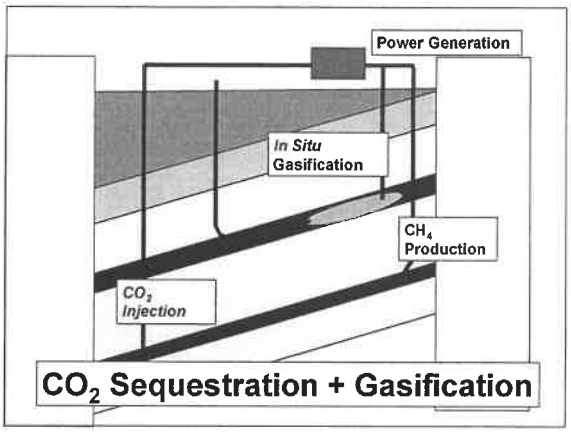


Is this being treated seriously?

Yes, e.g. Dutch feasibility study:-

"Between 54MTonne and 9GTonne of CO_2 can be sequestered at 4 sites. The price of the CH_4 produced will be competitive with natural gas if a bonus for CO_2 sequestration of 25Euros/Tonne is applied"

Now consider the combination!



The (new) King could live because:-

- Energy production via *in-situ* gasification (reduced environmental impact)
- CH_4 production with CO_2 sequestration (zero CO_2 production)

The (new) King could live because:-

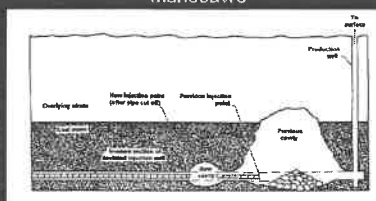
- No threat from unions
- UK's gas will run out, plenty of coal left
- U/G can access difficult conditions
- U/G more environmentally friendly
- Social conditions!
- Can be applied off-shore
- What are the alternatives? Imports?
- Development of new technology/knowledge for export
- *Forms part of an energy policy that provides security and surety of supply*
- *Bridges operational gap between conventional coal and nuclear plant and renewables*

Can we really afford to forget about coal as a source of energy?

Acknowledgments

The Coal Authority
DTI

Controlled Retracting Injection Point (CRIP) manoeuvre



To avoid the natural tendency of the burning front to move upward to the top of the coal seam (overriding effect) and to establish a more efficient burn geometry

Expected UCG Performances at Silverdale
(based on Ten Feet Seam)

Reactor geometry and pressure	
· Length	310 m
· Width	18 - 24 m
(based on 15 MW average)	
· Duration	4 - 5 months
· Coal gasified	14,000 - 19,000 tonnes
· Pressure	65 - 70 bar
Gas Heating Value	
(dry N_2 - free basis)	
· LHV	~ 10,000 kJ / m³
Oxygen utilisation	
· Power produced (for 100 m³ of oxygen injected per hour)	1 - 1.5 MW
· Coal gasified per oxygen injected	~ 3 (wt ratio)
Energy utilisation	
· Lost	15 - 10 %
· Chemical Energy Recovery	80 - 85 %

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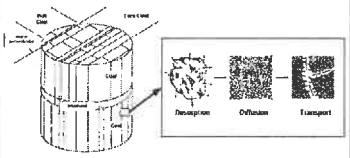
Coal Structure and Desorption Process



Output Per Well

- Single UCG well (200m length x 30m width) produces 292,400GJ (81.2GWh)
- Power output is 20MW+ per well (1728GJ/day)
- Duration 169 days

Value of production at current prices

Valued as surface coal (£1.1/GJ)	£1,900/day
Valued at gas price (0.55p/KWh)	£2,600/day
CBM well (5,600m³/day)	£ 299/day

Impact Comparisons

	PF+FGD +SCR	UCG	UCG+CO_2 Removal	NGCC
Global				
CO_2 kg/MWh	750	780	280	380
Regional				
SO_2 kg/MWh	0.60	0.02	0.02	0.001
NO_x kg/MWh	0.20	0.16	0.19	0.18
VOCs kg/MWh	0.01	?	?	
Local				
Particulates kg/MWh	0.09	0	0	
Water Pollution	++	+	+	
Visual Impact	++	+	+	
Noise	+	+	+	
Vehicle Movements	++	+	+	
Occupational Accidents	++	+	+	
Subsidence	++	+	+	

7. CONCLUSIONS

- The feasibility of underground coal gasification at the intermediate depth of European coal (600 metres) has been demonstrated.
- The new deviated drilling techniques were particularly successful in establishing gas flow circuits through the coal seam. The same techniques were successfully applied to the post gasification investigation of the cavity.
- Valuable insights have been obtained into the gasification process at intermediate depth. Coal, at this depth, was found to be readily ignitable and the subsequent gasification is effective. Particularly important for the future is the apparent confirmation that cavity growth is enhanced with depth.
- The influence of the geological conditions has been observed at various stages throughout the trial. The thickness, passion and dip of the coal seam, the presence of faults between injection and production wells and the high water ingress during gasification were all important factors. An important lesson for future projects is the need for detailed studies of the geological and hydrogeological conditions when projects of this type are undertaken.
- An important result has been the confirmation that the engineering completion of the injection and production wells operated satisfactorily. In addition, the CRIP manoeuvre was effective and important user experience has been acquired for the start up and control of the gasification process.
- With hindsight, additional safety devices should have been installed to prevent back flow in the injection well and the subsequent failure. Some re-engineering of the system is also required.
- The gasification process appeared to be highly responsive. An increase in oxygen rate produced an almost immediate rise in power output and decreases had the opposite effect. It is likely, although not proven in these tests, that the process could be stopped for a long period, perhaps several days or longer, and restarted immediately by oxygen injection. This feature, if proven, would be highly beneficial in power generation.
- Underground gasification has inherent environmental benefits in terms of gas processing and CO_2 removal. The cavity as a source of contamination is now better understood but dispersion of gases and liquids into the surrounding strata need further study.