Underground Coal Gasification (UCG)

by Bretwood Higman, Erin McKittrick, David Coil

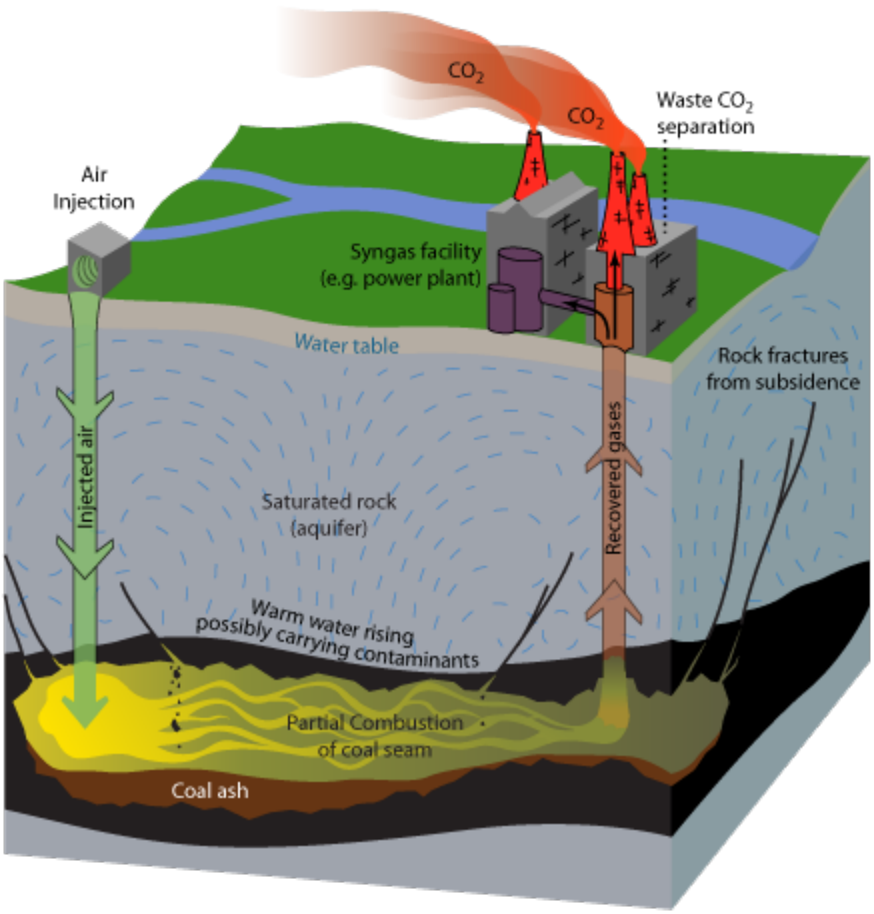
LAST MODIFIED: 12TH AUGUST 2019

CREATED: JAN. 19, 2018

Ground Truth Trekking

Table of Contents

Underground Coal Gasification (http://en.wikipedia.org/wiki/Underground_coal_gasification) (UCG) involves igniting coal in the ground, then collecting and using the gases that result from its partial combustion. Although the idea dates back over a century, very few UCG plants have ever been built. Underground gasification could potentially allow the use of coal that is currently uneconomical to mine. Underground gasification eliminates the need for strip mining (CoalMining.html) and transportation of coal, as well as potentially making carbon capture and sequestration (LowCarbonCoal.html) more practical. However, UCG produces large amounts of CO2, and the coal combustion wastes (CoalCombustionWastes.html) that are left behind can leach pollutants into nearby groundwater, and have caused major contamination in UCG pilot projects.



UNDERGROUND COAL GASIFICATION (/figures/UndergroundCoalGasification/) — Underground Coal Gasification involves igniting a coal seam underground and pumping out the partially burned gases that result.

History of UCG

Underground coal gasification is a technology that has been discussed and experimented with for over 150 years. It was used at several sites in the former USSR, including a facility in present-day Uzbekistan (http://www.lincenergy.com.au/yerostigaz.php) that has been in operation since 1961. Interest in UCG was high after World War II, and a number of pilot projects were started across Europe. Most of these projects were abandoned in the 1960s due to falling energy prices. Linc energy recently has conducted a four year test project (http://www.lincenergy.com.au/australian_projects_qld.php) in Australia called Chinchilla which gasified 35,000 tons of coal. Germany is also planning a test project (http://www.nytimes.com/gwire/2010/04/16/16greenwire-researchers-explore-coal-without-mining-in-bid-90786.html?pagewanted=1) in Aachen that would combine UCG with carbon capture (/Issues/AlaskaCoal/LowCarbonCoal.html). In the USA, there have been over 30 pilot UCG projects, most recently two large projects in Washingon and Wyoming (https://www.llnl.gov/str/April07/Friedmann.html) conducted by the Lawrence Livermore Laboratory. Additionally, Linc Energy, will begin a pilot project (http://www.greencarcongress.com/2009/05/linc-energy-wyoming-20090514.html) in the Powder River coal basin (http://en.wikipedia.org/wiki/Powder_River_Basin) within the next few years.

The UCG process

The form of UCG used in most modern projects consists of drilling two wells into a coal seam. Air or oxygen is injected into one well and a controlled combustion reaction is started in the seam itself - a more-controlled version of a natural coal seam fire (CoalFires.html). Gases are collected through the second well and are separated in a facility at the surface. This process produces primarily hydrogen and CO2 (https://www.llnl.gov/str/April07/Friedmann.html), with lesser amounts of carbon monoxide, methane, and trace amounts of other gases.

These gases are then burned to produce energy, as in a natural gas plant. Hydrogen is the primary energy-containing gas in the mix. The combination of carbon monoxide and hydrogen is called syngas (http://en.wikipedia.org/wiki/Syngas) and can be combusted directly to produce heat or can be liquefied and refined in processes (http://www.lincenergy.com.au/ctl.php) similar to that described for coal-to-liquids (CoalToLiquids.html). Although CO2 is one of the major products of UCG, it is simply a waste product and does not contain any recoverable energy. Because the combustion occurs underground, it heats the surrounding rock. This portion of the heat is not accessible for industrial use, therefore UCG burns more coal (per unit energy produced) than would be required if it was first mined. However, conventional mining and transport of coal also requires significant energy and have associated releases of greenhouse gases.

Environmental Impacts

Compared to conventional coal-fired power (AlaskaCoalPower.html), underground gasification can greatly reduce the impacts associated with coal mining (CoalMining.html), coal dust, and the emissions of sulfur dioxide and nitrous oxides (responsible for acid rain and smog). However, UCG has several major environmental costs: contamination of ground water, subsidence of the overlying terrain, and global warming impacts. There is also a potential concern with the spread of underground coal seam fires (CoalFires.html), although this has not been observed in any trials to date.

Groundwater Contamination

In underground gasification, there is no need for above ground disposal of coal combustion wastes (CoalCombustionWastes.html) such as coal ash. However, these pollutants are left behind in the coal seam, where they can leach out into surrounding groundwater. Groundwater contamination has been a major problem in almost all pilot UCG projects, most most well-documented (http://fossil.energy.gov/international/Publications/ucg_1106_llnl_burton.pdf) in the Hoe Creek project managed by Lawrence Livermore Laboratory. The combustion of coal traps a variety of toxic substances such as mercury (CoalMercury.html), phenol (http://en.wikipedia.org/wiki/Phenol), and benzene (http://en.wikipedia.org/wiki/Benzene) into the former coal seam. Additionally, the solubility of heavy metals in water can be increased if the coal seam is fully oxidized. Pollutants can leach out through the surrounding rock, or be taken up by water that enters the chamber. The Chinchilla pilot project (http://www.lincenergy.com/clean_energy_australia.php) attempted to address this problem by maintaining negative pressure inside the coal combustion chamber to limit the outflow of containments. However, the technology to prevent contamination is in its infancy, and groundwater pollution remains the single biggest concern with UCG. Groundwater contamination is particularly worrisome since the pollution source deep underground is inaccessible and permanent. Problems may crop up at any time during or after the project (including decades or centuries later) and cleanup will be difficult or impossible. Waste remaining underground presents a problem into the indefinite future (/Issues/InPerpetuity.html), making eventual leakage likely.

It has been suggested that contamination can be prevented by proper siting - meaning that UCG plants should be placed where there is no groundwater to be contaminated (such as a site where natural geologic seals isolate the burn zone from surrounding strata).

> “Isolating the site from current or future groundwater sources and understanding how UCG affects the local hydrogeology are essential.” from Science and Technology Review (https://www.llnl.gov/str/April07/Friedmann.html)

Project descriptions often contain vague statements such as:

> “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.” from Linc Energy information sheet (http://www.lincenergy.com/data/info_sheets/UCG_and_Groundwater.pdf)

It is unclear whether isolating a UCG operation from surrounding groundwater is possible on the long-term. Heating and subsidence from UCG might lead to fractures that would change groundwater flow. Also, heated water is lower density and lower viscosity, which also may affect groundwater flow. Thus pre-UCG groundwater conditions are unlikely to accurately reflect flow after a project is underway.

> “The European Groundwater Directive although not specifically written with UCG in mind, is likely to require that the groundwater surrounding the process is declared permanently unsuitable for other purposes like irrigation or animal consumption.” from Underground Coal Gasification: a clean indigenous energy option (http://www.coal-ucg.com/publishedarticleonucg.html)

Subsidence:

Subsidence (http://en.wikipedia.org/wiki/Subsidence) occurs when the ground sinks or collapses over an area where mining has occurred. Subsidence is inevitable with UCG because the supporting coal layer is being burned and removed as gases, leaving only residual ash and a void. However, most UCG projects propose to gasify coal seams that are deep enough to be inaccessible to conventional mining, and therefore the subsidence at the surface may be minimal and spread out. This deep subsidence may be subtle or invisible on the surface, but could change patterns of groundwater flow.

Global Warming:

Per unit of energy, burning coal releases more of the CO2 that contributes to global warming than any other fuel and UCG is no exception. CO2 release from a UCG project could potentially be limited through the use of carbon capture and sequestration (LowCarbonCoal.html) (CCS) technology (as CIRI suggests for its Cook Inlet proposal). However the use of CCS remains theoretical on a commercial scale and adds a large amount of expense and infrastructure (primarily pipelines) to a project. Because some of the energy from the coal in UCG is expended heating rock, more coal must be burned and thus more CO2 produced in order to produce the same amount of energy (ignoring transportation and mining emissions).

Effects on coal reserves

Because UCG could potentially access otherwise unmineable coal, the widespread usage of this technology would dramatically change the balance between the geologic coal *resource* (HowMuchCoal.html) and economically *recoverable coal reserves*.

The World Energy Council estimates that UCG could increase world coal reserves by 600 billion tons (http://ny.whlib.ac.cn/pdf/Survey_of_Energy_Resources_2007.pdf) (an increase of over 70%), providing a massive replacement for dwindling natural gas reserves.

UCG in Alaska

The Stone Horn Ridge project (/Issues/AlaskaCoal/StoneHornRidgeUCG.html) is the most prominent UCG project currently under active development in Alaska. In addition an Australian company called Linc Energy is exploring sites in the interior and Cook Inlet (/Issues/AlaskaCoal/Linc-Energy-UCG-Leases-AK.html) for possible UCG projects. *[CO2]: Carbon dioxide

---

Further Reading

> Underground Coal Gasification (UCG) Documents hosted by gtt (http://www.groundtruthtrekking.org/Issues/AlaskaCoal/Underground-Coal-Gasification-UCG-Documents.html)

> Wikipedia article "Underground Coal Gasification" (http://en.wikipedia.org/wiki/Underground_coal_gasification)

> A 1999 EPA study on UCG and similar technogies entitled "In-Situ Fossil Fuel Recovery Wells" (http://www.epa.gov/ogwdw000/uic/class5/pdf/study_uic-class5_classvstudy_volume13-in-situfossilfuelrecovery.pdf)