Underground Coal Gasification - A Power and Low Carbon Solution for India

Dr Michael Green

Founding Director, UCG Engineering Ltd
UCG Engineering Ltd Indian Experience

- Keynote address to UCG Workshop New Delhi 2006.
- Formed UCG Partnership (later UCG Association) with Indian Companies like ONGC, BHEL, Reliance as founder members.
- Collaborated with a Indian specialist steel manufacturer on UCG bid 2009.
- Presentation with Indian Oil and Gas to Rajasthan Ministers for a UCG State project 2012.

Presenter Michael Green
Founding Director, UCG Engineering Ltd
World & India Coal Production and COP21/22

The Coal Ministry has set target of 724.71 million tonnes for the current financial year (2016-17) against 538.75 million tonnes produced in the previous fiscal (2015-16).

- India has announced its commitment at COP21 global climate talks in Paris in November 2015, pledging to improve the carbon emissions intensity of its gross domestic product (GDP) by 33-35 per cent below 2005 levels by 2030, achieved with 40% renewables and clean technologies.

Implications for coal - Higher generating efficiency and possibly later CCS
UCG Technology around the World
Concept of UCG & Gas Composition

- Proven industrial process which enables coal, in situ, to be converted into syngas, by partial oxidation
- Syngas produced is made up of hydrogen, carbon monoxide, carbon dioxide and methane

Typical UCG Syngas Composition

- H₂ 27%
- CH₄ 24%
- CO 18%
- CO₂ 31%
Technology Trends for UCG

Shallow Coal – air blown
Thermal plant, power gen,

Shallow Depth
Enriched air, O2
For GTL

Medium Depth
Enriched air, O2
For GTL, Fertilisers

Deep Coal, O2
UCG CCS
Why UCG Now?

Elegant Engineering Solution
to capture energy from coal seams,  
Safe no people underground  
Product is transportable syngas.

Security of supply
Reduced dependence on imported fuels.  
Uses indigenous coal, at depth, irrespective of ash content

Competitive Energy costs
Estimates often lower than natural gas  
Costs stable and Independent of world markets

Advances in UCG Technology
Drilling, completion, controls  
Environmental impact now understood

Carbon Capture & Storage
Pre-combustion and processing advantages  
Local CO2 storage possibilities

Flexibility of use & suitable for poly-generation
  Existing or new power stations, GTL,  
  SNG, H2 and other chemicals
Worldwide Developments in UCG 2014

- Alaska (USA): Drilling started in Cooks bay.
- Canada: Pilot project completed in Manville.
- USA: Possible pilots in Wyoming and North Dakota.
- Poland: HUGE2 project and active development in Silesia Basin coal.
- Hungary: Mecsek Hills project.
- Ukraine: DTEK’s coal resources evaluated.
- Russia: First UCG project might take place in Chukotka.
- UK: More than 25 licenses have been issued.
- Bulgaria: Feasibility study completed for Dobruja coal seam.
- South Africa: Mpumalanga, Secunda, Sub-Saharan and Theunissen projects.
- Uzbekistan: World’s only commercial UCG project.
- Pakistan: Thar project to start production by 2018.
- China: 15 UCG trials.
- India: Another two coal blocks have been identified for UCG.
- Australia: Pilot projects decommissioned.
<table>
<thead>
<tr>
<th>Company/Organisation</th>
<th>Country</th>
<th>End Product</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>UCG Research Centre, Sino-coking, ENN Xinao, Seamwell, Honghi</td>
<td>China</td>
<td>Power Generation &amp; Coal to chemicals, hydrogen for fuel cells</td>
<td>25PJ/y (792MWt)</td>
</tr>
<tr>
<td>Coal of India, CMPDIL</td>
<td>India</td>
<td>Issuing Coal Blocks for UCG, Jharkhand &amp; Madhya Pradesh</td>
<td>166MT and 178Mt</td>
</tr>
<tr>
<td>EU – £2.1M Tops</td>
<td>UK, Pl, NL, SA, CH, AU, US</td>
<td>Technology Options for Coupled UCG * CCS Site Characterisation &amp; risk</td>
<td>Feasibility modelling, environment</td>
</tr>
<tr>
<td>Linc Energy/Carbon Energy (in administration)</td>
<td>Australia, China,</td>
<td>Power, SNG and CTL applications (Technology available)</td>
<td>400MW - 750MW</td>
</tr>
<tr>
<td>Yerostigas, Angren</td>
<td>Uzbekistan</td>
<td>Commercial Steam for Power Plant</td>
<td>100MW</td>
</tr>
<tr>
<td>Eskom</td>
<td>S Africa</td>
<td>Power Generation, co-firing &amp; CCGT, further pilot work</td>
<td>400MW</td>
</tr>
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South Africa UCG Eskom Project Status

UCG – Eskom’s Experience and Future Projects, Shaun Pershad May 2016

FFF Workshop to present Updates on the Developments in South Africa – Is there Gas?
El Tremedal, Spain, In-Seam Configuration and Plant 1993-1999
UCG in India
Indian Coal and Lignite Resources
between 300m and 1200m depth

<table>
<thead>
<tr>
<th>State</th>
<th>Geological resources of coal (billion tonnes)</th>
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<tbody>
<tr>
<td></td>
<td>Proved</td>
</tr>
<tr>
<td><strong>Coal</strong></td>
<td></td>
</tr>
<tr>
<td>1 Jharkhand</td>
<td>17.354</td>
</tr>
<tr>
<td>2 Odisha</td>
<td>1.332</td>
</tr>
<tr>
<td>3 Chhattisgarh</td>
<td>1.019</td>
</tr>
<tr>
<td>4 West Bengal</td>
<td>3.102</td>
</tr>
<tr>
<td>5 Andhra Pradesh</td>
<td>1.136</td>
</tr>
<tr>
<td>6 Madhya Pradesh</td>
<td>3.506</td>
</tr>
<tr>
<td>7 Maharashtra</td>
<td>0.196</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>27.647</td>
</tr>
<tr>
<td><strong>Lignite</strong></td>
<td></td>
</tr>
<tr>
<td>1 Tamilnadu</td>
<td></td>
</tr>
<tr>
<td>2 Rajasthan</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
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Courtesy A Khadse Resources and economic analyses of underground coal gasification in India, Fuel 142 (2015) 121–128
India To Auction Eight Coal Blocks For UCG Projects

- **Draft Policy for development of UCG** submitted for approval - Dec 15 and Central Mine Planning and Design Institute Limited (CMPDIL) will be the nodal agency for all business related proposals and regulations.

- **Eight lignite and coal blocks** identified for the development of underground coal gasification. The process of documentation is under way, and by the end of this year all documents will be prepared for the tendering process,” said coal secretary Anil Swarup. May 2016.

- **IIT (Mumbai)** has specialised in the packed bed modelling and laboratory testing of coal for UCG, and have a series of computer models for residence times and cavity models, including spalling, which would be invaluable to support any full scale testing of UCG in the model blocks.
Engineering Objectives of UCG Development

Critical UCG Technologies

- Site Selection, geological analysis,
- Process oxidants ($O_2$, $H_2O$, $CO_2$) and its effect on Syngas composition.
- Underground engineering for control (CRIP)
- Material selection for intense operating conditions.
- Risk Analysis for Pollutant abatement

Pilot Programme

1. To confirm that the site is suitable for UCG, and demonstrate that a pair of UCG wells can be successfully drilled & completed.
2. To ignite the seam and maintain gasification and correctly shut down the process, under fully monitored conditions.

Scale-up to Commercial Operation

1. Expand Pilot to 5PJ/y plant as first stage
2. Build pipeline to nearby Power Station or construct 50MW facility on site
Typical Operating Parameters of a UCG Pilot

- Design output of Pilot Test MW: 20
- Operating life of test days: 100 days
- Total Gas Volume (dry) for test Nm³: 10,600,000
- Energy in gas produced GJ: 138,000
- Coal required for trial t: 9,600
- Estimated length of channel gasified m: 93
- Flow Rate in Production Well Nm³/h: 5,500
- Oxygen demand Nm³/h: 1,600
- Process water requirements Nm³/h: 1.60

Pilot test, typically 4 years from approval will enhance project success.
MANAGING PROJECT RISK

LAYERS OF PROTECTION APPROACH TO HEALTH, SAFETY AND ENVIRONMENTAL RISK MANAGEMENT

• KNOWLEDGE BASE
  – UCG has long history of R&D, pilots and some large scale operations – the Good, the Bad and the Ugly
  – Use what went well
  – Learn from what went wrong – don’t repeat the same mistakes
  – Small scale demonstration operation before scale up to commercial development

• SITE SELECTION
  – Key for good technical, environmental and safety performance – well understood geological setting
  – Depth is good - isolation from aquifers and air
  – Baseline monitoring

• ENGINEERING DESIGN – WELLS & PLANT
  – Multiple layers of casing over shallow aquifers – metallurgy for high temps and corrosion resistance
  – Cement design – for CO₂ and temperature resistance
  – Built in real-time monitoring for well integrity and surface plant
  – Fail safes designed in – based on stringent O&G principles

• OPERATIONS AND PROCESS
  – Expert operations staff – HSE culture and training
  – Real-time monitoring – process, wells, emissions
  – Clear procedures for dealing with excursions from normality
  – Emergency response plans in place

• POST-OPERATIONS
  – Long term monitoring
  – Lessons learned approach - continuous improvement processes

From CNR Presentation by M Green to EGOS, Manchester Oct 2015
Key Points for UCG in India

- Coal for power generation is still growing worldwide. UCG fired IGCC is a viable option, for large-scale syngas production for countries with indigenous coal.
- Correct site characterisation for UCG is critical. Key technologies are around process and environmental control, risk assessment, monitoring and modelling.
- Fully instrumented and monitored UCG pilot is an essential step.
  - 70 UCG tests and operations and recent developments in horizontal wells, modelling of strata and the cavity, monitoring have greatly improved confidence in the process, particularly in deep coal seams.
  - Opportunities exist for collaboration on UCG between the research centres with expertise in UCG, like IIT, the European Union with its interest largely in UCG-CCS options, and the Companies that need cheaper
thank you