Underground Coal Gasification an Alternative Clean Mining Method of the Future

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Abstract

China, like other coal rich countries, continues to support the development of underground coal gasification (UCG) projects recognising its potential as an alternative clean energy source. Whilst a number of projects around the world are reported “active,” exploration and production work remains limited to a few projects. The progress of UCG can be compared to the growth and development of other unconventional hydrocarbon resources where technological advancement together with effective geological evaluation and analysis, resource control and project management has provided the opportunity to unlock significant energy resources on a global scale. UCG as an industry has stalled at an early stage of development and further work is required to unlock its potential before financial institutions and investors view it as commercial. The successful application of technology together with the introduction of effective process management and monitoring and control systems can develop UCG into a commercial industry having the potential to access and exploit coal resources that would otherwise remain in-situ.

This paper reviews the measures required to manage UCG project development matching operational delivery with the in-country setting together with meeting the needs of investors and other stakeholders drawing on the author’s experience of working in emerging energy sectors in Asia.
There are numerous "alternative" energy sources; Underground Coal Gasification (UCG) has the potential to contribute to future energy needs.

The route from concept and pilot to full commercial development and resource exploitation is not guaranteed and is unlikely to follow a straight line; successful commercialisation of a sector will often follow a less direct "zig zag" route.

Commercial development of UCG will require the industry to demonstrate its ability to show:

- Technology and working practices can be applied that give reproducible delivery/performance results.
- It provides cost effective recovery of energy compared with conventional underground coal extraction and use.
- The fuel supply and its characteristics are stable, competitive and less environmentally damaging than conventional coal, hydrocarbon and other similar resources.
- That projects can operate in full compliance with all in-country laws and regulations and guidance.
UCG projects will need to be able to withstand independent review and reporting that will give investors, partners and other stakeholders confidence that the project can deliver and has considered fully the following:

- Legal
- Financial
- Technical
- Health Safety Environmental and Community (HSEC)

In evaluating and presenting a UCG project it is critical to understand the cultural and working environment of the host country, failure to understand and appreciate the impact of local factors will result in delay, cost overrun and underperformance as an upside and cancellation and legal recourse on the downside.
UCG as an Alternative Clean Energy Source!

- Abundant minable coal and substantial resources that are inaccessible, unsuitable or uneconomic to mine by conventional methods
- These resources represent a potentially significant source of energy
- UCG provides an opportunity to unlock this resource offering an alternative carbon energy fuel with a lower emission footprint to that of coal use
- The concept of UCG has been successfully demonstrated globally using different technologies and operating systems
- Development of UCG will require advanced technology, monitoring, control and management systems
- Technology is readily available in the energy industry; commercialisation will require the selection and use of compatible equipment and working methods matching the cultural and working environment
- All in cost of energy production (US $/GJ) up to 50% lower than coal
Market Opportunities for UCG in China

China’s growing economy and industry needs offer opportunities for an alternative clean energy source:

- 75% increase in overall energy demand by 2035
- 10% of energy consumption by 2020 from gas
- Growth in gas consumption estimated as 7.5%/a to 2035
- 30% of unconventional gas supply from coal seam by 2035
- Unconventional gas supply to increase to 500PJ in 2020 and 1,350PJ by 2035
- Gas demand is expected to exceed supply by 35% in 2011
- Annual gas consumption increased by 20% in 2010
- Current well head price (US $/GJ) is US $5, industrial use US $10 to US $15
- Recent 25% increase in gas prices in 3rd Qtr. 2010

Increase in gas demand is driven by GDP and the need to reduce GHG emissions
Key legal documents and process will include review and assessment of:

- Ownership or exploitation rights of the coal asset
- Confirmation of, and security of asset
- Corporate structure and ownership of any JV parties
- Liabilities of any JV parties and any existing contractual position
- JV structure, ownership, governing law and language
- Payments, money transfers (in and out) and taxation
- Need for in-country legal entity
- Employment and banking issues
- Gas or energy sales contract
The Commercial Development of UCG

Key financial project indices are:

- Capital expense Y1 to Y5
- Payback period on initial capital investment
- Gas sales Y1 to Y5
- Project life and time to ramp up to full production
- Total Project revenue
- NPV and IRR
- Installed capacity (equivalent MWₑ) or natural gas equivalent (BM³)
- Modelling - source of capex and opex cost assumptions, revenue generation
- Key model assumptions and variance of key financial indices
- Corporate governance of investor funds
- Timing of tax or royalty payments
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Financial - Project Model Sensitivity Analysis

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<thead>
<tr>
<th>item</th>
<th>unit</th>
<th>downside</th>
<th>base case</th>
<th>upside</th>
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<tbody>
<tr>
<td>Coal resource to reserves</td>
<td>%</td>
<td>40</td>
<td>50</td>
<td>60</td>
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<tr>
<td>Reserve extraction ratio</td>
<td>%</td>
<td>40</td>
<td>50</td>
<td>60</td>
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<tr>
<td>UCG efficiency</td>
<td>%</td>
<td>70</td>
<td>75</td>
<td>80</td>
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<tr>
<td>UCG gas sales revenue</td>
<td>%</td>
<td>60</td>
<td>80</td>
<td>100</td>
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<tr>
<td>Gasifier drilling costs</td>
<td>%</td>
<td>-20</td>
<td>0</td>
<td>20</td>
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<tr>
<td>Capital start-up costs as % of total drilling costs</td>
<td>%</td>
<td>40</td>
<td>32</td>
<td>24</td>
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<tr>
<td>Opex surface infrastructure as % of drilling cost</td>
<td>%</td>
<td>100</td>
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<td>60</td>
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<tr>
<td>Opex contingency</td>
<td>%</td>
<td>15</td>
<td>10</td>
<td>5</td>
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Technical and operational considerations will include:

- Resource and reserve (JORC and/or SPE)
- Geological and hydrogeological
- Staffing and resources
- Project support
  - International experts, suitable “competent persons”
  - Domestic sub contractors and services
- Availability and experience in-country services
  - Geological and hydrogeological
  - Exploration and monitoring drilling
  - Gasifier drilling equipment
  - Gasifier process control and management
  - Environmental monitoring and support
- Infrastructure and logistics
- Contracting/procurement and payments
- Local relationship issues
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**Technical** and operational considerations - drilling costs are likely to be in the order of 50% of the total project costs. Failure to maintain drilling operations in line with design and performance needs will result in significant costs and under performance. Key issues are:

- **Design of underground gasifier**
  - Length and position of in-seam lateral
  - Radius design and control
  - Casing and production string size and installation
  - Surface headwork's

- **Selection of drilling contractor**
  - Drill rig
  - Downhole steering equipment
  - Drill rods and other ancillaries
  - Experience in coal
  - In-country experience
  - HSE documentation and management
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Technical and operational considerations - drilling, the good
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Technical and operational considerations - drilling, the bad
Health Safety Environmental and Community (HSEC) needs to include:

- HSEC documentation and practices
  - Policy and manual
  - Safe working procedures
  - Use and issue of PPE
  - Induction and training
  - Incident and accident reporting

- Permits and approvals

- Access, site preparation and restoration

- Understanding local services and procedures

- Capability of in-country monitoring and analytical services

- National and local policy, regulation and guidelines

- Management of on-site activities

- Managing the difference between local and international standards

- Relationship management
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Dealing with HSEC issues
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HSEC - the ugly
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Initial milestones for a UCG project include:

- Establishing a sound contractual base with the in-country partner
- Understanding fully the cultural and working practices
- Ensuring all permits and approvals are in place to undertake any works
- Review and reporting of the coal and energy resource/reserves
- Geological and hydro-geological reporting
- Establishing an environmental monitoring and testing programme
- Understanding the capability and limitations of service providers
- Design, performance and delivery capability appraisal
- A robust cost base established as a step towards commercialisation
- Operate in full compliance with all HSEC policy and practices
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Underground Coal Gasification an Alternative Clean Energy Source of the Future?

Legal:

- Is the asset real, do we have confidence in the reported data and can we secure the asset?
- Can legal due diligence peel away the layers?
- Do we have the right in-country partner and has the project identified their roles and responsibilities?
- Are we a hands-off JV partner or hands-on acting as the project operator?
- Roles and responsibilities aligned with contractual deliverables, project performance and liabilities
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Underground Coal Gasification an Alternative Clean Energy Source of the Future?

Financial:

- What is the in-country project cost of gas production?
  - Capex, Opex and what is included and what's excluded?
- Real sales price and off-take agreement and conditions and timing
- Working in an environment where lowest cost is best
- Contractual position, payments and claims
- How to secure the release of money from project revenue
- Controlling political risk
- Are we prepared to spend money on “works below ground”?
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Underground Coal Gasification an Alternative Clean Energy Source of the Future?

Technical:

- Resource and reserves are JORC and SPE suitable measures?
  - JORC developed for coal mining operations; very different production process than UCG development, mine development removes geological uncertainty
  - SPE - known stable reservoir not destroyed by the extraction process
  - Is the project prepared to spend money up front on quality geological exploration?

- Are our services providers the real deal?

- Protecting Intellectual Property (IP) - is UCG development reliant on “a black box” or the application of proven technologies and practices from other resource extractive and exploitation industries?

- Relationship management
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Underground Coal Gasification an Alternative Clean Energy Source of the Future?

HSEC:

- Operating to national or good industry standards
- Understanding local practices
- Quality and availability of in-country services
- Supervision and enforcement
- Ability to demonstrate full HSE compliance including a controlled shut down of the gasifier in a known time period
- Need for high standards that may be well above the normal practices
- Managing local relationships without venturing over to the “dark side”
Schematic layout of a UCG reserve