UCG and Groundwater

02 Environment Series

This information sheet provides an overview of how Underground Coal Gasification (UCG) interacts with groundwater, how drawdown of groundwater is minimised, and contamination prevented.

Role of groundwater in UCG

Groundwater plays two important roles in the UCG process:

1. It supplies water needed for the gasification reactions. The rate at which water enters the process affects product synthesis gas (syngas) composition and operating temperature.
2. The pressure exerted by groundwater, called hydrostatic pressure, provides containment of the UCG process. The structure and integrity of the coal and overburden geology also provides containment for UCG. The overall containment pressure is a factor of the hydrostatic pressure and the integrity of the overburden.

By operating the process below the containment pressure, there is a net migration of groundwater towards the operating UCG cavity.

How inflows affect the UCG process

Groundwater ingress to the UCG process is a major factor determining syngas quality. Greater water ingress will produce higher concentrations of hydrogen and carbon dioxide and lower the operating temperature.

The desired gas composition depends on the proposed end use of the syngas. Syngas for Gas to Liquids (GTL) is more susceptible to changes in hydrogen content than gas for power generation.

The amount of water ingress and water available to the process is a factor of:

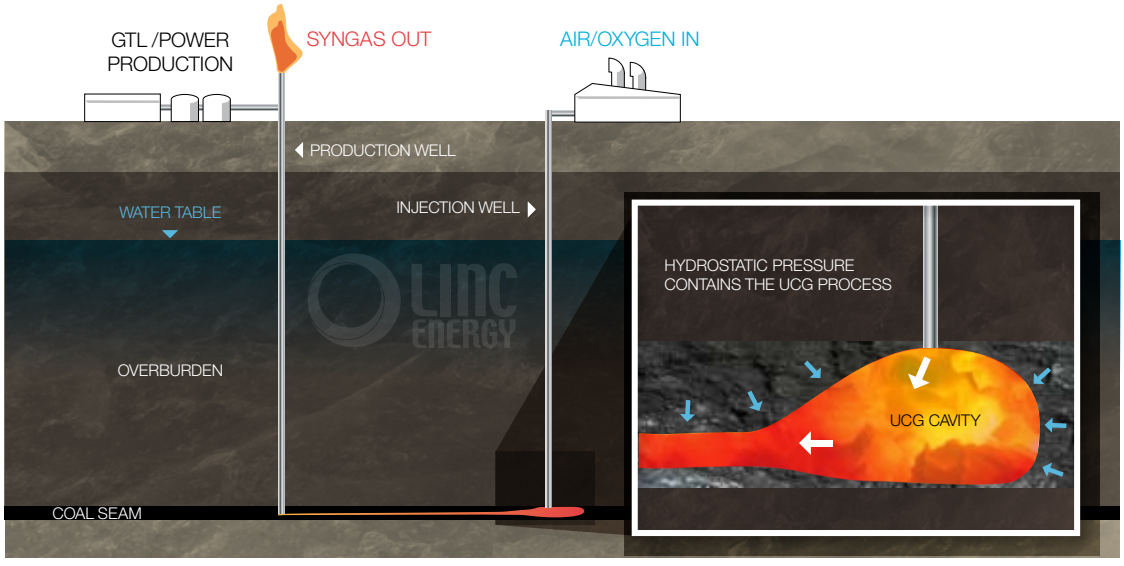
- The inherent moisture of the coal.
- Permeability and structure of the coal and overburden. Coal or overburden with higher permeability and more fractures allows more water to flow through it and provide more water to the process.
- The difference between hydrostatic pressure (the force of water inwards) and operating pressure (the force of gas outwards). Operating significantly below hydrostatic pressure allows more water to flow in than when the operating pressure is closer to the hydrostatic pressure.

Aquifer drawdown

Ingress of water from the aquifer surrounding a UCG operation ultimately results in drawdown of the surrounding or overlying aquifer. The rate of drawdown is dictated by the combination of hydrogeological and operating conditions.

For UCG, it is important to maintain sufficient hydrostatic pressure for optimal UCG operating conditions whilst ensuring that water ingress meets the needs for production of optimal quality syngas.

This means that control measures such as aquifer recharge or cavity steam injection may be needed, depending on the characteristics of a UCG site.



UCG and Groundwater

02 Environment Series

Potential sources of contamination

The contaminants potentially produced from a UCG operation are ultimately a factor of the coal properties and gasification conditions.

The potential sources of contamination from UCG are:

- Loss of syngas into the surrounding geological formations
- Leaching of residual ash or tars remaining in a spent UCG cavity.

Gas loss

When syngas is generated it is very hot and contains gaseous hydrocarbons. When the gas cools, the gaseous hydrocarbons condense to liquids. If gas is lost from the UCG cavity into the surrounding rock and the gas cools, it can deposit liquids in the formation and act as a source of groundwater contamination.

The volume and extent that gas travels in the formation outside of the UCG cavity ultimately dictates the risk of contamination. In the very few UCG trials that have resulted in groundwater contamination, gas was lost through the formation to the atmosphere, meaning that a continual flow of gas deposited liquids in volumes significant enough to cause contamination.

As part of routine operation, gas can be lost to the vicinity immediately around the cavity through natural or induced fractures in the formation. Linc Energy's experience is that, because the gas is not being continuously pushed out into the formation, deposition of liquids is minor and leads to only trace level changes in groundwater quality in the immediate vicinity of the cavity.

Gas loss is minimised by operating below the containment pressure and selecting an appropriate site for a UCG operation.

Decommissioning

Decommissioning a UCG operation plays an integral role in minimising groundwater contamination.
It allows for cleaning of the remaining contaminants in the cavity and the drawing in of any contaminants from the groundwater around the cavity.

During decommissioning, the pressure in the hot cavity is released and large amounts of steam are generated. This steam acts to clean most of the liquids that may have condensed in or near the cavity and allows them to be treated at the surface. Likewise, cavity flushing as part of decommissioning deals with leachate generated from the ash.

Monitoring

By regularly monitoring the groundwater around a UCG operation, changes in water quality and hydrostatic pressure can be tracked and, where necessary, appropriate responses carried out.

Site selection

Appropriate site selection plays a major part in preventing groundwater contamination. Ideal UCG sites have competent and low permeability overburden, coal permeability suited for the proposed end use of the product syngas, high containment pressure and aquifers with appropriate environmental values.

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

UCG Explained

Preventing Groundwater Contamination

Groundwater Use in UCG

AUSTRALIAN HEAD OFFICE
32 Edward Street
GPO Box 1315
Brisbane QLD 4001
AUSTRALIA
p +61 7 3229 0800
f +61 7 3229 6800

UNITED STATES HEAD OFFICE
1200 17th Street
Suite 2100
Denver CO 80202
UNITED STATES
p +11 303 623 0510
f +11 303 623 0547

linc@lincenergy.com.au www.lincenergy.com.au