# Syngas, fuel cells and CCS – the future for coal?

*Post-combustion carbon capture and storage techniques seem to get more attention than separating the carbon dioxide beforehand (pre-combustion) and using the resulting hydrogen to create electricity.* Alisa Murphy *outlines the approach taken by B9 Coal.*

The global population is projected to reach nine billion by 2050 and as standards of living rise, so too does energy consumption. By 2030 the world's primary energy demand will have risen by 40% and humanity will need the capacity of two Earths to absorb carbon dioxide waste and keep up with natural resource consumption. Renewables have not yet reached the required stage of development to meet growing demand reliably and affordably; a transitional solution that efficiently and cleanly uses our remaining fuel reserves is essential.

The energy industry has faced stringent proposals from governments worldwide since 1990's Kyoto Protocol, ensuring that the industry is legally bound to reduce emissions. The UK government is consulting on Electricity Market Reform (EMR) to secure the supply of reliable, low carbon and affordable electricity, addressing the coalition's key target of being 'the greenest government ever'.

The EMR states that the UK's power market, currently dominated by fossil fuels, needs to lead the decarbonisation of the economy. Building on this, the UK Committee on Climate Change (CCC) recently proposed that the power sector should be close to zero carbon by 2030, in order to allow for the electrification of other sectors such as heat and transport.

Fossil fuels have facilitated an impressive rate of human development, but at the expense of warming and polluting our planet. The use of coal as a fuel predates recorded history and currently accounts for almost half of world primary energy production. Demand is set to increase by around 53% by 2030.

The potential for clean coal is something of an elusive phenomenon, a prospect that many are trying to bring to commercialisation. Carbon capture and storage (CCS) has recently gained recognition in policy and technology circles as a key alternative to high-emitting energy generators. This increased profile has been cemented by government commitment in the UK and EU, who are currently in advanced stages of developing funding opportunities for these first-of-a-kind power projects.

B9 Coal was established in 2009 in London with the objective of pursuing viable CCS projects whilst simultaneously making a significant contribution to the creation of a sustainable energy mix. The company aims to stimulate a reassessment in attitudes towards fossil fuel power generation while exploring the possibility of decoupling coal use and the adverse environmental impacts traditionally associated with it. B9 Coal believes the combination of coal gasification and alkaline fuel cells will rapidly allow the generation of low carbon electricity from the world's abundant coal reserves, while minimising environmental impacts and capturing carbon.

## Game-changing CCS

CCS technology was described by former UK Government Chief Scientific Advisor Sir David King as 'the only hope for mankind' – a statement that the energy industry is not taking lightly. The emergence of new technologies such as alkaline fuel cells and underground coal gasification will serve to accelerate the development of truly game-changing CCS projects in the race against climate change.

CCS is a means of mitigating the contribution of fossil fuels to global warming. Carbon dioxide is captured from fossil fuel power plants and transported by pipeline or ship to be stored in geological structures. The UK government is committed to investment in this technology and the Department of Energy and Climate Change (DECC) is developing a CCS Roadmap that will set out the timescales on which CCS needs to be deployed in the UK to meet climate change targets.

B9 Coal's fuel cell power stations offer a CCS-ready solution, as a result of the alkaline fuel cells inclusion in the process. The fuel cells require synthesis gas (syngas) from a gasifier to be separated into pure streams of both hydrogen and carbon dioxide, making it very simple to capture pure carbon dioxide for storage. This solution takes CCS well beyond an expensive retrofit process, offering a commercially attractive model.

## Spirit of the coal

Coal gasification is the reaction of coal with a controlled amount of oxygen and water vapour at high temperatures. The process produces syngas: a mixture of hydrogen, carbon monoxide and carbon dioxide. First discovered by the 17th century Flemish scientist Jan Baptista van Helmont, the gas was dubbed the 'spirit of the coal' and burnt for domestic illumination. In 1812, the first commercial coal gas works was built by the London and Westminster Gas Light and Coke Company to illuminate the Westminster Bridge celebrations as the New Year dawned. This coal gas was traditionally referred to as 'town gas' for its widespread use in towns for street illumination, heating and cooking.

Coal gasification has been used on a commercial scale worldwide for more than 35 years by the electric power industry. There are currently more than 420 gasifiers operating in some 140 facilities worldwide, with nearly 20 plants operating in the US. China is expected to achieve the most rapid growth in coal gasification, with around 29 new gasification plants licensed and/or built since 2004.

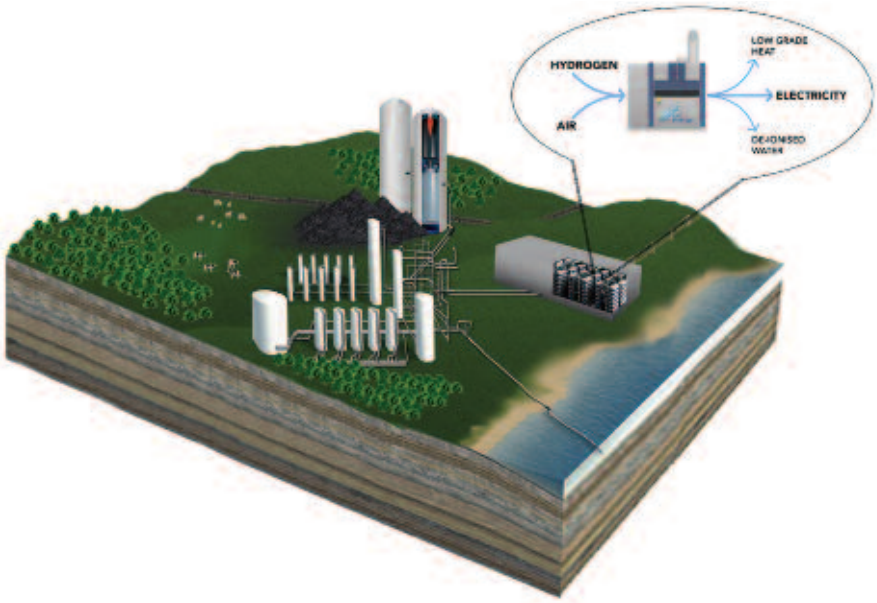
The process has a range of commercial and environmental advantages over combustion. Harnessing coal's energy through gasification is more efficient than conventional combustion as the syngas has applications with new, highly efficient technologies. Coal gasification is also much cleaner as no pollutants (including nitrogen oxides, sulphur dioxide, fine particle pollution, and mercury) or solid impurities (including ash, chloride and potassium) are released into the atmosphere.

B9 Coal is offering a unique power generation solution – efficient and scalable coal gasification with fuel cells for electricity and CCS. After gasification, the syngas is put through a three-stage cleanup process comprising gas water shift, acid gas removal and finally pressure swing absorption. This removes impurities and produces pure hydrogen, used to power the fuel cell, and carbon dioxide which is captured and ready for transport. Alkaline fuel cells are the most efficient method of converting hydrogen into electricity and the pure stream of carbon dioxide is captured at no additional cost. This is a world first combination of technologies, all of which have historical credibility but are now re-emerging as a flagship solution for the future.

## Alkaline fuel cell

The alkaline fuel cell was first demonstrated by Sir William Grove in the 19th century. UK Company AFC Energy has taken this out-of-fashion technology and created a commercially viable method for clean power generation. Its fuel cell is low cost, low temperature and low pressure. Uniquely, the technology is also fully scalable and modular, giving B9 Coal's model the ability to load follow to meet peak demand. AFC Energy boasts partners including AkzoNobel, Ineos, Centrica, Air Products, WSP Group and Linc Energy. The technology is gaining momentum across a range of markets, including chlor-alkaline, waste-to-energy, clean coal and natural gas.

AFC Energy's technology is focused on




**The B9 approach – after gasification, the syngas is separated to create carbon dioxide, which is buried, and hydrogen, which is used in fuel cells to create electricity**

large-scale industrial applications, with the objective of producing the lowest possible unit cost electricity. The cells are modular by design and operate using hydrogen and air at low pressure and low temperature. These essential features aid mass production, simple assembly, easy maintenance and significantly lower costs.

The cell operates at 60% electrical efficiency, making it highly competitive with the most sophisticated gas turbine operating at maximum output. Unlike gas turbines however, the scalable fuel cells maintain their high output from full capacity to zero and back again under fast-changing loads. Power stations built of stacks of these scalable cells would be ideal for balancing the grid and providing back-up to the most sporadic of renewables. The technology could re-generate electricity using 'green' hydrogen produced by renewably-powered electrolysis and the rejected hot water from the cells (about 70°C) is ideal for combined heat and power applications.

## B9 Coal in action

B9 Coal is engaged in a flagship project at Hatfield Colliery near Doncaster that may mark the first ever large-scale deployment of these technologies in a CCS project. The company has entered into an agreement with Powerfuel Power, which envisages the creation of a joint venture to exclusively develop low carbon fuel cell power stations in the UK. B9 Coal will be responsible for installing up to 300 MW of AFC Energy's fuel cell technology alongside Powerfuel's planned integrated gasification combined cycle power station. The agreement also includes an option to rollout the technology to further territories worldwide in the future. Grant Budge, Chief Operating Officer at Powerfuel Power said the project will demonstrate 'the lowest carbon capture technology commercially available today.'

In February, Powerfuel submitted an application to DECC under the European Union's New Entrant Reserve (NER) 300 call for proposals. This EU funding mechanism is linked to the European Emissions Trading Scheme and is designed to provide funding for first-of-a-kind renewable energy and CCS projects.

Within the NER300 submission, B9 Coal, Powerfuel and AFC Energy have stated a desire to demonstrate alkaline fuel cells at a nominal 60 MW scale, taking a feed from Endex Reactors. An Endex Reactor is a pre-combustion capture system for natural gas or syngas developed by Calix Limited and, if successful, the demonstration could pave the way for a new generation of clean power plants, with lower capital and operating costs.

B9 Coal, and its affiliate B9 Gas, also recently announced their intention to create a unique, climate-friendly natural gas power station in response to the CCC's call for the application of CCS to natural gas to be included in the DECC competition. The project would use the known technology of steam methane reforming to convert natural gas to hydrogen which is then fed to AFC Energy's alkaline fuel cells to create a modular, on-demand, decarbonised power plant. The proposal would offer the ability to load follow – something conventional natural gas turbines cannot. Excess hydrogen can be stored overnight and used to generate electricity to meet peak demand, guaranteeing a consistent and reliable supply of power. The scalable nature of the fuel cell system ensures that there is no loss of efficiency during up and down cycles, unlike conventional gas turbines.

B9 Gas is in talks to acquire an existing hydrogen generating plant with potential CCS and hydrogen storage facilities.

## Learn, address and protect

The process of CCS is now widely accepted as having a key role to play in tackling the challenges of reducing carbon emissions. The International Energy Agency estimates that for global carbon dioxide emissions to be reduced to half of the current level by 2050, CCS will be needed to deliver about 20% of the abatement, requiring storage of over 10 Gt of carbon dioxide per year. Based on these projections it has been estimated that CCS could be worth £3–6.5bn a year to the UK by 2030, sustaining between 70,000 and 100,000 jobs.

However, to achieve these kind of results we will need to build new coal-fired CCS plants at the same rate as combined cycle gas turbine plants were constructed during the dash for gas in the 1990s. The UK government has committed to public sector investment in four CCS demonstration projects, however development on this programme has been hugely stalled – something which is not only frustrating for the energy industry but also highly detrimental to emissions targets.

Low carbon ambitions cannot be achieved without continued support, development and uptake of emerging clean energy technologies, which have the potential to change the energy landscape in years to come. Coal will inevitably be a substantial part of the future energy mix; therefore the only viable answer is to reassess the ways in which we extract, process and capture resources from it. Either we choose to continue in a short-sighted and irresponsible way, or learn from the past, address the present, and work to protect the future.

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## Underground coal gasification

In the future, B9 Coal hopes to develop underground coal gasification (UCG), the process of gasifying coal in-situ. UCG provides access to coal 'stranded' deep underground, eliminating the need to mine it and process it through a surface gasification plant. UCG technology has evolved through numerous trials since the early 1900s and commercial-scale UCG sites for power generation have been operating in the former Soviet Union for over 40 years.

In the UK alone, UCG could potentially give access to an extra 17bn tonnes of coal, without the major environmental impacts of conventional mining. The process could therefore have immense benefit in terms of UK energy security and the ability to generate power from indigenous resources. To achieve this, B9 Coal has partnered with Linc Energy – developers of UCG technology based in Australia. The company has been testing alkaline fuel cells at its demonstration facility in Chinchilla, Queensland, which has been operational for 10 years.