Modern Practices in UCG

03 UCG Series

Technological advances in the last few decades have increased the number and reliability of tools that can be used to predict, control and monitor UCG operations. This information sheet explores the techniques that are bringing UCG into the modern age of energy production.

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Analysis and modelling

Advances in modelling software and ready access to high powered computers have made modelling issues related to UCG much more accessible.

The types of information that can be analysed online or collected in the field and analysed quickly in a laboratory have also significantly increased. This enables UCG conditions to be more precisely controlled, with benefits in terms of overall process control, environmental impact management, energy efficiency improvement and cost reduction.

Geological modelling

Understanding the geological setting is critical to effectively planning and managing a UCG operation. While methods to determine geological structure are mostly the same, modern tools now allow for more rapid analysis to determine UCG-suitable coal seams, which also provide a base for a range of other modelling applications.

Analytical techniques combined with geological models are used to determine the:

- Characteristics of the coal seam (including volume, quality, variability, structure, strength, permeability, geochemical and thermal properties)
- Characteristics of the surrounding geological formations (including structure, strata, features like faults, variability, strength, permeability and thermal properties)
- Effects of heat transferred from the UCG cavity on the roof and floor of the cavity and the surrounding strata.

The geological information and model is used as the base for all other models used to predict the UCG process and its environmental effects.

Hydrogeology

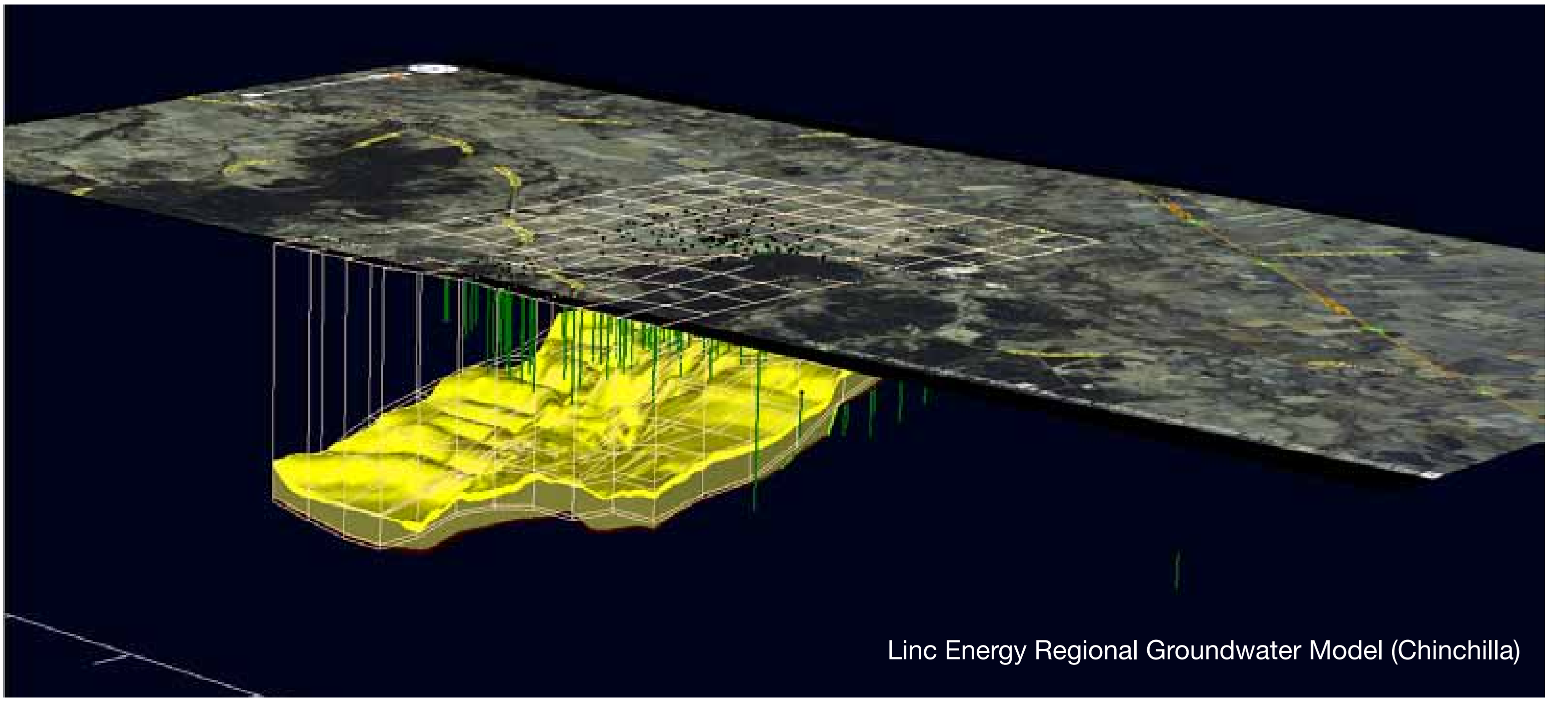
Hydrogeological models are comprised of short-term, near field simulations, and longer term groundwater flow and contaminant fate predictions.

The near field simulations use reservoir models to estimate:

- Water ingress to the cavity and gas loss to surrounding formation
- Containment pressure.

Predictions from this model can be used to assess the risks of short-term gas loss to the surrounding formation.

Longer term groundwater modelling is conducted to determine overall



Linc Energy Regional Groundwater Model (Chinchilla) impacts to groundwater flow rates and direction, thereby determining aquifer drawdown. Contaminant fate modelling is also conducted to determine the rate of contaminant decomposition and transport pathways.

Combined with knowledge of the baseline condition and values of the groundwater in the region, this is an important impact assessment tool.

Cavity growth

Cavity growth modelling predicts the shape, direction, temperature, volume and rate of growth of the UCG cavity. It is used to determine:

- The best generator design and burn plan at a particular site
- The maximum amount of time a single cavity could run prior to product gas deterioration
- Optimised generator design for maximum economic gas extraction.

Cavity modelling is conducted using computational fluid dynamics principles. Reactions are simulated between the interface of the coal seam and the cavity.

Input streams to the generator are the oxidant and steam (injected or from groundwater), and the gasification products from the coal wall, where the reaction rate is controlled by mass and heat transfer. The interface temperature between the coal seam and cavity is important for sub-models of drying, devolatisation and spalling (rock fall).

Subsidence

Modelling of subsidence has been perfected in the underground coal mining industry over many years. The same models are used to predict subsidence for UCG, given the ability of modern UCG operations to precisely and predictably extract coal.

Subsidence modelling has two important aspects for UCG:

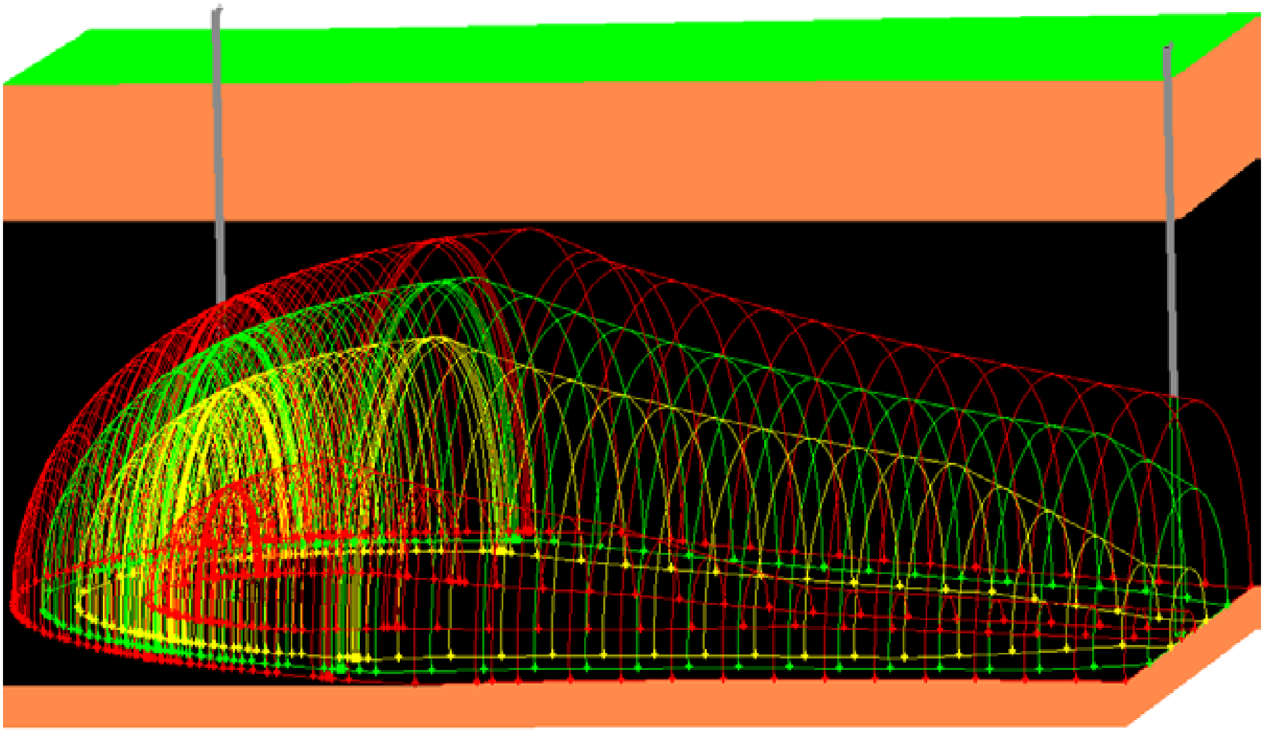
- Predicted deformation of the land surface (if any)
- Determination of the likely propagation of fractures through the overburden.

Predictable subsidence modelling is a key UCG tool, as the above aspects are important for impact assessment, and as an input to the groundwater and gas quality models.

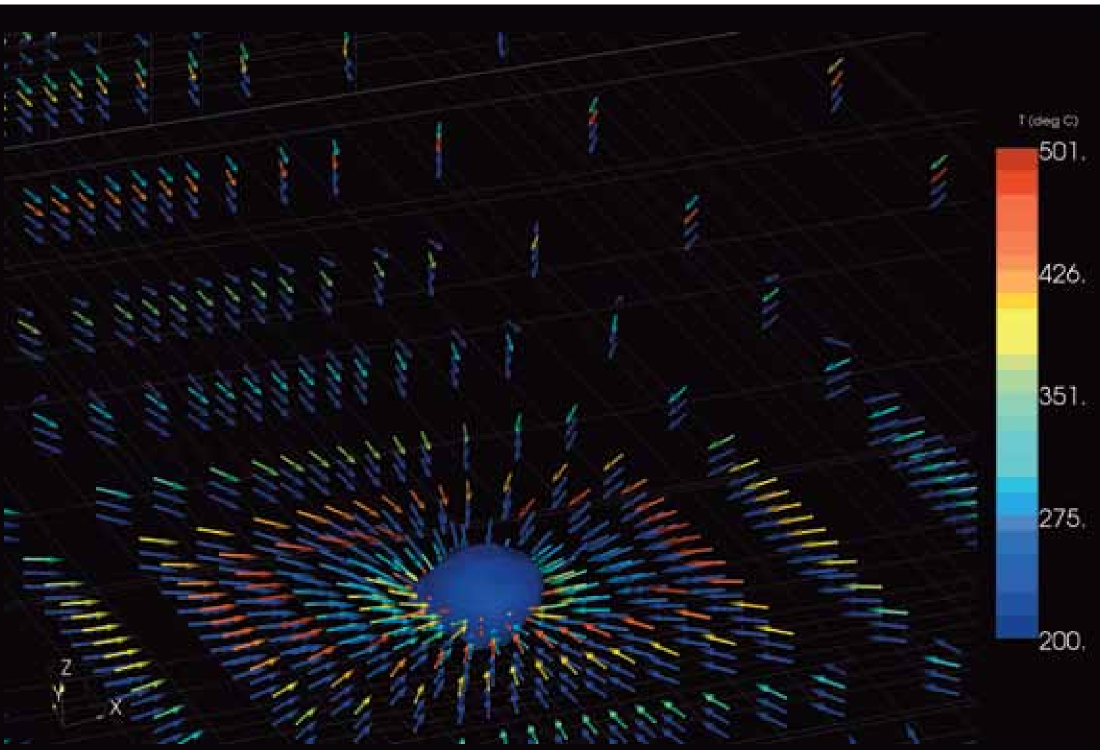
Gas quality

It is important to be able to predict the gas quality from the UCG operation so target resources are more likely to yield gas with a composition suited to the downstream needs. The gas quality can be predicted based on specific amounts of coal, oxygen and steam that are available for reaction at specific temperatures.

Gas quality is determined using established reactor engineering principles that are used in a wide range of process engineering applications.



Linc Energy Time Series Cavity Growth Model (not to scale)



Linc Energy Near Field Generator Model

Modern software systems are able to complement this area of work and assist to provide repeatable reactor performance and gas quality outputs that consider the wide range of chemical species and competing reactions that are naturally occurring.

This work also provides important information about the control mechanisms that can be used to control generator performance and the resulting gas quantity and quality.

Modern well construction and linkage methods

Well integrity is important to control the gasification process during operations. Material selection for well construction has been developed so a well can withstand the high temperatures generated from the UCG process.

A link must be created between the injection and production wells to allow for gas production at commercially significant flow rates. Linc Energy has chosen in-seam directional drilling as its preferred linkage method because:

- It is more predictable and reduces the number of wells needed
- Allows for extraction of the maximum amount of coal from a well pair
- Allows for re-ignition, changing injection points, and ease of insertion and recovery of down-hole instrumentation
- Full production can commence almost immediately upon construction.

Once a laborious and painstaking task, in-seam directional drilling has undergone significant advances in the last two decades, making this form of linkage much more feasible. These advances include:

- Instrumentation for sensing coal seam boundaries and hole trajectory from down-hole sensors
- Devices that monitor both drilling parameters (coordinates) and geophysical properties of the surrounding strata
- The use of target devices that enable the drill head to seek the target.

Development in UCG techniques and configurations

UCG has been conducted commercially in the Former Soviet Union (FSU) since the 1930s. Since the 1970s it has been limited to one operation due to an abundance of competitively priced natural gas. FSU operations have safely produced large volumes of high quality syngas with basic methods of control and monitoring. Knowledge of geology and coal has significantly improved since, and so too has the array of tools available (mainly through advances in the petroleum and gas sectors) to be used to construct, analyse, predict, control and monitor UCG operations.

As a largely experimental technology in western countries, UCG has been researched extensively under a variety of conditions. These conditions have included different coals (rank, thicknesses and depths), UCG generator configurations, oxidant types, linkage methods and operational methods.

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The primary driver is to develop commercially viable UCG technology for successful application in western world, deregulated energy markets. The key to this is the extraction of the maximum amount of coal from a well pair to maximise capital efficiencies and economies of scale. This has increased the use of directionally drilled connections.

These modern configurations are based on minimising the number of wells, optimising cavity growth for consistent gas quality, and minimising environmental impacts, and have been proven.

Process control and monitoring

Process parameters are governed by geological and hydrogeological properties. The rate of gasification is dependent on the flow rate of the oxidant to the generator, while the thermochemical efficiency of the process is dependent on the oxygen/water ratio into the cavity. These relationships allow the gasification process to be controlled from the surface.

The operating cavity is confined by the surrounding rocks of the coal seam. Groundwater influx creates a ‘steam jacket’ around the chamber, reducing in-situ heat loss. Optimal pressure promotes controlled groundwater flow into the cavity, confining the chemical process to the desired space and preventing leakage.

Operational pressures in the cavity are controllable. Achieving ideal UCG temperatures depends on the careful control of water influx and gas flow. Gasification temperatures can be estimated before the start of operation by considering input of the oxidant, which is then monitored during operation.

After the operational phase, the generator is fully depressurised so the gas pressure in the generator cannot exceed hydrostatic pressure between the base of the production well and the surface. The gasification process cannot continue without the supply of oxygen. The flow of reactants to the generator is achieved by actively pumping against a considerable back pressure. There is then no possibility of the gasification process continuing beyond a controlled period.

It is essential to have the tools to measure the key parameters to control the gasification process and a successful UCG operation.

A number of tools are available to verify modelled predictions, monitor the UCG process and to detect any changes in the environment. These include using:

- In-stream instruments to measure gas pressure in the cavity
- Piezometers to measure hydrostatic cavity pressure and groundwater
- Geotechnical instruments to monitor earth motion, both on the surface (subsidence) and underground
- Online infrared absorption gas analysers and/or gas chromatography to continually monitor syngas quality
- Electrical resistivity and passive acoustic techniques to remotely monitor the location of the reaction zone
- Branched thermocouple circuits, formed by interconnecting individual thermo-elements to sense temperature differentials
- Tracers injected during operation to measure void volumes, residence times, and dispersivity in the underground system.

The injection flow rate and composition, and temperature and pressure of the process, are measured at various points in-situ and in the injection and production wells to facilitate control of the generator. These parameters can be continually assessed against validated UCG process technology model outputs to confirm that operations are progressing in accordance with design and operational expectations.

About Linc Energy

Linc Energy is an Australian energy company which listed on the Australian Securities Exchange (ASX) in May 2006 and the OTCQX in December 2007. Through the unique combination of Underground Coal Gasification (UCG) and conventional Fischer-Tropsch technology to produce Gas to Liquids (GTL), Linc Energy is developing a significant energy business based on the production of cleaner energy solutions for the future.

Related information sheets

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Subsidence

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