Underground Coal Gasification, State of the Art

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Outline of Presentation

- Introduction
- Technology
- UCG Activities in Europe
- Developments Worldwide in UCG
- Future Directions for UCG
- Concluding Remarks
Concept of UCG & Status

- Research previous trials
  - Former Soviet Union (1930-1990’s)
  - Europe (1950-60’s) (1987-present)
  - US (1975-1990)
  - Asia (Australia, China, India) & S Africa - 1990’s onwards

- Commercial
  - 500-1200MW Uzbekistan & Siberia 1990’s
  - US designs 1990’s Urea & SNG
  - Renewal of interest worldwide since 2004
Why UCG Now?

• Security of supply
  – indigenous coal
  – Unmineable coal

• Carbon Capture & Storage
  – Pre-combustion processing
  – Local storage options

• Advances in UCG Technology
  – Drilling, completion, control

• Production Costs for clean syngas
  – Competitive against natural gas (EU, US)

• Flexibility of Syngas for poly-generation
  – Existing or new power stations, GTL, SNG, H2 and other chemicals
Low Carbon UCG-CCS

- High Pressure, pre-combustion gas suitable for CO$_2$ capture
- Significant engineering synergies between UCG & CO$_2$ injection and storage.
- UCG can improve storage of CO$_2$ through enhanced CBM.
- UCG with oxy-fired combustion has potential benefits, because oxygen supply already available.

Professor Paul Younger, Newcastle March 08“ The cavities are ideal candidates for sequestration. We are absolutely sure UCG-CCS works
Technology for UCG

Configuration used for European Trial

Soviet Scheme

Chinese Long tunnel, 2 stage Method
Oil and Gas Technologies in UCG

- Exploration using 3D seismic survey, interpretation, core drilling
- Directional drilling, steering, intersections and branching
- Advanced completions for moveable injection, hot multi-phase flow and sour gas
- Downstream processing—filtering, washing and acid gas removal

Production Well EU Trial (1992-1999)
Availability of Sophisticated Steering Systems for Inseam Drilling

- Rotary steerable assemblies, with in-built closed loop control.
- Wide range of on-line geo-logging tools gamma, resistivity, forward scanning, acoustic, etc.
- Electronic telemetry to be surface.
- Active and passive
- Magnetic devices for well intersections.
Environmental Risk Management

- UCG requires management of the environmental emissions risks to air and ground water.
- Active process control to ensure cavity flows are always inward.
- Careful site selection and monitoring essential under the EU Ground Water Directives.
- Hydrogeological modelling required.
- Deeper coal seams reduce the environmental risk.
European Activities in UCG
European UCG Trial at 550m Depth (1992-1999)

- Two successful ignitions, and seven satisfactory manoeuvres of the CRIP moveable injection system.
- Directional drilling produced satisfactory well construction.
- Gasification at greater depth enhances methane formation and cavity growth.
- The engineering operated satisfactory and the process is controllable, stopped and restarted.
- No evidence of contamination spread beyond the cavity or subsidence was observed.
History of UCG in Poland 1960-2008

Mars Mine experiments 1960

Conceptual studies of vertical UCG J Palarski 1980’s

Hydrogen from UCG, GIG 2007
Feasibility and Support Studies in Europe

- European feasibility studies underway for power and SNG underway in:
  - Czech Republic, Hungary, Poland, Slovenia, Bulgaria, Ukraine & Russia
- European Universities,
  - Silesia Inst of Technology, Wrocklaw, Cardiff, Cranfield, Delft, Heriot-Watt, Imperial College, Leige, Keele, Nottingham, Newcastle, Stuttgart & Zaragoza
- EU Collaborative UCG Project - FP7?
  - Deep Lignite or sub-bituminous
  - Power, Hydrocarbons and H₂
  - CO2 capture and storage (CCS)
UCG Developments Worldwide
UCG Activities in 2008

**USA & Canada**
- US Nat Labs undertaking reviews
- GasTech Inc 5MW demonstration involving BP
- Wyoming Business study
- New entrepreneurial initiatives in US & Canada

**Europe**
- EU Project underway
- Firth of Forth 2nd phase
- Hungary, and E Europe interest growing

**China**
- 11-16 State sponsored trials
- Start of entrepreneurial activity
- Demonstration by Xinao in Mongolia underway

**India**
- ONGC Site selected, and technical designs underway
- Reliance, BHEL, NLC and others planning trials
- Coal of India review

**South Africa**
- Eskom trial produces first gas
- Sasol and others doing feasibility work

**Australia**
- Linc IPO financial offering raised to A$65M for UCG-GTL
- New Joint venture with CSIRO demonstration 08
- At least one other new initiative in S Australia

**Worldwide Activity**
- UCG Partnership with training & annual Conference
- Technology suppliers worldwide, UCGEL, Ergo, Linc, In Situ Energy
Australian Developments

- **Linc Energy,**
  - Successful share offering in 2006, now worth $1.5B
  - Development of a GTL plant is underway
  - New projects starting in S Australia, Vietnam & USA (Dec 08)
- **Carbon Energy (2006)**
  - Joint venture with CSIRO gas now started (Oct 2007)
- **Cougar Energy (2007)**
  - Site for 400MW CCGT Plant in S Australia
  - Using Ergo energy.

Carbon energy Configuration for 100 day trial
Angren UCG Power Station, Uzbekistan

- UCG Co-fired Plant operating for 30 years
- UCG used in dedicated 100MW steam turbine
- Linc Energy have bought a majority stake in the plant
UCG in South Africa

- Eskom UCG Trial at Majuba Coal field, 3.5m thick at 300m depth (Jan 2007).
- Air-blown co-fired 350MWe IGCC unit planned
- Sasol initiated a new UCG trial project at Secunda as a potential feedstock for CTL Plant.
Other Feasibility Studies in Asia and Pacific

- Indonesia
- Vietnam
- Pakistan (Thar Coalfield Power & GTL)
- Japan
- Chinese Mining Companies, e.g. Xinwen, Ezhuang
- Mongolia
- New Zealand (Solid Energy)

Test site under construction 2006
Future Directions for UCG
Estimated World Coal Resources for UCG

World Coal Resource 8000 BT

- Coal Balance
- UCG Reserves
- UCG Potential
- Mining Reserve (BP)
Average Costs of UCG for two recent studies – Europe & Powder River Basin

- European Case Study 2007 (O2 fired)
- European Case Study 2007 with CO2 capture (O2 fired)
- Powder River Basin Study 2007
- LLNL study

US NEMEX Nat Gas price Feb08
~$8/MMBTU
Spot price >$16/MMBTU

Polish industrial gas June08 = $9.5/MMBTU
Offshore potential for UCG

- Potentially inexhaustible coal resource in thick seams
- Current infrastructure for drilling, pipelines, platforms
- UK Feasibilities Study complete for Scotland and NE England
- Proximity of CO$_2$ sequestration sites
"The UCG Partnership is the centre of excellence for UCG"

- Holds the definitive data base for UCG and UCG with CCS and website.
- Promotes public awareness of UCG & related aspects of CO2 storage.
- Large membership base from industry, Government and finance.
- February 2009 Next UCG International Conferences.
- Annual Training Course at Imperial College and elsewhere
Concluding Remarks

*UCG offers a source of readily usable gas for indigenous coal, which is ready for use, and has significant advantages in terms of cost, security of supply and CO2 capture and storage.*

*Modern UCG technology has been extensively tested and is being evaluated commercially in coal countries around the world, mostly in the private sector.*

*First movers are in place to exploit UCG as a profitable commercial clean coal opportunity*

*For Poland, UCG with CCS is an excellent low carbon solution*