Water management issues in the underground gasification of coal and the subsequent use of resultant voids for long-term CO_2 Storage

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Overview

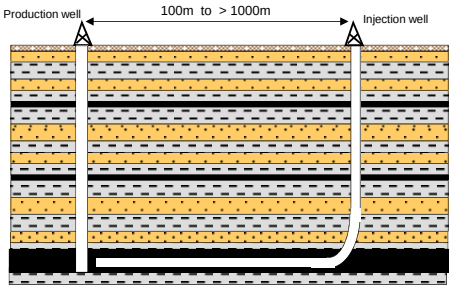
- The UCG process
- Coupling UCG directly to CCS
- Groundwater issues in UCG
- Risk assessment for CCS in UCG goaf

Underground Coal Gasification

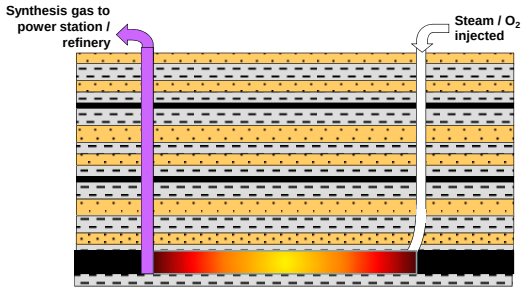
UCG -CCS

… with carbon capture and storage

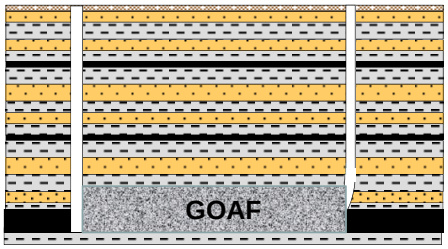
The process: UCG



The process: UCG



After UCG – goaf formation



Goaf

UCG: history

- First UCG experiments were carried out in County Durham, UK, by Sir William Ramsay in 1912 – experiments halted by World War I
- Stalin then adopted UCG in the former Soviet Union, where it has been undertaken at industrial scale since the 1950s
- Interest in UCG in the West waned with the development of abundant oil and natural gas
- Significant pilot trials in China
- Currently operating commercially in Australia

UCG to date …

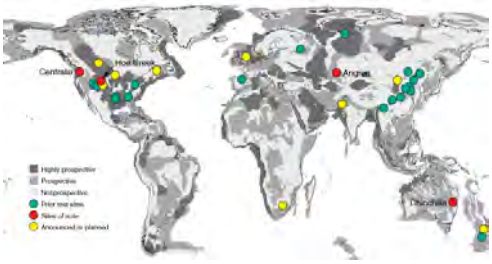


Image courtesy of UCG

Underground coal gasification in action

Diesel production from UCG in Australia, using the Fischer-Tropsch process

Groundwater issues in UCG

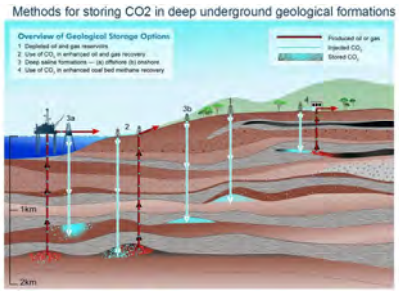
- Water quantity issues:
  - Some water is good (saves on generating steam at surface)
  - Too much water is bad (hinders ignition and burn zone propagation)
- Pollution concerns:
  - Organics: phenols, benzene, PAHs, heterocyclics
  - Inorganics: salinity (Na-Cl), NH_4, As, B, Zn, Se, U

Managing groundwater issues in UCG

- Water quantity issues:
  - hydrologically intelligent selection of sites, seams and production scheduling in multiple seam sequences ("bottom-up" best)
- Pollution issues:
  - Use groundwater protection logic
  - Asess risk using the standard approach of:

    Source → Pathway → Receptor

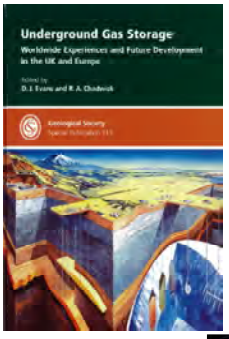
CCS – the aspiration



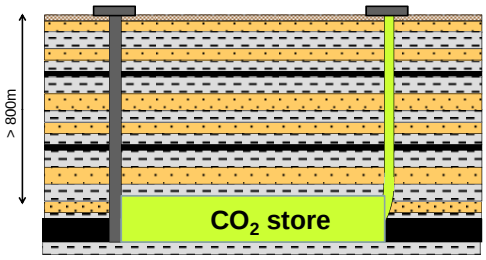
Source: IPCC CCS Report

Underground gas storage: not a new technology

Up to 1000 tonnes of H_2 stored in solution mining caverns in salt in densely populated urban area – has operated safely for > 60 years



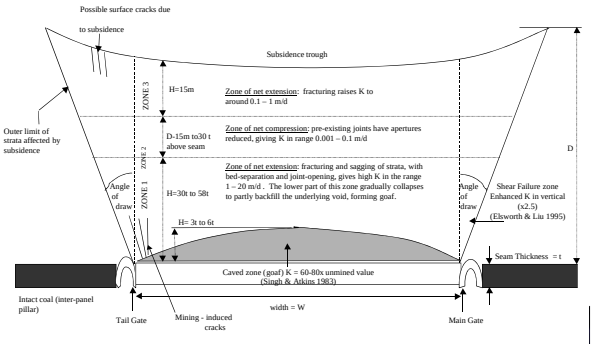
The vision: CCS in UCG goaf & overburden



CCS in UCG goaf and overburden

- UCG likely to be undertaken closer to large static CO_2 sources than many spent oil and gas reservoirs (especially in N Sea region): saving on transit costs
- Typical permeabilities of goaf (1 to > 20 d) far greater those of deep saline aquifers (i.e. 0.01 to 1 d)
  - Thus it will be up to **2000 times easier** to inject CO_2 into UCG goaf than into deep saline aquifers
- However, CO_2 occupies 3 – 5 times the volume of original coal: access to pore space in fractured overburden (above goaf) will also be required
- Hydrogeological experience from longwall mining gives abundant grounds for optimism over the development of CO_2 storage zones in goaf & fractured overburden

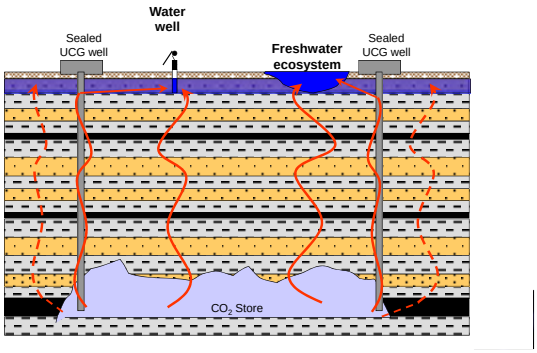
Strata deformation and permeability development above collapsing mine voids



Risk assessment for CCS in UCG goaf

- Most of the contaminants produced during UCG are not very soluble in water
- However, super-critical CO_2 is one of the most powerful solvents known; it will dissolve them, so if CO_2 migrates, the contaminants will certainly migrate with it
- Hence for risk assessment of CCS in UCG goaf the only important task is to evaluate the risk of CO_2 migration

Risk assessment for CO_2 storage in UCG goaf / overburden



Man-made infrastructure likely to be principal risk pathway: cf. abandoned mine waters

Line of unsealed exploration boreholes, near abandoned Milluni Tin Mine, Bolivia

Typical adit discharge, Ynysarwed, South Wales

Project Ramsay: assessing the UCG-CCS opportunity in North East England

- Multidisciplinary team of specialists led by Newcastle University assessed potential reserves, drilling and processing technologies, surface engineering issues, and financial scenarios
- Identified more than 5 billion tonnes of coal in workable seams at depths suitable for CCS in goaf and overburden
- Company now being established to pursue the opportunity commercially

Conclusions

- UCG has great potential to support the transition to a renewable energy future without further damage to the atmosphere
- Application of hydrogeological lessons learned during longwall coal mining suggests significant scope for CO_2 storage in and above goaf formed by collapse of UCG voids
- Groundwater issues can be managed using the same principles used in conventional mine water management situations

Thank you ◊ *Merci beaucoup* ◊ Tapadh leibh ◊ *O'wela'lin*

“Jowl the top an' keep thi timmer in”

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