Underground Coal Gasification

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Coal Gasification Simplified

Coal + Water + Heat + Pressure = SYNGAS

\[ C + H_2O \rightarrow CO + H_2 \]
Underground Coal Gasification

Overview UCG Process

GTL / POWER PRODUCTION
SYNGAS OUT
AIR / OXYGEN IN

PRODUCTION WELL
INJECTION WELL

WATER TABLE
OVERBURDEN

COAL SEAM

HYDROSTATIC PRESSURE CONTAINS THE UCG PROCESS
UCG CAVITY

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GTL – in simple terms

UCG GASIFICATION

RAW SYNGAS

GAS TREATMENT

H₂ + CO SYNGAS

FT REACTOR

Cₙ+Hₙ GASES, LIQUIDS & WAXES

PRODUCT WORK UP / REFINING

ELECTRICITY GENERATION

ULTRA-CLEAN
- DIESEL
- NAPTHA
- JETFUEL
- LPG

WAXES

TAIL GAS & STEAM

WATER & OXYGENATES

• ELEMENTAL SULPHUR
• COAL TARS & OILS
• CARBON DIOXIDE
• WATER
• ASH
Carbon Capture

- Syngas needs ‘cleaning’ prior to further use

- The gas cleaning process often creates a clean CO₂ waste stream, ready for the sequestration process
Syngas is versatile

UNDERGROUND COAL GASIFICATION

AMMONIA

METHANOL

CARBON MONOXIDE

HYDROGEN

OXO ALCOHOLS

FISCHER TROPSCH

SNG

TOWN GAS

REDUCTION GAS

GAS TURBINES

CO₂

NH₃

UREA

FORMALDEHYDE

MTBE

ACETIC ACID

PHOSGENE

RESIN

POLY URETHANE

DETERGENTS PLASTICISERS

FUELS, WAXES, OTHERS

METALS

ELECTRIC POWER
UCG Operations - Chinchilla

*Australia's Leader in Clean Coal Technology*
GTL Demonstration Plant - Chinchilla

Australia's Leader in Clean Coal Technology
GTL Demonstration Plant Chinchilla

Australia's Leader in Clean Coal Technology
Angren, Uzbekistan

UCG: Smaller Footprint, Lower Impact
Soil Remains Intact
...for future (or co-incident) land use

Yerostigaz UCG, Uzbekistan
Environmental Aspects

Groundwater

• Linc’s UCG process relies upon in-situ moisture content of the coal seam

• Groundwater movement is minimized in Linc’s UCG operations because natural hydrostatic pressure is needed for UCG process

Groundwater Quality

• Quality maintained by limiting groundwater outflow

• Linc’s Chinchilla trials have experienced no groundwater contamination in over 10 years of operation

Subsidence

• Linc Energy targets no surface impact
Controlling UCG Impacts

- PREDICT
- CONTROL
- MONITOR

Figure 6 Temperature distributions in the boundary of cavity
Understanding Geology

Site Selection -
One of the most critical factors in successful UCG

• Example acoustic borehole imaging log and mapping of geological joints/fractures
Understanding Overburden properties

- Comprehensive study of overburden characteristics is undertaken at all new prospective UCG targets.
- Overburden rock strength is characterized by laboratory measurements and mapping of joints/defects.
- Thermodynamic strength is analyzed.

Roof material from Chinchilla Generator 4 site

Australia’s Leader in Clean Coal Technology
Cavity growth prediction
Most Important Controls

• Site selection - many variables

• In operations - minimizing gas loss by controlling hydrostatic pressure

• Decommissioning - leave a clean cavity

• Monitoring
Hydrology Modeling

Chinchilla, Queensland
Dewatering Coal Seam is Undesirable for UCG

Linc Energy’s advanced UCG technology requires that normal groundwater levels be maintained.

This is opposite to all other forms of energy extraction from coal.
Groundwater and the UCG process

- Production Well
- Very minor vertical leakage
- Injection Well
- Complex zone of drying and gas/groundwater interaction
- Mainly lateral flow in seam
Controlling Groundwater Inflow

To manage groundwater inflow UCG takes advantage of a simple principle:

- By operating at or slightly below the hydrostatic pressure of the coal seam, water inflows can be maintained at the designed level.
Controlling Subsidence

- Linc Energy has developed advanced subsidence modeling techniques for UCG generator design
  - Targeting “no surface impact” design
  - Extraction width is designed to control fracturing in the roof materials
  - Pillars are designed to provide for UCG subsidence control.
- Modeling process similar to that used in underground coal mining
Subsidence Model

JOB TITLE: LINC ENERGY: UCG CHINCHILLA Wo=30m Wp=20m [LE-18]

FLAC (Version 6.00)

LEGEND

19-Dec-08 20:53
step 20500
1.750E+02 < x < 5.250E+02
0.000E+00 < y < 3.500E+02

Maximum principal stress
-1.20E+07
-1.05E+07
-9.00E+06
-7.50E+06
-6.00E+06
-4.50E+06
-3.00E+06
-1.50E+06
0.00E+00

Contour interval = 5.00E+05
Boundary plot

GEONET Consulting Group
Brisbane, Australia
Decommissioning: Phase I

Production Well
- Maintained flow

Reduced flow or shut in

Injection Well

Drop in pressure, increased gradient, increased inflows

Steam Generation
Decommissioning: Phase II

- Production Well
- Shut in, vented periodically
- Injection Well

Maintained low pressure. Cavity periodically vented to prevent gas pressure building and displacing water.

Gasification extinguished, water recovering.
Decommissioning: Phase III

Production Well → Shut in → Cavity purged and water treated → Used to pump out cavity → Injection Well → Cavity water recovered
Syngas Flare - Chinchilla
Commercial UCG Project Phase I

- A “stranded” coal seam of 30’ thickness:
  - contains over 34 million tons of coal per 640 ac. section
- A single UCG generator:
  - consumes approximately 80-90 tons/day
  - produces over 8.0 mmcf/d of syngas
- An operating panel of 6 UCG generators:
  - produces over 50 mmcf/d of syngas
  - could support a gas turbine plant of 100 MW
  - Could operate for well over 100 years in 34 mt resource
Commercial UCG Project Phase II

- World Class UCG – GTL project:
  - producing 20,000 bbl/day of clean synthetic diesel, jet fuel and other liquids and valuable by-products
  - Producing all its own power requirements plus over 200 MW of exported power
  - consuming approximately 20,000 tons/day of coal
  - producing commercial quantities of pure CO2 ready for EOR sequestration or other purpose
  - Could operate for over 20 years in 3,200 acres of coal seam if 30’ thick (5 sections).
Social and Economic

- Safety – no people underground & no surface mining

- Contribution to Energy Security & Independence for America
  - Wyoming: In-state utilization of coal-generated power.
  - Wyoming: In-state supply of FT diesel and jet fuel

- Creates major ‘new’ royalty stream for Wyoming

- Source of new jobs

- Less land use conflict
Social and Economic

- Significant value added from coal that is otherwise ‘valueless’
- New types of support industries
- Long term source of power
- Clean coal utilization
Summary

• Linc Energy’s UCG technology is well developed and ready to be implemented commercially.

• Product quality can be controlled within specific limits dictated by site characteristics and can be manipulated above-ground to suit selected applications.

• Site characteristics are used to design and control underground processes.
Thank You

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