CATCH Theme of the Month: Why meeting our new net zero target needs biomass, gasification and CCS

When we start thinking about our future energy system, one technology that has high strategic value is BECCS – BioEnergy Carbon Capture and Storage. BECCS comprises two key elements – biomass and carbon capture and storage (CCS), used together to deliver "negative emissions".

The need for negative emissions just got more important because our 2050 decarbonisation target changed from an 80% greenhouse gas (GHG) reduction vs 1990 to a 100% GHG reduction, or "net zero", in June this year. But, it will be near impossible to remove all sources of anthropogenic GHG emissions – for example, from aviation and from agriculture. Some means of greenhouse gas removal (GGR) from the atmosphere will be required to create an offset - we call these offsets "negative emissions". There are a range of potential GGR technologies under development, including negative emission fuel cells and direct air capture, but these cannot be cost-effectively deployed today.

More immediately, we can use biomass combined with CCS (BECCS) – examples of biomass are specially grown energy crops such as Miscanthus which looks a little like bamboo and which can be seen growing around the East Riding and North Lincolnshire, and byproducts of the forestry industry. As a renewable energy source, this ability to deliver negative emissions makes biomass unique amongst the set of renewable energy technologies available to us. Modelling by the Energy Technologies Institute (www.eti.co.uk) has demonstrated that bioenergy and CCS are two of the most important renewable technologies available to the UK. On an energy system basis (i.e. the total cost of providing all our power, fuel and heat) – doing without either biomass or CCS will each on their own double our future energy system cost – doing without both would likely prevent us from even meeting our 80% GHG reduction target. Their value when deployed together, lies in their ability to offset other, more expensive interventions in very hard to decarbonise sectors elsewhere in the energy system, especially aviation and shipping.

Plants (biomass) absorb carbon dioxide (CO_2) from the atmosphere as they grow. Providing the rate of biomass removed (through harvesting, fires etc) does not exceed the rate of biomass growth and that the carbon stock in the plantation soil is maintained or increased through sustainable land management, then if that biomass when harvested is used as a fuel to generate power and the resultant CO_2 captured and permanently stored, then there will be a net removal of CO_2 from the atmosphere – hence "negative emissions".

Producing electricity or hydrogen using BECCS technologies maximises the potential percentage of carbon dioxide that could be captured. CCS technologies could also be added to gaseous or liquid biofuel production facilities, but the proportion of carbon captured would be lower, as between a third to a half of the carbon is retained in the final product.

While afforestation and wood in construction also available to us to store carbon and are established techniques, they require continual monitoring to maintain the level of carbon stored. Deployment of BECCS provides permanent storage of carbon and is consistently highlighted by the ETI and others including the Government's advisors, the Committee on Climate Change (CCC), as a strategically valuable technology in meeting the UK's 2050 targets cost-effectively.

There are a variety of techniques to deliver BECCS. One of the more effective ways is to use hydrogen produced from biomass using gasification – this is often known as pre-combustion capture because the CO_2 is removed from the process before any combustion takes place. Gasification converts the energy held within a difficult to use solid fuel into an easier to use gas, called syngas. Once cleaned and polished to make the gas as clean as natural gas, we can react it with steam to yield separate streams of hydrogen and CO_2. The hydrogen can go on to be used to produce power in a gas turbine or engine, or used in some other way, while the captured CO_2 is routed to permanent storage.

Hydrogen is not the only option for using cleaned and polished syngas – it can instead also be used

- Directly in a gas engine to produce clean power at higher efficiency at small scales than is possible using biomass directly (for example, a private wire arrangement to a data storage centre which has high cooling demands), or

- to produce clean burning renewable fuels such as aviation fuel, or
- to produce renewable chemicals, such as the acetyls made at Saltend.

This flexibility of gasification, both in terms of the feedstocks it can use, and the products it can make, gives it an important resilience to quite different future energy scenarios.

While biomass gasification has been deployed commercially, to date, plants have not usually included an effective syngas cleaning and polishing step, meaning that the full flexibility of gasification has yet to be realised. Humberside is playing its part in developing gasification with Energy Works in the centre of Hull and the planned Velocys project on the south bank, backed by British Airways, Shell and the Department of Transport. The Velocys project is particularly interesting as they plan to produce aviation fuel from cleaned and polished syngas produced from wastes – if you can make aviation fuel from wastes then it is highly likely you can go on to use a similar version of the technology to make hydrogen from wastes and biomass. Further afield, and a key part of my ETI bioenergy programme, there is the ETI's commercial gasification project in Birmingham (see https://www.eti.co.uk/programmes/bioenergy/waste-gasification-commercial-development-plant and https://www.kew-tech.com/) which is currently undergoing commissioning and the Fulcrum Bioenergy plant in the USA backed by BP. Instead of making aviation fuel, the Birmingham plant is demonstrating high efficiency power production at the smaller scale using an innovative gas engine fuelled by clean and polished syngas.

Humberside is one of the highest emitting regions in the UK; it is well placed to develop BECCS and to take advantage of the benefits it would realise:

- Located at the northern end of the UK's "grain belt", there is agricultural expertise, capability and capacity available – growing energy crops like Miscanthus can potentially strengthen farming businesses and benefit the agricultural system. Terravesta, the leading light in producing Miscanthus in the UK is based just north of Lincoln. Immingham port is set up to receive and manage biomass imports.
- Two important gasification projects are developing in Humberside, one of which will demonstrate the technology needed to produce hydrogen from biomass. There is gasification expertise within the region, including at CATCH Consultants and at Hull University.
- The ETI's Thermal Power with CCS project delivered by SNC Lavalin, AECOM and the University of Sheffield, identified Humberside as one of the key cluster areas for developing CCS. Humber benefits from a short pipeline out to store as well as having a set of large-scale emitters which could provide "base load" CO_2. Included in these is Drax Power who are already investing in CCS with C-Capture. Further afield is Sheffield University's PACT centre which carries out nationally important CCS research and has just received further funding from BEIS to expand their work.
- There is interest in the region to build up a Humber hydrogen industry – attendance at two recent workshops led by Aura was high.

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