
UNDERGROUND COAL GASIFICATION FOR POWER GENERATION

SANEA

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Wendy Poulton – General Manager Sustainability and Innovation

Eskom's Clean Coal Programme

- Improved efficiencies on 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

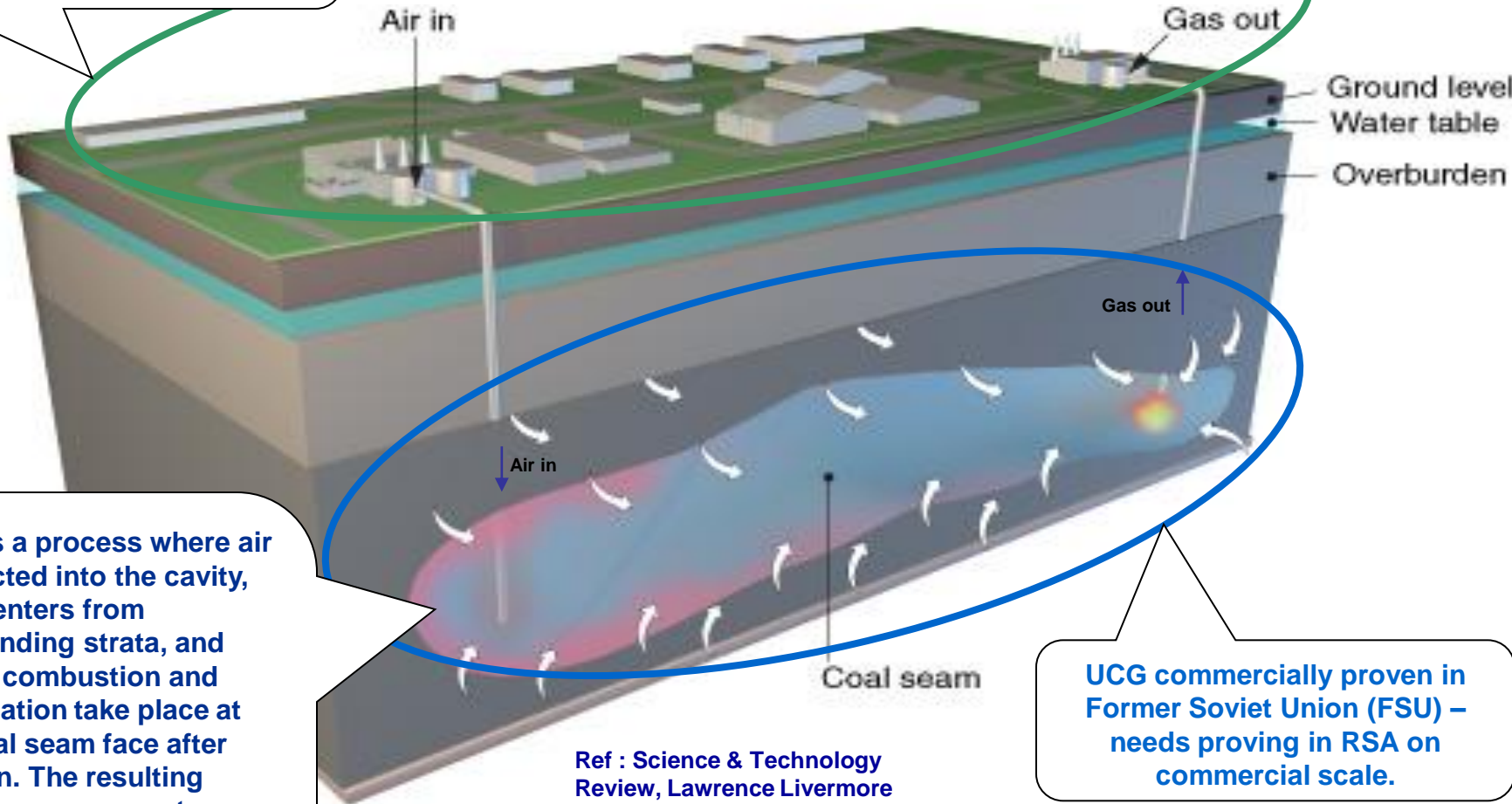
IGCC = Integrated Gasification Combined Cycle

Underground Coal Gasification

Process Principles

The Principles of UCG

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



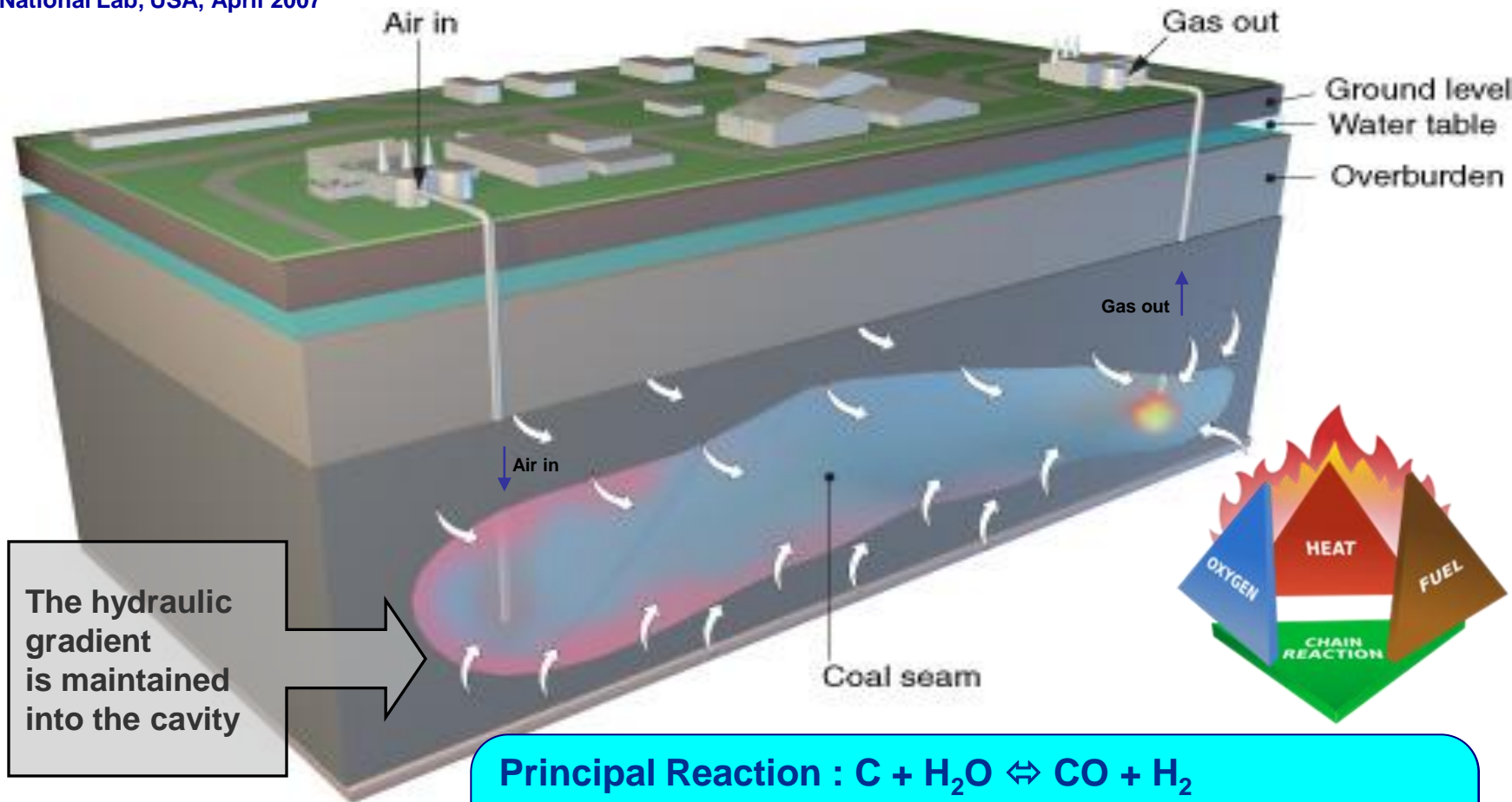
• **UCG** is a process where air is injected into the cavity, water enters from surrounding strata, and partial combustion and gasification take place at the coal seam face after ignition. The resulting high-pressure gas stream is returned to the surface, where the gas is dried and then combusted in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

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

The Control of UCG

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



Strategic Drivers

Eskom's UCG Strategic Drivers

1. Security of supply

Baseload option



2. Clean energy

Lower CO2 Emissions (16 - 25 % lower than super critical PF coal)



3. Flexibility

Modularity, lead time



4. Utilize Unminable Coal

Potentially 350GWe



Better utilisation than conventional mining

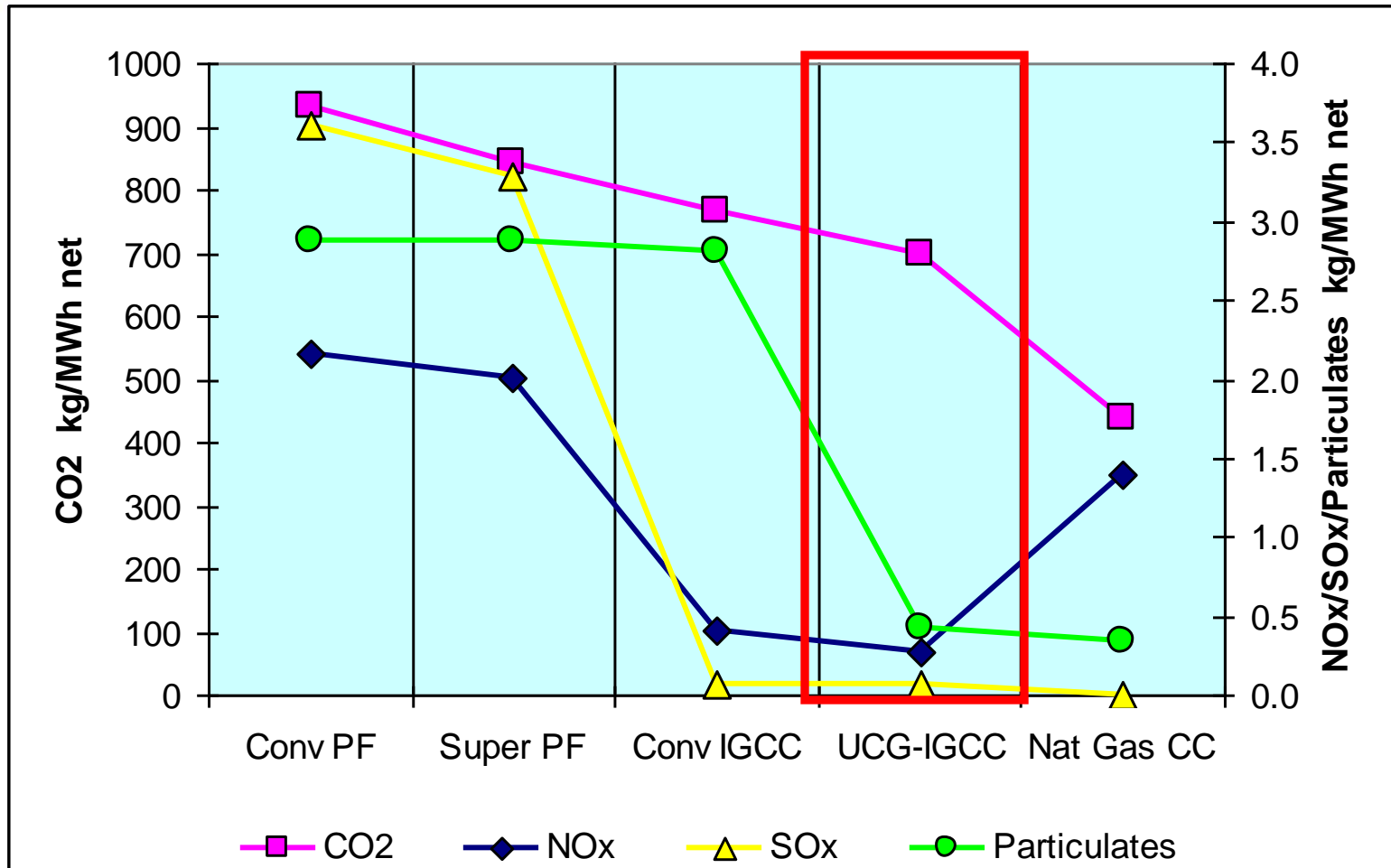


5. Lower cost option

Competitive R/MWh



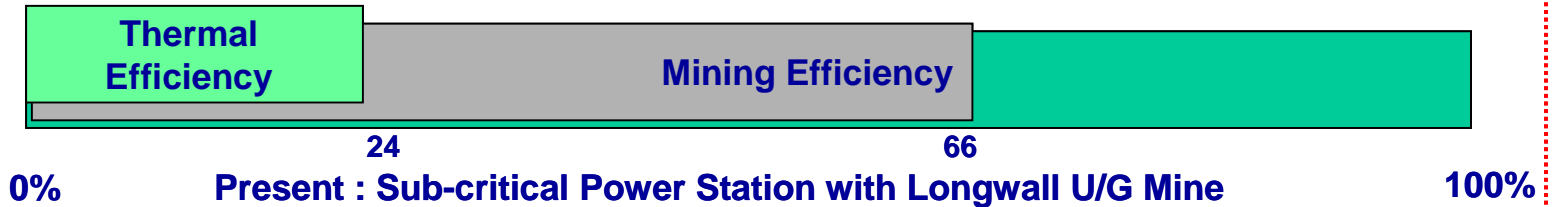
UCG-IGCC Comparative Emissions



Ref : Australian ACARP LCA study, Case Study B20, June 2002

Resource Utilisation Efficiency

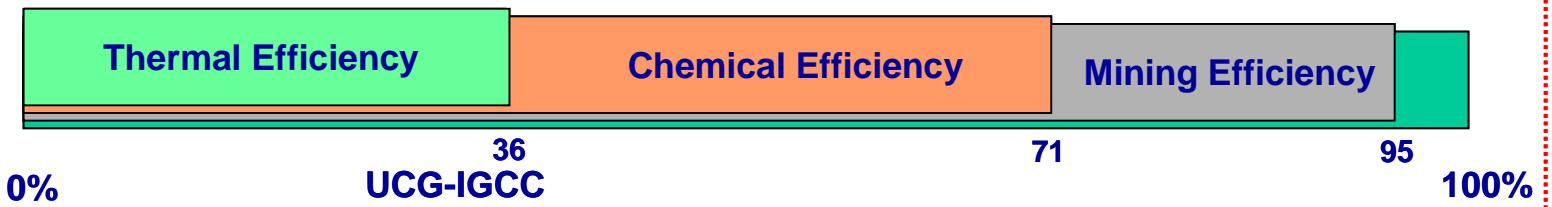
23.8% of coal resource utilised



33% of coal resource utilised



36% of coal resource utilised



Coal Value Chain Reduction

Conventional mining and power station operations



UCG mining and power station operations



Underground Coal Gasification

World Trends

UCG History

- 1868 - UCG conceived in **UK**
- 1930's – 1950's – RD&D followed by commercial UCG plants in the **former Soviet Union**. Angren (Uzbekistan) remains in operation today (since 1955).
- 1958-1987 – national demonstration sites in **USA, EU** and **New Zealand**
- 1990's - “Commercial” UCG operations commence in **China** designed to extract residual coal reserves from previously worked underground coal mines.
- 1999 - UCG successfully piloted in Chinchilla, **Australia**
- 20th January 2007 – Eskom commissioned a 5000 Nm³/h pilot plant on Majuba coalfield, based on FSU technology

UCG History – *Status as of 2003*

Country/ Region	Coal Gasified	Duration	Investment
Former Soviet Union	>15 million tons	since 1950's	US \$10 000 million
USA	50 000 tons	since 1970's	US \$2-300 million
EU	<10 000 tons	1970-90's	US \$100 million
Australia (Chinchilla)	>32 000 tons	1999-2003 (in conservation mode at present)	A\$10 million

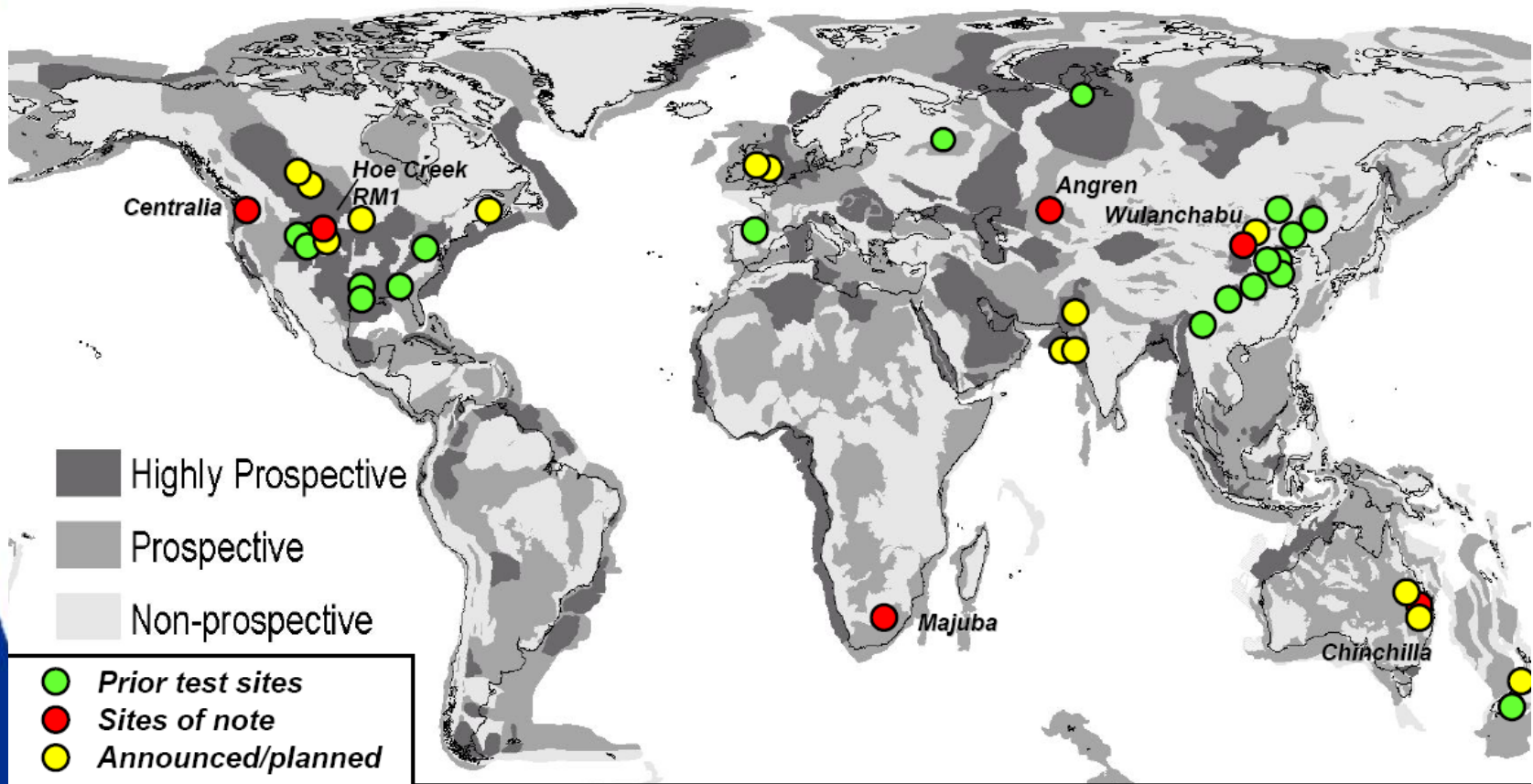
UCG – Current World Trends

- **FSU – Uzbekistan** : Angren commercial plant dismantling
- **New Zealand** : starting site characterisation R&D with *eUCG*
- **USA** : investigating the potential of UCG + H₂ production + CO₂ sequestration with *eUCG*
- **UK** : DTI investigating for deep coal reserves
- **Australia** : Linc Energy IPO successful. Pilot plant recommissioned.
- **India** : approved a feasibility study with *eUCG*
- **Pakistan** : approved a feasibility study with *eUCG*
- **Vietnam** : study underway with JV : Marubeni, Linc and Vinacomin
- **Swaziland** : propose a conceptual CTL application with UK UCG technology
- **RSA** : Eskom, and several other entrants

UCG – Current World Trends : Jul 2008

Source : Dr J Friedman, Lawrence Livermore National Lab, USA

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



Over 66 FSU, 33 US and 40 other international projects

THE CHINCHILLA PROJECT

Queensland, Australia

- pilot plant operated Nov 1999 to Apr 2003
- little visible infrastructure
- no groundwater /surface contamination *
- no surface subsidence
- 1 week shutdown possible
- 100% availability
- 95% coal usage
- 75% energy recovery
- pilot plant recommissioned in Sept 2007

* *By independent audit by Golder & Associates, for Australian EPA*



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Underground Coal Gasification

Eskom Approach

Eskom's UCG Activities

- UCG technology potential noted - April 2001
- 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 given for the design of a 40 MW OCGT (105 000 m³/h) demo plant**
- **Engineering and EIA to commence in 2010 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 Maroga (Eskom CE)



100 kWe diesel genset

Eskom UCG Demonstration Site



Eskom's UCG Activities

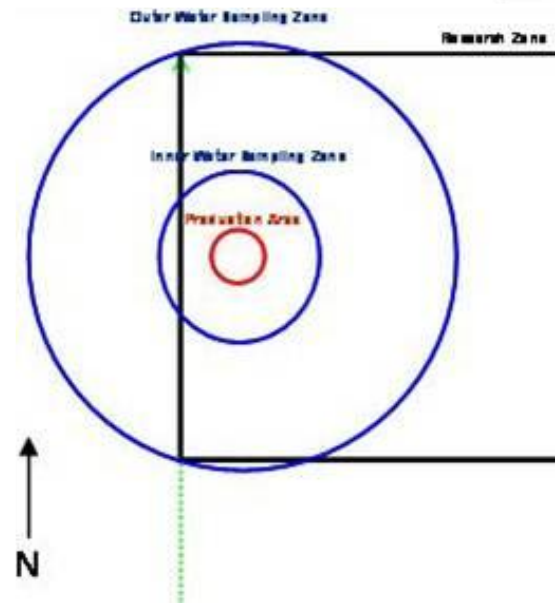
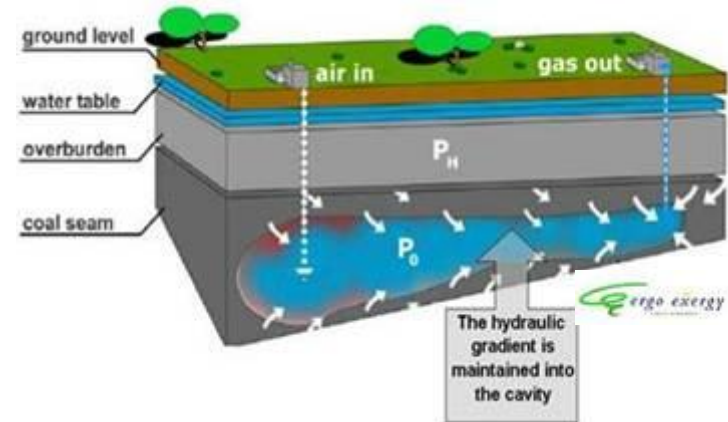
Operating Data - first 20 months :

- 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 °C (344 °F)
- Maximum well exit temp (normally temporary) = 368°C (695°F)
- 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, SO₂, PM₁₀ etc.
- Additional comprehensive audit completed early 2008, for : meteorological parameters, CO, CO₂, SO₂, H₂S, NO, NO₂, BTX, NH₃, PM₁₀ , 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 :

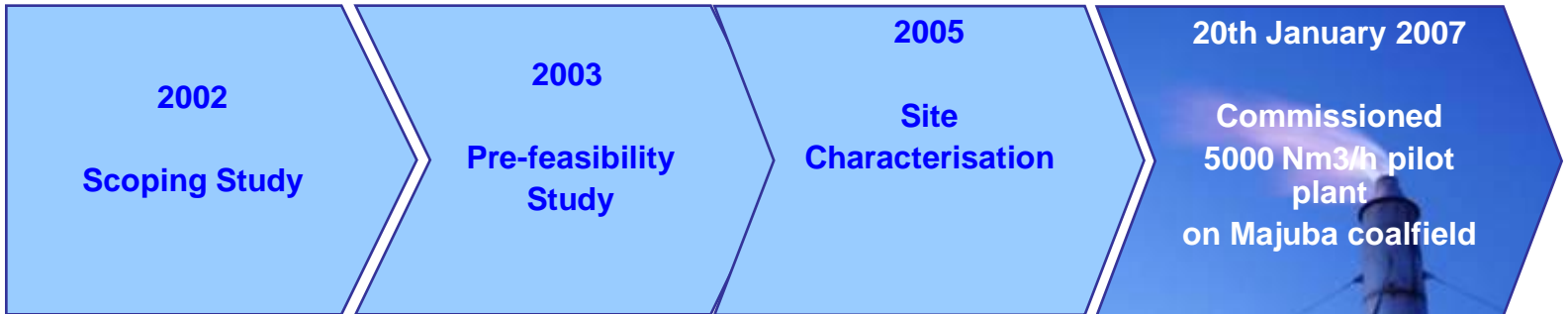
- Comprehensive plan in place with management and rehabilitation procedures. Regular audits done.
- Baseline flora & fauna survey and soil tests done prior to UCG starting up
- Majuba site shows natural vegetation re-establishes rapidly after drilling disruption
- Surface impact minimal post-gasification
- 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

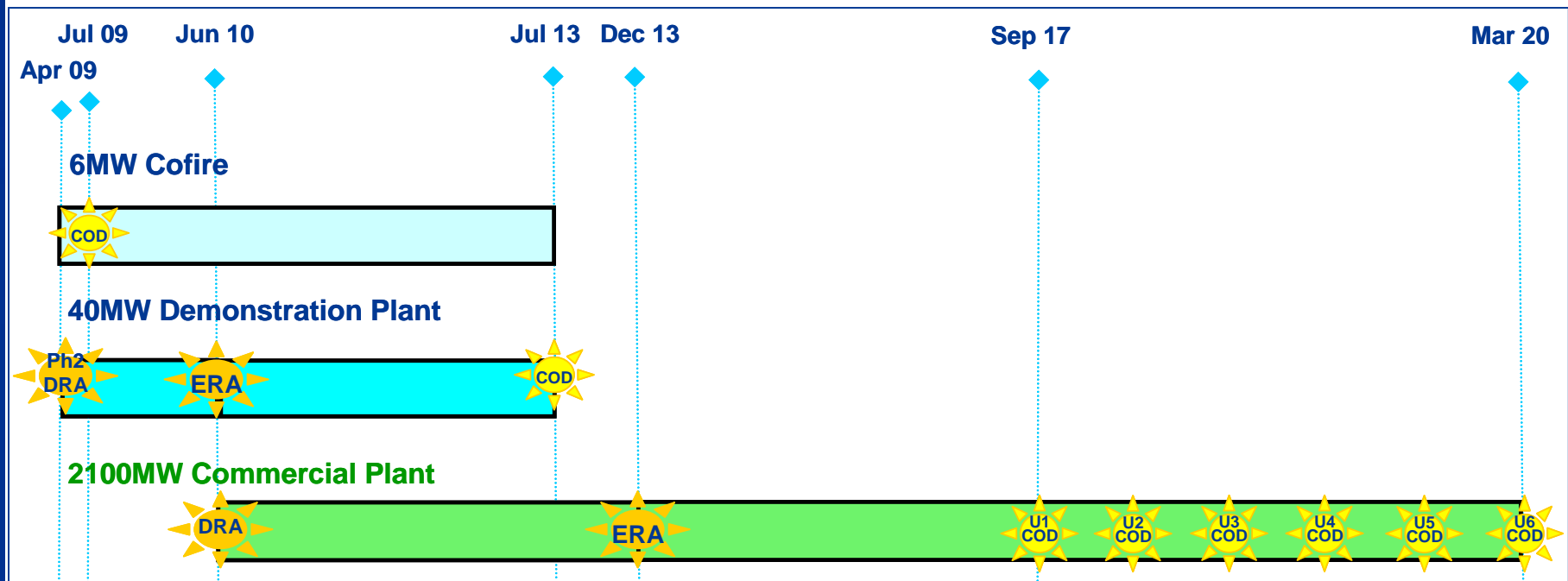
Potential Eskom Commercialisation Route

Indicative Developmental Approach

Complete



To do



DRA = Decision Release Approval = Design, Engineering, Costing

ERA = Execution Release Approval = Procure, Construct and Commission

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.

UCG Conclusions

- UCG is an Eskom clean coal option which allows the effective extraction and use of our coal resources
- UCG has a role to play in the reduction of greenhouse gases and has possible potential for carbon capture and storage
- UCG is gaining momentum worldwide
- UCG pilot has been operating reliably for 29+ months
- No environmental concerns have been noted to date
- Based on work to date, UCG appears to be a very promising, stable and viable primary energy (baseload) option
- Eskom is embarking on commercialisation of the technology, in parallel with a demonstration at 40 MW scale

Thank You

