Programme Area: Bioenergy

Project: Biomass to Power with CCS

Title: Executive Summary

Abstract:

Bioenergy production coupled with CCS could provide up to 10% of UK energy in the 2050s and deliver substantial net negative emissions. At the time of writing (2012) Bioenergy with CCS was thought to have the potential to remove 50 - 100 Mt of CO2 from the atmosphere each year by 2050. More recent analysis, published in the Bioenergy Insights papers, suggests that this figure is closer to 55 Mt CO2/yr.
The Biomass to Power with CCS project found that uncertainties in the data resulted in large potential uncertainties in the conclusions, particularly with regard to the looping technologies. This made the comparison of the eight technologies, and drawing definitive conclusions, difficult. The project team recommended further investigation of the data, in particular data relating to chemical looping technologies.

Context:

The Biomass to Power with CCS Phase 1 project consisted of four work packages: WP1: Landscape review of current developments; WP2: High Level Engineering Study (down-selecting from 24 to 8 Biomass to Power with CCS technologies); WP3: Parameterised Sub-System Models development; and WP4: Technology benchmarking and recommendation report. Reports generally follow this coding. We would suggest that you do not read any of the earlier deliverables in isolation as some assumptions in the reports were shown to be invalid. We would recommend that you read the project executive summaries as they provide a good summary of the overall conclusions. This work demonstrated the potential value of Biomass to Power with CCS technologies as a family, but it was clear at the time of the project, that the individual technologies were insufficiently mature to be able to 'pick a winner', due to the uncertainties around cost and performance associated with lower Technology Readiness Levels (TRLs).

Purpose: Arising IP
Restrictions: No additional restrictions

ETI Executive Summary

Programme: Bio Energy

Project Name: Biomass to Power with CCS

Introduction

Biomass produced in the UK could provide up to 10% of UK Energy in 2050. The sustainability issues involved in land-use changes and greatly increased UK biomass production is being analysed in other bio energy projects. The Biomass to Power with CCS Project focussed on developing a detailed understanding of the technical and cost barriers associated with biomass to power with Carbon Capture and Storage (CCS) technologies.

Biomass conversion to heat and/or power combined with CCS could provide the UK with substantial net negative CO2 emissions, with the potential to remove 50 to 100 MT of CO2 from the atmosphere on an annual basis (depending on capture rates) and provide 80 to 120 TWhr of electricity annually. A technology choice that is capable of creating "50 to 100MT of negative carbon" could be compelling, depending on the cost at which this technology option can be developed and deployed.

Biomass and CCS are seen as two of the highest cost sensitivity parameters as highlighted in the UK Energy System Modelling Environment, ESME. The combination is HIGH/HIGH in terms of opportunity costs and scenario resistance.

The project outputs link into both the Biomass Value Chain Model and the ETI's UK Energy Systems Model and are critical for contextualising the prioritisation matrix for biomass resource use through to 2050.

Basis of Design

While cost has been reported to be a major barrier in terms of CCS for biomass, the technical challenges and technology developments required are not clear. Detailed work is currently ongoing in terms of assessing CO2 capture with coal and gas-fired generation. However limited work is being conducted on the assessment of dedicated biomass to power with CCS or of co-firing fossil fuel fired generation with higher rates of biomass with CCS.

The objective of this project was to

- develop a techno-economic assessment of the barriers in terms of biomass to power with CCS systems;
- provide an assessment and comparison of various potential biomass to power with CCS configurations (at both small and large scale); and
- an assessment and comparison of dedicated biomass/CCS combinations with co-fired biomass/fossil/CCS combinations.

The project, launched in April 2011, was led by CMCL Innovations and includes Doosan Babcock (Chief Technologist), EDF, Drax, E4Tech, Imperial College and the Universities of Leeds and Cambridge. It was completed in August 2012.

Key Findings

A copy of the consortium executive summary is included as background to this paper. Copies of all project deliverables are available from the ETI member portal. The ETI strategy manager highlights the following insights from the project;

1. The uncertainties in the data result in large potential uncertainties in the conclusions, particularly with regard to the looping technologies. This makes the comparison of the eight technologies, and drawing definitive conclusions, difficult. However there are some significant points worth making;
    a. Cost of CO2 capture is less than £190/te, but can be as low as £90/te depending on technology, scale and feedstock price. Increasing the scale of dedicated biomass plants from 50MWe to 250MWe can reduce the cost by around £20/te
    b. Dedicated biomass power plants couple with CCS offer the lowest cost negative CO2 emissions, with over 1.4te of negative CO2 emissions per tonne of biomass (odt).
2. Chemical looping, due to its higher efficiency and lower specific capex, appears to offer lowest cost negative CO2 emissions. However, as mention highlighted above better data is required to confirm this conclusion.
3. The chemical looping data needs to be further investigated and sensed check with an independent engineering contractor.

Dedicated biomass chemical looping combustion and, to a lesser extent, co-fired carbonate looping came out as two of the more attractive biomass CCS technology combinations for possible development and demonstration in the UK. This was due to:

- their attractive prospects in terms of offering relatively high efficiency and low capex at a range of scales,
- the significant level of existing UK expertise (at least at the academic level),
- the potential for first mover advantage to make a significant impact in the IP space, given the size of the budget available to ETI.

However, there are several technical hurdles to be overcome in the development and scale-up of the two looping technologies, and large uncertainties attached to the cost estimates considered in this study. The project consortium acknowledges the low TRL of chemical looping and recommends a 50% contingency on costs estimates.

The project consortium recommends the following UK technology demonstration for consideration:

- A flexible pilot plant with dual inter-connected circulating fluidized bed (CFB) reactors, suitable for investigating, testing and demonstrating primarily chemical looping combustion, but that can also be used to test and demonstrate post-combustion carbonate looping capture, as well as oxy-fuel combustion of biomass.

Further Work

The Bioenergy SAG agrees that chemical looping technology has significant potential. It does though have some significant concerns, as reflected in the comments above. As a result, the SAG is recommended that the ETI carries out a further study as part of developing their strategy for this important area. The recommended next step is to:

- Understand lessons learned and experiences of existing chemical looping pilots in Europe.
- Present these findings to key engineering consultants (Foster Wheeler, Jacobs) develop a more technical, rather than an academic, view.

The Technical Committee agree this recommendation and authorised the commissioning of the follow on project.