UNDERGROUND COAL GASIFICATION - Burning coal in situ and storing CO_2

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Underground coal gasification, first tested in the Durham Coal field in 1910, is the partial burning of the in-situ coal seam to produce a usable gas for heat and power generation (figure 1). The process has been demonstrated in over 60 pilots throughout the world and a UCG power plant from the Soviet era has been operating in Uzbekistan for 40 years. Recently a revival of interest has occurred in the coal producing countries of Europe, Asia, Australasia, North America and S Africa for power generation, hydrocarbons and chemical production, driven by security of supply, advances in drilling technology and the potential for lower cost production.

The UK did its own UCG trials in the 1950s, it participated in the EU trials of 1990s, and UK companies and universities are currently involved in commercial and research projects in China, India and the EU.

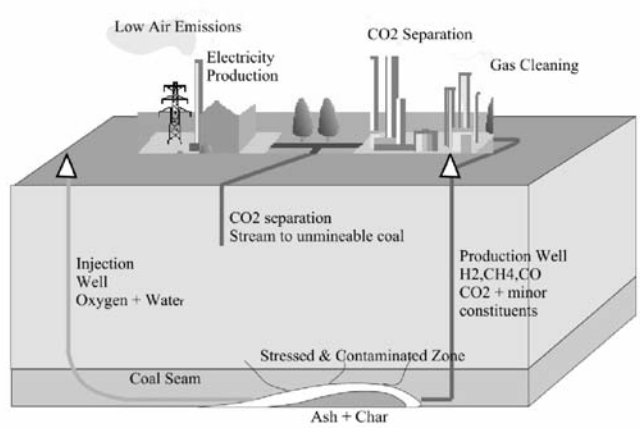

Figure 1: UCG with CCS for Power Generation

The mainland of Britain still has an estimated 100BT of useable black coal and considerably more under the North Sea[1], but coal production by traditional mining methods has decreased to 17.1MT/y in 2012, while coal imports increased by 37% to 44MT/y. UCG is in a position to make a major contribution to Britain's energy supply; bringing security of supply, high efficiency combined cycle gas turbine generation (CCGT) and independence from overseas suppliers of fuel or technology.

The UK initiative on the feasibility of UCG (2000-2004) conducted by the then UK Department of Trade and Industry (now DECC) examined the environmental impact, coal resource, advanced drilling technology, economics and public perception of UCG in the UK[2]. It concluded that UCG with CCS has the potential for the exploitation of UK coal resources, particularly under river estuaries and nearshore, and identified the Firth of Forth as a leading demonstration opportunity for an industrial consortium to exploit UCG in the UK.

Figure 2: Exploration Areas for UCG (2012, courtesy UCG Ass)

A variety of companies, mainly UK and Australian have since taken up the challenge of UCG in the UK, and London also hosts the UCG Association annual conferences, training courses and worldwide information service on UCG. Furthermore, the UK Coal Authority leads most other countries in the licensing of UCG and has issued more than 18 provisional exploration licences for UCG in estuaries and offshore coal fields since 2008 (figure 2) in places like the Firth of Forth, the Humber and Swansea Bay. The Welsh Government and the North East Region continue to support UCG development in their areas.

South Africa has become the new focus for commercial UCG. The largest company Eskom, and the petrochemical giant

Sasol announced in June 2013 the formation of a one billion Rand (£63M) joint UCG development programme and a major African coal mining company has committed £13M for the licensing of UCG technology for sub-Saharan commercial UCG projects. Roman Abramovich has recently announced an agreement to study UCG technology to convert coal to diesel fuel in the Chukotka region of Russia in order to decrease its reliance on imports.

UCG TECHNOLOGY AND RISKS

Given the right geological conditions, the record of testing and demonstration leaves no doubt that a commercial UCG project could be developed in the UK and elsewhere, and the estimates of levelised cost of electricity (LCOE), when compared with the alternatives for power generation (figure 3) are lower. The commercial risks largely result from the absence of a fully operational UCG project, although there are many feasibility and demonstration studies around the world. Concerns about ground water contamination and the public perception of all unconventional gas (shale, CBM, UCG), both on and offshore are further risk factors. So far, there has been a lack of appetite for investment in these technologies in the UK, due to the current economic climate, but projects are moving forward overseas.

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Advances in technology by the oil and gas industry have greatly enhanced the reliability and environmental control of the UCG process. The process wells are constructed and connected by directional drilling; ignition and control use coiled tubing engineering and advanced geo-mechanical modelling is used for site selection and monitoring support of the coal seam. Pressure control of the underground process and new techniques for well abandonment minimise the spread of contamination.

UCG has impressive credentials in the area of low carbon. Firstly, gas turbines for power generation work efficiently (>50%) with medium-calorific value UCG syngas, (hydrogen, methane and carbon monoxide) and the high pressure gas reaching the surface can be decarbonised, partially or completely, by the shift and acid removal processes (all well proven technologies) at a lower cost than for competing gas and coal alternatives. The resultant pipeline CO_2 is then available for underground storage or use in enhanced oil recovery, for example, in the North Sea. The Government's £1B power generation CCS programme, announced in April 2013, is likely to be undertaking FEED studies followed by demonstration (>300MW) of two plants using these technologies. The results are directly relevant to UCG-CCS.

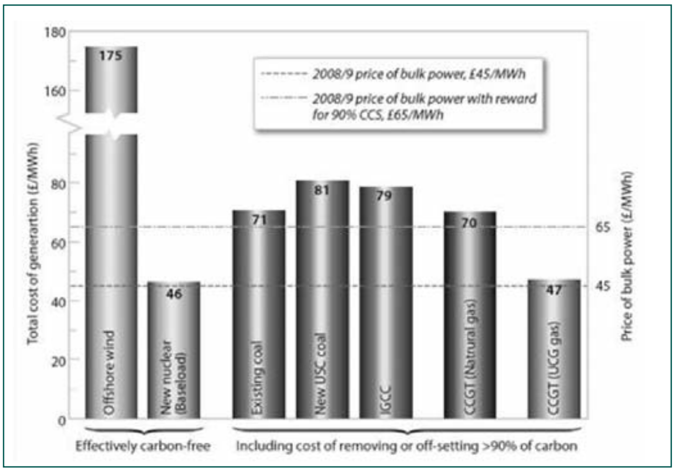

Figure 3: Costs of Electricity (courtesy UCG Ass)

In addition, research into UCG-CCS, is pointing to some interesting and novel approaches to achieve the same low carbon result. One of these is the option of storing CO_2 in the abandoned cavity. An EU supported modelling and economic study of UCG-CCS in the Dobroujda Coal Deposit, Bulgaria has shown that deep coal seams (>1,200m depth) can permanently store 20-25% of the CO_2 produced in the cavity alone, and more in the surrounding stressed strata. Storage costs are low because the UCG process and monitoring boreholes are reused and CO_2 transportation costs are virtually eliminated. Geological and hydrogeological modelling of the deposit by Bulgarian and UK scientists have shown that stress fields, contamination pathways and subsidence can be satisfactorily evaluated, and that the UCG and CO_2 injection processes will be contained within the strata.

An EU study, led by Poland (HUGE, or Hydrogen Underground Gasification Europe) found that the sequential firing of the UCG process with air followed by steam, could achieve hydrogen levels in excess of 70%, thereby partially decarbonising the product gas without expensive acid gas separation techniques. The project has recently been extended as HUGE2.

Another exciting area, with application to UCG, is the oxy-firing of gas turbines, described as a potential game changer, because only power, water and compressed CO_2 ready for storage are produced from the cycle. A British Peace Prize Winner and big players like Toshiba and the US based Exelon are engaged in the prototype development.

CONCLUSIONS

In summary, coal must be clean to survive as a long-term fuel. UCG, which achieves coal extraction and conversion to high pressure clean syngas without men underground, can meet the challenge. Innovation by the EU, the UK and others in UCG-CCS has identified process, cost and environmental impact improvements. UCG activity, leading to commercialisation in coal countries like S Africa, Central Europe and N America is under way, and the UK offshore coal resources are prime targets for exploitation by UCG-CCS.

References

1 A Cluff Letter to Financial Times 6th May 2013

2 Review of the Feasibility of Underground Coal Gasification in the UK. DTI Publication, URN 04/1643, October 2004.