Programme Area: Bioenergy

Project: Biomass Value Chain Modelling

Title: Executive Summary

Abstract:

A summary of benefits case assessment completed as part of the BVCM project

Context:

The development of the BVCM model has been ongoing since the project first started in 2011. The documents published here relate to the intial phases of model development. They do not included later developments and are therefore not representative of the current BVCM model, or in some cases, its findings. For a more recent overview of BVCM and the findings derived from it, readers are encouraged to look at the insights and reports published by the ETI, here: http://www.eti.co.uk/insights and here: http://www.eti.co.uk/library/overview-of-the-etis-bioenergy-value-chain-model-bvcm-capabilities

BVCM is now managed by the Energy Systems Catapult (ESC). Any questions about the ESC should be directed to them at: info@es.catapult.org.uk

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ETI Executive Summary

Programme: Bioenergy

Project Name: Value Chain Modelling Project

Deliverable: BI2002 / WP4-D5 “Benefit Assessment Report”

Introduction

This report provides the benefit case of accelerating - by means of a technology demonstrator - technologies identified as promising by analysis of the UK bioenergy system using the Biomass Value Chain Model (BVCM) toolkit.

The Biomass Value Chain Model is a UK-wide spatially-explicit national optimisation model. It models pathway-based bioenergy systems over five decades (from 2010 to 2059). It currently includes seven bioresources (winter wheat, oilseed rape, sugar beet, Miscanthus, Short Rotation Coppice Willow, Short Rotation Forestry, and Long Rotation Forestry), and more than 50 distinct technologies for preatreatment and densification, gaseous and liquid fuel production, and power, heat, and combined heat and power generation (including carbon and capture technologies for power generation). The model either minimises a combined metric (referred to as objective function) which is a weighted sum of discounted whole system cost, CO_2 and non-CO_2 GHG emissions, or maximises energy production under a set of constraints, including cost, emissions, and minimum levels of demand of any energy vector (or total amounts of energy) to be met through bioenergy.

Approach

The benefit case is assessed based on two main criteria: value of technology acceleration and demonstrator benefits. The value of accelerating a technology is measured by estimating the additional energy system cost - compared to a reference case - if the development of that technology is delayed. As reference, the consortium assumed a bioenergy system which meets, at lowest system costs, the requirements on bioenergy coming from the ETI ESME model. The demonstrator benefits are measured based on the technology innovation needs and the suitability of a demonstrator to meet such needs, and the competitive advantage of the UK over the rest of the world.

Based on the analysis of a wide range of case studies using the BVCM toolkit, the benefit cases for biosynthetic natural gas (bioSNG), biohydrogen, pyrolysis fuels, and carbon capture and storage (CCS) technologies for power generation are assessed in detail.

Results and insights summary

The benefit assessment was undertaken by looking at: a) value of technology acceleration; b) benefit of doing a demonstrator; and c) overall benefit. The main insights from the benefits assessment are:

a) Value of technology acceleration

The value, at UK system level, of accelerating the selected technologies from the case study analysis was estimated by executing optimisation runs with a delay in the expected capital cost reduction in the selected technologies, and comparing the results with those from a reference case (ESME). Based on results of the case study analysis, the value of acceleration has been calculated for the following technology options:

- Gasification coupled with synthesis of BioSNG
- Gasification coupled with synthesis of hydrogen
- Pyrolysis fuels[1]
- CCS technologies[2]
    - Dedicated chemical looping CCS
    - Co-fired and dedicated oxy-fuel CCS
    - Cofired combustion + amine CCS

The value of technology acceleration is greatest for CCS technologies (see figure 4.1). This is due to their relatively low TRL level, and the relatively large carbon sequestration requirement on bioenergy resulting from ESME. Biogenic hydrogen and biogenic synthetic natural gas follow CCS technologies in terms of value of acceleration. The value for pyrolysis is instead very modest, due to the low level of liquid fuels expected from bioenergy in ESME.

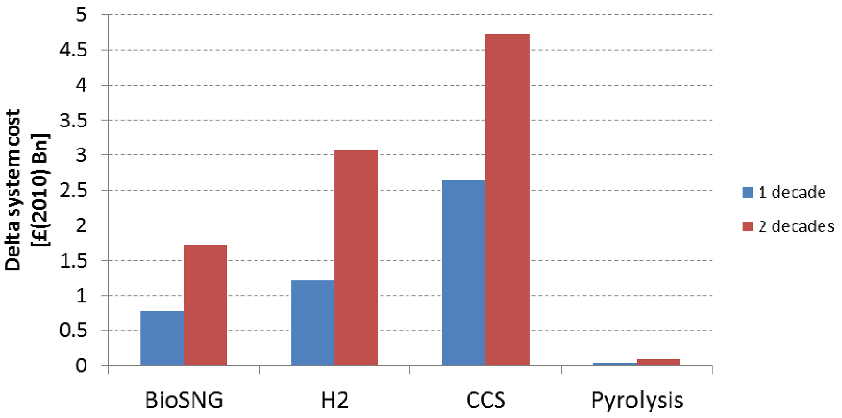

Figure 0-1 Value of technology acceleration. Value is expressed as variation in bioenergy system costs (over the whole 50 years period) compared to the reference case, based on a 1 and 2 decades delay in technology cost reduction.

b) Demonstrator benefits

The benefit of a demonstrator programme is measured based on the technology innovation needs and the suitability of a demonstrator to meet such needs, and the competitive advantage of the UK over the rest of the world. The findings are:

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[1] In case of pyrolysis, we apply the delay in cost reduction to the whole pyrolysis fuel chain, i.e. to both pyrolysis and pyrolysis upgrading. The rationale being that the development and deployment of the two technologies will occur hand in hand

[2] For CCS technologies, the delay is applied to the 3 selected options simultaneously.

Value chain	Suitability for demonstrator	UK competitive advantage	Overall demonstrator benefit
Biomethane	OO(O) Potentially high for integrated systems using novel methanation reactor design	OO Higher in syngas cleanup and methanation, but lower in gasifiers. Also, some demo plants already being planned elsewhere.	**OO**
Biohydrogen	OO(O) Potentially high for integrated systems using novel, low cost H_2 separation technologies	O Relatively unpopulated arena, with no particular UK competitive advantage	**O(O)**
Pyrolysis fuels	OOO High across the chain	OO High competitive advantage, but arena already very crowded worldwide	**OO(O)**

Table 0-1 Overall demonstrator benefits (o) lowest suitability, (ooo) highest suitability.

c) Overall benefit

The selected technology chains were ranked based on the value of technology acceleration and the demonstrator benefit, as assessed in the previous sections. The analysis showed:

- the benefit of accelerating CCS technologies which employ biomass emerges as the largest in terms of opportunity costs. This is most notably due to the fact that biomass CCS technologies are the only technology option for carbon sequestration currently in the model[3]. However, the assessment of a demonstrator benefit is not in the scope of this project, so more investigation in this direction is needed.
- acceleration of biohydrogen would be required in order to meet the ETI trilemma, although the value addition of a UK demonstrator may be limited.
- BioSNG technology emerges as the largest in terms of ETI trilemma requirements. Potential benefit of a UK demonstration activity in biomethane exists, although a series of demo plants are already planned for the near future abroad.
- opportunities exist for pyrolysis fuels, mostly based on UK competitive advantage, but their value to the energy system is modest compared to the options above.

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[3] Other “non-technology” options are available for sequestration, e.g. (re-)afforestation, which we will attempt at exploring during Phase 2 of the BVCM project.

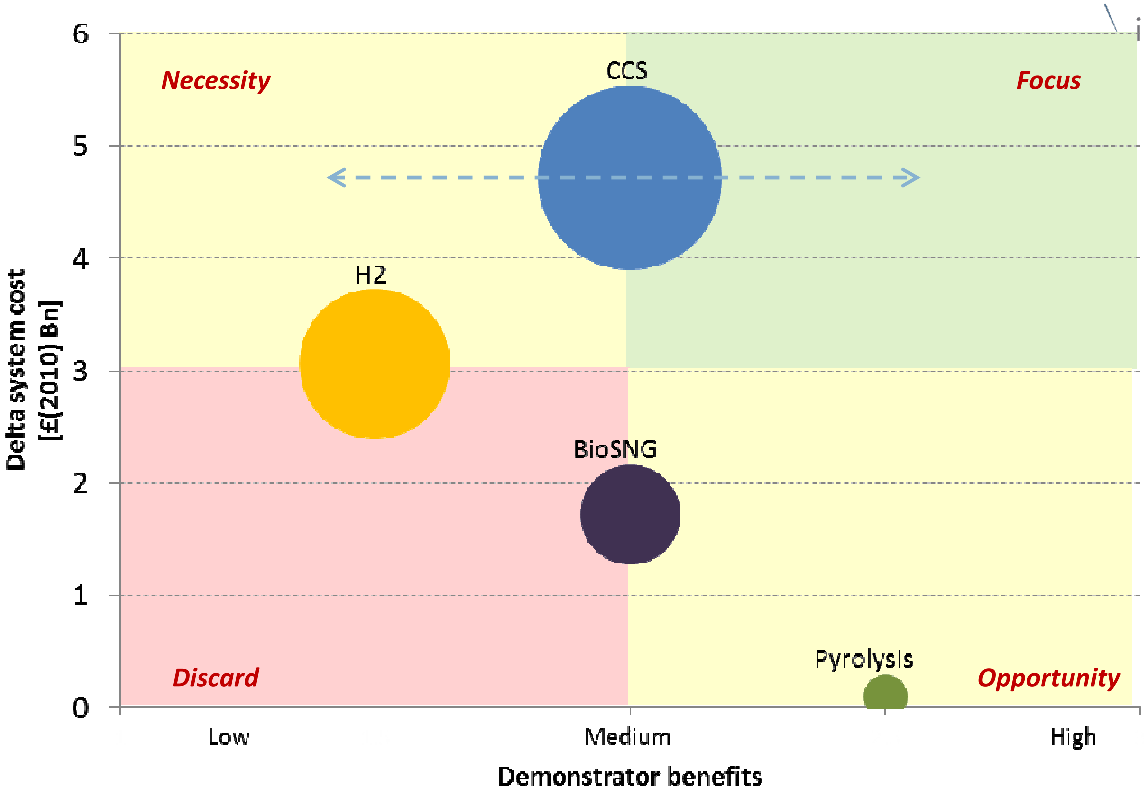

Figure 0-2 Overall benefit case

Key findings

The benefit of accelerating CCS technologies - particularly dedicated chemical looping CCS, co-fired and dedicated oxy-fuel CCS, and cofired combustion with amine CCS - emerges as the highest amongst all bioenergy technologies. This is most notably due to the fact that development of biomass CCS technologies is required if negative emissions are to be achieved from the bioenergy sector[4]. Acceleration of biohydrogen would be required in order to meet the biohydrogen target from ESME, although the value addition of a UK demonstrator may be limited. BioSNG technology emerges as the highest in terms of value of technology acceleration, and potential benefit of a UK demonstration activity in bioSNG exists, although a series of demo plants are already planned for the near future abroad. Opportunities exist to accelerate the commercialisation of pyrolysis fuels, mostly based on UK competitive advantage, but their value to the energy system is modest compared to the previous options, due to the relatively small role expected for biofuels in ESME.

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[4] The assessment of the benefit of CCS technology demonstrator is not in the scope of this project, so the reader should refer to other related projects on this topic for more info, e.g. the ETI BioCCS project.

The benefit case analysis in this report is based on the BVCM toolkit developed as of end of May 2012. Although several additional model functionalities and scenarios have been envisaged for investigation in Phase 2 of the project, it is reasonable to say that a good level of confidence exists at this stage around the model results, given the number of scenarios explored during Phase 1 and the quality of the data currently in the model. It is therefore suitable to use current model results in helping defining the ETI bioenergy technology demonstrators.

Next steps

This is the last formal deliverable for the BVCM project as originally conceived in the Technology Contract. Possible further model developments have been identified based on the Consortium's judgement and on the experience gained from the runs and sensitivity analysis runs so far. Some of these developments have been already identified in the course of the project and will be covered in Phase 2:

- Seasonality effects. Improvement of the model functionalities by taking into account seasonal effects on biomass characteristics and availability.

- Value of strategic transport fuels. At the moment, when optimising on costs and/or energy, the model typically chooses road transport fuels over jet fuel. This is mainly due to the extra costs and emissions associated with the hydrogenation required for achieving jet fuel specifications. However, from a UK-wide strategic point of view, it may make more sense to generate jet fuel, as this may have more economic value. A possible model development is therefore to implement an objective function that maximises the value of the biogenic energy vectors.

- Value of carbon sequestration of long rotation forestry. The current model does not take into account the potential benefit of storing carbon stocks by means of long term forestry, and additional functionality in this regard can be added.

- Improved modelling of credits (economic and GHG) from co-products, e.g. by modelling how credits will vary in the future, and including possible saturation effects.

- Improved modelling of land constraints, i.e. limiting the area in each cell than can be realistically used to produce biomass for bioenergy.

- Constrain the location of CCS technologies to areas where it is expected that CCS infrastructure will be located (e.g. Thames Estuary, Humberside).

- Further alignment between the BVCM and the ESME model, i.e. aggregating and feeding back BVCM technology and resource data to ESME.

Technologies acceleration opportunities and benefit case reports will be updated accordingly at the end of Phase 2, expected in October 2012.

The proposals for technology acceleration, and therefore potential technology demonstrators, in bioenergy have been tested with the Bioenergy SAG. The importance of biomass gasification to H2 or bioSNG, and bio-CCS using chemical looping technology is being explored further to identify what are the technology barriers and whether ETI can play a meaningful role in accelerating the technology.