ESKOM’S UNDERGROUND COAL GASIFICATION PROJECT

SA/EU Bilateral Meeting

5/6 May 2008

Eskom’s Clean Coal Programme

- Conventional sub critical Pulverised coal
- Supercritical Pulverised coal – Medupi & Kusile
- Ultrasupercritical Pulverised coal
- Fluidised Bed Combustion
- Conventional and advanced emissions control
- Surface gasifier - IGCC
- Carbon Capture and Storage

- Underground coal gasification – IGCC

IGCC = Integrated Gasification Combined Cycle
Underground Coal Gasification

Process Principles

The Principles of UCG

- UCG is a process where air is injected into the cavity, water enters from surrounding strata, and partial combustion and gasification take place at the coal seam face after ignition. The resulting high-pressure gas stream is returned to the surface, where the gas is dried and then combusted in a high-efficiency power station to generate electricity.

Surface Plant commercially proven with other gases – needs implementation for UCG

UCG commercially proven in Former Soviet Union (FSU) – needs proving in RSA on commercial scale.

Ref : Science & Technology Review, Lawrence Livermore National Lab, USA, April 2007
Underground Coal Gasification

Current World Trends

UCG – Current World Trends : Jul 2008

There has been a dramatic increase in commercial
UCG interest world-wide: July, 2008

Over 66 FSU, 33 US and 40 other international projects
Underground Coal Gasification
Eskom Approach

**Eskom’s UCG Activities**

- UCG technology potential noted - April 2001. An extensive review of world-wide capability for commercial development was conducted
- Ergo Exergy Technologies Inc. (Canada) contracted in for eUCG
- Scoping study - Nov 2002, highlighted potential at Majuba colliery
- Pre-feasibility study - Dec 2003, confirmed Majuba potential
- Detailed site characterisation study - July 2005, confirmed the potential
- 20th January 2007 – Eskom commissioned a 5000 Nm³/h pilot plant on Majuba coalfield
- 31st May 2007 – first electricity generated from UCG gas at Majuba
- 7km x 600mm NB steel pipeline built to link UCG with Majuba U4
  - Sep 2009 – cofiring 15 000 Nm³/h UCG gas into Majuba U4
  - Approval being sought for a 40 MW OCGT (105 000 m³/h) demo plant
  - Engineering and EIA to commence for a new 2100 MW power station, based on UCG and Combined Cycle Gas Turbine-Steam Turbine

Dr Lennon, MD (Eskom Corporate Services), Minister Erwin & Mr Manopa (Eskom CE)
Eskom UCG Demonstration Site

Eskom’s UCG Strategic Drivers

1. Security of supply
   - Baseload option
   - Lower CO2 Emissions (16 - 25% lower than super critical PF coal)

2. Clean energy
   - Lower CO2 Emissions (16 - 25% lower than super critical PF coal)

3. Flexibility
   - Modularity, lead time
   - Potentially 350GWe

4. Utilize Unminable Coal
   - Better utilisation than conventional mining

5. Lower cost option
   - Competitive RMWh
The only cleaner coal-based technology is the proposed ultra-supercritical PF

Resource Utilisation Efficiency

23.8% of coal resource utilised

Present : Sub-critical Power Station with Longwall U/G Mine

33% of coal resource utilised

Potential : Ultra-supercritical or Conventional IGCC with Longwall U/G Mine

36% of coal resource utilised

0%  UCG-IGCC  98  71  66  65  64  63  62  61  60  59  58  57  56  55  54  53  52  51  50  49  48  47  46  45  44  43  42  41  40  39  38  37  36  35  34  33  32  31  30  29  28  27  26  25  24  23  22  21  20  19  18  17  16  15  14  13  12  11  10  9  8  7  6  5  4  3  2  1  0%
Coal Value Chain Reduction

Conventional mining and power station operations

UCG mining and power station operations

Further UCG Benefits

- Reduced coal mining & washing ➔ transportation ➔ grinding & ash disposal
- Less risk to human life by not having to send people underground
- Less materials handling, maintenance & cleaning on surface plant
- Gas quality is more stable than coal quality
Underground Coal Gasification

Eskom RD&D

Eskom’s UCG Activities

Operating Data - first 20 months:
- Total coal consumed/gasified = 4 950 tons
- Total gas produced = 22 545 000 Nm³ (0.796 bcf)
- The average efficiency is above 75% and has been as high as 82.5% based on a coal energy content of 20 GJ/ton.
- The CV during normal operation (this excludes problems as result of a lack of production wells etc.) varied between 4.1 and 4.8 MJ/Nm³ of gas.
- Current gas production rate = 4500 Nm³/hr (0.004 bcf/d)
- Average well exit temperature = 168 ºC (344 ºF)
- Maximum well exit temp (normally temporary) = 368ºC (695ºF)
- Average water consumption = 0.58 litre per kg of coal, but does increase when in stable gasification mode.
Environmental Impacts

Water:
- Water from surrounding aquifers monitored from shallow and deep boreholes
- UCG is monitored extensively with piezometers (for measuring pressure & temperature)
- No UCG contamination evident

Environmental Impacts

Air:
- Baseline air quality tests done prior to UCG starting
- Permanent meteorological station on the UCG site: wind speed/direction, ambient temperature, barometric pressure
- Eskom’s continuous ambient emission monitoring station 9 km away monitors meteorological parameters, SO$_2$, PM$_{10}$ etc.
- Additional comprehensive audit completed early 2008, for: meteorological parameters, CO, CO$_2$, SO$_2$, H$_2$S, NO, NO$_2$, BTX, NH$_3$, PM$_{10}$, PM$_{2.5}$ etc.
- Permanent monitoring site will be sited this year
- UCG-IGCC promises a 25% reduction in greenhouse gas emissions, compared to conventional power stations
Environmental Impacts

Land:
- Comprehensive plan in place with management and rehabilitation procedures. Regular audits done.
- Baseline flora & fauna survey and soil tests done prior to UCG starting up
- Majuba site shows natural vegetation re-establishes rapidly after drilling disruption
- Surface impact minimal post-gasification
- Subsidence is being monitored at Majuba using devices for conventional underground monitoring. The potential strata collapse has also been modelled.
- No subsidence observed yet.

Underground Coal Gasification

Potential Eskom Commercialisation Route
**Indicative Developmental Approach**

- **2002**: Scoping Study
- **2003**: Pre-feasibility Study
- **2005**: Site Characterisation
- **20th January 2007**: Commissioned 5000 Nm³/h pilot plant on Majuba coalfield

**UCG Commercial Plant Proposal**

- 2100MW combined cycle gas turbine plant operating on UCG gas
- Gas requirement will be 3,856,000 m³/h (2.3x10⁶ cfm)
- Mine exploration, power plant FEED and permits estimated to be three years
- Construction time and full UCG mine development estimated to be three years from LNTP
- Expected staff for power plant and mine is 1000 people.
- Coal Value Chain is substantially reduced in length
- Levelised life cycle cost (R/MWh) is less than the equivalently sized conventional SC-PF plant
UCG Conclusions

- UCG has been operating reliably for 27+ months
- No environmental concerns have been noted
- UCG is considered by Eskom to be a stable and viable primary energy option
- Eskom is embarking on commercialisation of the technology, in parallel with a demonstration at 40 MW scale

Thank You