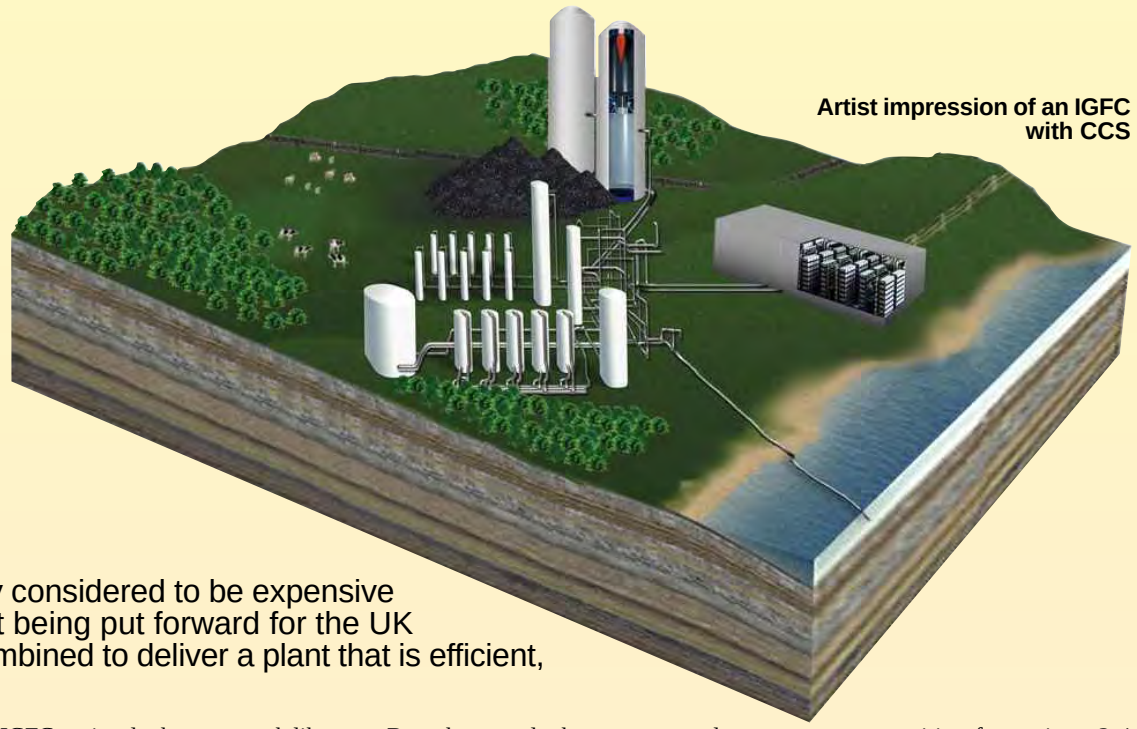
Building tomorrow's power plant today



Artist impression of an IGFC with CCS

Fuel cells, gasification and carbon capture are all widely considered to be expensive technologies of the future. Yet the proposer of a project being put forward for the UK CCS competition believes all three can be effectively combined to deliver a plant that is efficient, clean and economic. **Junior Isles**

Alisa Murphy believes that now is the time to start building the power plants of the future; and she aims to practice what she preaches. As the Director of UK-based B9 Coal, Ms Murphy is pulling together a consortium that plans to develop a project that will "put the UK at the forefront of carbon capture technology".

The consortium of major industrial partners, will propose a 500 MW project for the UK Department of Energy and Climate Change (DECC) carbon capture and storage (CCS) competition.

Notably, the project would showcase the use of fuel cells operating on syngas derived from coal gasification – a power system that many would consider to be one for the future rather than the present.

Murphy stressed, however: "We believe the way to get CCS adopted is to make it commercially attractive, and by promoting technologies that are equipped for our future energy needs rather than looking backwards at retrofitting old and dirty technology."

B9 Coal was formed in 2009 with the specific aim of ensuring penetration of alkaline fuel cells (AFCs) developed by AFC Energy into the power generation market. Murphy explained: "AFC Energy wants to remain focused on the technology and not be distracted by very large scale integration projects that require different skill-sets, time and energy. B9 Coal was formed to take care of what we think is the largest market for AFC's fuel cell – power generation from coal and gas. This includes large scale power projects with carbon capture."

B9 Coal sees fuel cells as a "pull-through" technology for CCS. Murphy said: "While there's a place for retrofitting old coal plants, the main focus should be on building power station projects for the future. Coal will continue to play a significant role in the power generation mix for some time to come so we have to do something about the emissions. So if you can marry it with a power generation technology that has low capital cost, high efficiency and is scalable, it will help with the adoption of CCS since you are not asking people to do something that will result in the loss of efficiency. You can build a plant that doesn't have the energy penalty and get carbon capture at the same time."

The project being put forward for the DECC competition is a 500 MW plant at a potential site owned by Rio Tinto Alcan at Lynemouth in Northumberland. The project would replace an existing coal fired station that provides power for the aluminium smelter at the site.

The project that B9 Coal is pioneering is somewhat unique and if selected for funding would represent a departure from the UK's current focus on post-combustion capture technology. Known as an IGFC (integrated gasification fuel cell) project, it does not involve combustion – although in terms of defining CCS projects, some would place it under the banner of pre-combustion technology.

When asked if this could be a problem for B9, Murphy said: "The government's focus on post-combustion has caused a lot of controversy. I can understand the argument that we have a large number of coal fired power stations and have to do something about the emissions from them. The government hasn't yet come forward with their requirements for projects 2-4 but my feeling is that there will be more of an emphasis on showing a more diverse range of technologies. This is important so that we can explore the technologies in order to know what the best technologies are. The government has talked a lot about showing global leadership on CCS… it can't do this if there's a continued focus on post-combustion."

From an engineering perspective, an IGFC project looks very much like an IGCC project in terms of the gasifier and the gas clean up process. The syngas is cleaned and cooled and goes into a water-gas shift. However, the key difference is that there is an additional stage because pure hydrogen is needed for the fuel cell.

The AFCs require hydrogen with a purity of 99.95 per cent, as opposed to the 90 per cent purity seen in IGCC plants after the clean up process. Therefore a pressure swing absorber (PSA) is included to absorb the remainder of the carbon dioxide under high pressure and separate it from the hydrogen stream. The hydrogen will then be fed to the fuel cell while the CO_2 will be compressed so that is ready for transport and storage.

B9 Coal's Lynemouth project will use a surface gasification process where coal is reacted at high temperature with a controlled amount of oxygen to produce syngas. "It is fairly standard technology," noted Murphy.

Building a 500 MW project based purely on fuel cells is unusual. Murphy commented: "People are surprised by this because no other fuel cell companies are talking about large scale industrial power generation but that is what makes AFC Energy's technology unique. The modular nature means that if you can build one megawatt, you can build hundreds of megawatts. They are very easy to manufacture and it is a very simple modular scale up. It is just a case of how many can be installed in the given space."

With each fuel cell cartridge delivering about 10 kW, Murphy estimates that the 500 MW project would require about 2 acres (8100 m^2) of land.

An alkaline fuel cell converts oxygen (from the air) and hydrogen (from a supply) into electrical energy and heat. It is chemically comparable to a battery that will provide electric power continuously, as long as it is fed with hydrogen and air. The only by-products are demineralised water and heat, both of which have a commercial value. Excluding water, an alkaline fuel cell is a zero emission device.

In AFC Energy's fuel cell, the electrolyte is an alkaline liquid: in this case, potassium hydroxide (KOH). This is a very cheap electrolyte, akin to an industrial bleach. It has a very high electrical conductivity that helps an AFC to have the highest electrochemical efficiency of all types of fuel cell – 60 per cent electrical efficiency.

This is one of the main advantages that Murphy cites compared to gas turbines. She also says capital costs are lower. Target costs are £400 000/MW. But when you look at costs you also have to look at efficiency."

Perhaps more important, however, are the maintenance costs and the benefit of having no moving parts. She commented: "Maintenance costs are significantly lower due to the ease of maintenance. Each individual fuel cell cartridge is monitored. If there is a problem with even an individual plate within a cartridge, that cartridge can be isolated and switched off and replaced. The target is a 12-month cycle for cartridge maintenance but the commercial offering is a 3-month cycle. However, you never have to power down the station for maintenance. Because each cartridge is individually controlled there isn't the possibility for something to go wrong with the entire system… this is something utilities find very appealing."

The ability to switch individual cartridges on and off also means, according to Murphy, that such a plant has the load following capability that is becoming increasingly important. "In the future we will have to find ways to meet peak demand and have generation that can match the renewable portfolio. You can load follow by switching off banks or simply passing less hydrogen through the system," she noted.

Looking still further ahead Murphy also believes that the technology is ideal for the transition to a hydrogen economy. "As options for hydrogen storage are developed there is fantastic potential for operating peak load models. Hydrogen could be stored and fed to the fuel cell plant, which could then be operated to match demand. The fuel cells will operate at 60 per cent electrical efficiency no matter how much hydrogen is passed through them."

The UK CCS competition stipulates that the minimum plant size has to be 350 MW. The proposed Lynemouth project surpasses this requirement, having been sized to provide enough power for the smelter with sufficient left over for export to the grid.

DECC is yet to release details for the competition for projects 2-4 and how they will be financed. But in any event, B9 Coal intends to seek funding through the EU's NER300 mechanism and will be putting together a special purpose vehicle with various partners who not only have the relevant expertise but could also provide funding. Special equity partners will also be brought in.

This approach is absolutely necessary for the proposed Lynemouth project. The UK CCS competition calls for the demonstration of an end-to-end CCS solution. This will require the involvement of major multi-national companies with expertise in areas such as industrial gas supply, pipelines, storage, engineering and regulation. "These are large projects and you really need a consortium with the relevant expertise," said Murphy.

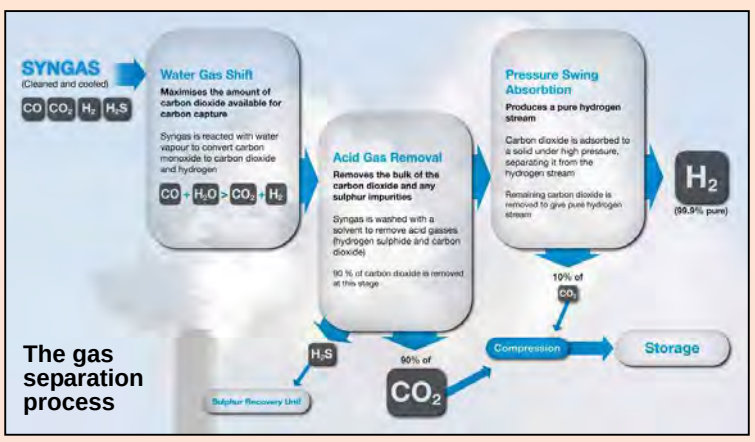
With most of the partners already in place and pre-FEED (front end engineering design) work under way, B9 Coal is now waiting for DECC to issue its requirements.

However, Murphy noted: "This is just one project for us; we are not looking to own and operate a plant and project manage the whole thing. We see ourselves as a developer that will develop a pipeline of projects with the fuel cell at the centre, bringing together companies to take advantage of the opportunities."

In the early stages, B9 Coal sees opportunities for projects that could involve electricity generation from a combination of small turbines and fuel cells.

Already there are plans to install 330 MW of fuel cell capacity at the Hatfield project owned by Powerfuel Power Ltd. These fuel cells will be installed alongside the IGCC plant that Powerfuel is building. The timeframe of this project, like Lynemouth, is looking at completion by around 2015.

The start-up of such projects in as little as five years would be a tremendous achievement and go a long way to making the power plant of the future very much a reality of the present.



The gas separation process