Underground coal gasification

by

Gordon Couch
The CCC will shortly be publishing a report on UCG covering
• what UCG involves
• UCG potential
• the technologies applicable
• trials and prospective developments
• geological and environmental issues
• syngas use
• conclusions

This presentation is a summary of the main findings
What UCG involves

- reacting (burning) coal in-seam in air/oxygen, possibly with steam, to produce a syngas
- the reactor will operate at just below hydrostatic pressure which increases at \(~1\) MPa for every 100m depth
- gasification forms mainly H₂ and CO, plus CO₂, CH₄, tars, H₂S and COS
- the product mix can vary widely depending on the coal, oxidant used, reactor temperature and pressure, and gas residence time
- the syngas can be used to produce power and/or chemicals/liquid fuels
What UCG involves
UCG potential

- using the energy stored in coal in an economic and environmentally sensitive way
- exploiting otherwise unmineable coal
- if UCG were successfully developed the world’s coal reserves would be substantially increased
UCG potential

Reserves (economically recoverable)
~ 900 Gt

- 64% coal
- 19% oil
- 17% natural gas

Resources
~ 18 Tt

- 95.5% coal
- 2.3% natural gas
- 2.2% oil
Restricting factors

- The reactions take place underground and out of sight, surrounded by a huge heat sink.
- Only a limited number of parameters can be either controlled or measured.
- Modelling can play a substantial role, but almost none have been validated.
- Site selection criteria have not yet been well defined.
- There are environmental issues if there is gas escape through fractured rocks, and u/g water contamination - although these can be prevented.
- It requires a unique multi-disciplinary integration of knowledge from geology and hydrogeology with the thermodynamics of gasification.
Advantages/opportunities

- coal can be extracted and used with minimal surface disturbance
- most of the ash remains underground
- significant trials are now producing encouraging results
- with the increasing value of energy and more (successful) experience with UCG, it could provide low-cost syngas in a number of countries with substantial coal resources
The generic methods for UCG

a) Vertical wells
- 5-20 m linked by hydrofracturing and/or reverse combustion

b) Vertical wells
- ~40 m no flow
- linked by an in-seam borehole

c) Linear CRIP
- >100 m

- CRIP

d) Parallel CRIP
- >100 m
- ignition well
UCG development

Has largely been concerned with establishing:

- methods to enhance the connection between the wells
- techniques for drilling in-seam boreholes
- methods for igniting the coal in the u/g reactor
- process control methods, and syngas quality
- a satisfactory level of resource recovery
- site selection criteria
- designing pilot tests and interpreting the results
- scale-up implications, and cost reductions for commercial-sized operations
- the contribution from lab work is limited and pilot in-situ tests are essential
The test work

- the major trials have been in the USSR, in Europe, the USA and in China, over 50+ years
- during which other technologies have progressed dramatically (e.g., computer power and use & directional drilling)
- tests rarely ‘proved’ more than 1 or 2 aspects of the technology, and many had unwanted side effects
- the USSR claimed commercial scale operations, but only some 15-20Mt of coal was gasified and syngas quality was variable
- the US DOE programme from 1973-89 addressed engineering concerns and compared methods for enhancing coal permeability. The development of the controlled retracting injection point (CRIP) was a major advance
Field trials (Perkins, 2005)
The test work

- the main trials are described in the report in some detail, with discussion of the results obtained and their limitations
- too much has been made by some, of the fact that the process has “been tried and tested for more than fifty years”
- the much discussed Spanish trial in 1997 lasted for just 9 days and 4 days
- there are useful reviews in: DTI (2004); Beath and others (2004); Burton and others (2006)
- much of the work took place in relatively shallow seams. Most has been in subbituminous and high volatile (non-agglomerating) bituminous coals
Four current projects

UCG commercial operations are being assessed in:

- Australia by Carbon Energy at Bloodwood Creek and Linc Energy at Chinchilla
- South Africa at Eskom’s Majuba power plant
- China at the Gonggou mine, Wulanchabu city, Inner Mongolia

Pilots have been successfully carried out with no reported environmental problems. All are planning to expand to demonstration and then commercial scale, but this will take time.

The pilot results can provide the basis for a full assessment of the commercial possibilities.

Relatively little has been published about the outcomes (or the problems/challenges).
UCG at Bloodwood Creek

- UCG surface facility: ~100 m x 50 m
- 30 m spacing
- 600 m panel length
- Ignition well
- Production well (product): $H_2$, $CO$, $CH_4$, $CO_2$
- Injection well (oxygen and steam): 30 m x 30 m x 10 m block consumed in the demonstration trial
- CRIP
- Coal seam: 8-10 m thick

© IEA Clean Coal Centre

www.iea-coal.org.uk
Other pilots planned to start shortly

- Australia, Cougar Energy at Kingaroy for a 400 MWe power plant (2009)
- South Africa, by Sasol (2009)
- USA, in Wyoming by GasTech
- Russia, Promgaz plan to trial newly developed technology
- in the UK a licence for UCG has been issued for a development in the Firth of Forth, Scotland, and
- in Canada a project in Alberta is planned for 2012 in a deep seam at 1400 m
Site selection

The single most important decision that will determine the technical and economic performance of UCG is site selection.

A successful test in one location where the geology is favourable does not prove that UCG can be widely applied. It will need a series of successful demonstrations in different geological settings to establish where UCG can be safely carried out on a commercial scale without environmental damage.

This is because coal seams lie in such a wide variety of geological and hydrogeological settings in terms of depth, and the properties of the associated rock formations and aquifers.
Constraints

- A lack of understanding of the requirements of a successful UCG project by both investors and regulators.
- Poor coverage in the literature.
- An acute skills shortage of people with appropriate interdisciplinary academic and management experience.
- A lack of understanding of the geological knowledge needed.
- The fact that the technology is being promoted by different industry groups who generally do not want to share knowledge. With a fledgling technology like UCG, cooperation would seem to offer great benefits.
- The lack of government involvement and support, which could ensure the spread of knowledge and understanding which would underpin the extensive deployment of a technology with enormous potential.

© IEA Clean Coal Centre www.iea-coal.org.uk
Conclusions

• despite 50 years of trials no commercial UCG project has been demonstrated
• the development of new technologies and the increase in the value of energy may change this
• there has been a great deal of recent progress with some projects showing considerable promise
• the current pilots could result in commercial-scale operations within about five years, providing greatly increased confidence in the technology
• keeping more of the knowledge in the public domain could greatly enhance the chances of UCG becoming an accepted and widely applicable technology
References


