The Potential for Underground Coal Gasification in Indiana

Evgeny Shafirovich and Arvind Varma
School of Chemical Engineering, Purdue University
West Lafayette, IN

With contributions by
John Rupp and Maria Mastalerz
Indiana Geological Survey, Bloomington, IN

CCTR Advisory Panel Meeting, June 5, 2008
Indiana and Coal Gasification

- Coal gasification is promising for the future use of Indiana coals.
- The gasification process produces **syngas** (CO/H\(_2\)), which can be used to generate electricity or produce liquid hydrocarbon fuels, natural gas surrogates and other valuable chemical products.
- Advanced coal gasification methods include solutions for **CO\(_2\)** capture.
- Earlier feasibility analyses focused on the construction of new coal gasification plants in Indiana.
- An alternative method: **underground coal gasification (UCG)**.
CCTR Project on UCG

- **Participants:**
  - Purdue’s School of Chemical Engineering
  - Indiana Geological Survey (sub-contractor)

- **Period:** April 2008 – January 2009

- **Objective:** analyze the feasibility of using UCG in Indiana, specifically
  - Analyze the **current status** of UCG technology and determine **criteria** for site selection
  - Analyze available data on Indiana’s coal resources and determine **suitable** locations for UCG
  - Identify the **most promising** UCG locations and provide characteristics for each that allow comparison and selection
What is Underground Coal Gasification (UCG)?

- Injection and production wells are **drilled and linked** together in a coal seam.
- Air or oxygen is injected and the coal is **ignited**.
- Groundwater is utilized.
- The gasification process produces primarily **H₂, CO, CH₄** and **CO₂**.
- The produced gases flow to the surface through the production well and cleaned.

Advantages of UCG over Conventional Mining and Surface Gasification

- Lower capital costs
- No human labor underground
- Lower surface disruption
- Increased coal resource availability
- No handling of coal and solid wastes at the surface
- Direct use of groundwater
- Cavities formed as a result of UCG can be used for CO$_2$ sequestration
Potential Problems of UCG

- Difficulties in linking the injection and production wells
- Insufficient thicknesses of coal seams
- Variation of product gas composition
- Lower heating value of the produced gas
- Groundwater pollution
- Subsidence
- Public concerns about potential loss of control
History of UCG

- Proposed by brothers Siemens in 1868
- First patent: A.G. Betts in 1909
- FSU: over 17,000,000 metric tons coal gasified by 1996
  - 1928: Development started
  - 1937: The first commercial-scale UCG plant
  - 1996: The last UCG plant in Russia shut down
  - A power plant in Angren, Uzbekistan, remains in operation after ~50 years
History of UCG, cnt’d

- **USA: 1972-1988**
  - Over 30 UCG experiments, 50,000 tons coal gasified

- **Western Europe: 1982-1999**
  - Trials in Belgium, France, Germany, Spain, and UK

- **China: 1980s-present**
  - At least 16 tests, several commercial UCG projects

- **Australia: 1999-present**
  - A large pilot (Chinchilla) produced syngas for 3 years before a controlled shut-down and controlled restart, 35,000 tons coal gasified.
History of UCG, cnt’d

- Patents from 1988 to 2008
  - Russia: 44
  - China: 22
  - North America: 0
Current Status of UCG

- **Modeling**
  - Lawrence Livermore National Laboratory
  - University of Queensland, Ergo Exergy

- **Commercial projects, to produce electric power, liquid fuels, and synthetic natural gas**
  - Australia (Linc Energy)
  - China (XinAo)
  - Canada (Laurus)
  - India (GAIL)
  - South Africa (Eskom)
  - USA (GasTech)
CCTR Project: Plan of Work

- **Phase 1**: Analysis of UCG current state of science and technology and determination of criteria for site selection
  - IGS has defined criteria for underground mining, but the criteria for UCG are different
  - Specific requirements for the depth and thickness of coal seams (contradictory information on the thickness, unclear effects of partings, splits, etc.)
  - Literature search, consultations with experts, modeling
  - Purdue will determine the UCG criteria
Phase 2: Analysis of Indiana’s coal resources and determination of suitable UCG locations

- Using the available database of Indiana coal resources and characteristics, IGS will create maps to identify locations that match the UCG criteria

- For the suitable locations, additional important information will be provided:
  - coal heating value
  - concentrations of sulfur, mercury and other impurities
  - the feasibility to use the UCG cavities for CO₂ sequestration
  - the availability of other potential sequestration locations
Phase 3: Selection of the most promising UCG locations

- Locations that are suitable for UCG will be analyzed by Purdue and IGS to select the most promising UCG locations
- In particular, product transportation issues will be considered
- Special attention will be paid to environmental aspects, including the risks of groundwater pollution and uncontrolled combustion
CCTR Project: Expected Results

- The Final Report will include
  - Characteristics of UCG current status
  - Conclusions on the feasibility to use UCG in Indiana
  - A list of the most promising locations
  - A list of characteristics for each location that allow comparison and selection