Richard Taylor

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Title: ‘Introducing the Bioenergy Value Chain Model: spatial optimisation, linkages and insights’

Biography:

Richard is a London-based Managing Consultant who joined E4tech in 2008. He has led the delivery of many of E4tech’s bioenergy and system modelling projects, focusing on topics such as biomass resource sustainability, techno-economic analysis, innovation needs, and the commercialisation status of different conversion options. Richard previously worked within the wind power and investment banking sectors, and holds Masters degrees from Warwick University and Imperial College London.

He is currently leading the ongoing development work of the "Bioenergy Value Chain Model" for the Energy Technologies Institute, working with Nouri and Sheila Samsatli from Imperial, and today will be explaining some of BVCM’s functionalities and sharing some of the new insights, generated by the ETI, gained from the model.

Background

Bioenergy is selected by many whole energy systems models to play an important role in the decarbonisation of the UK energy system to 2050. However, the bioenergy elements of wider models are typically represented at a relatively low resolution, with only a few different biomass types and conversion technologies, and without explicit consideration of supply chains. In order to model the bioenergy sector in much greater detail, in 2011 the ETI commissioned a consortium to develop a Biomass Value Chain Model (BVCM). E4tech have led a team of Imperial Consultants, Black & Veatch, Agra CEAS Consulting, EDF/EIFER, Forest Research, Rothamsted Research and University of Southampton in conducting this ~£1.3million project.

Methods

BVCM is the first optimisation model that considers the UK's bioenergy system spatially at 50km resolution – matching biomass feedstocks with logistics and conversion technologies to show how bioenergy pathways can best be developed to meet UK energy, cost and emissions targets to 2050. BVCM is a flexible optimisation framework implemented in the AIMMS modelling platform, linking a large library of data sourced from the project partners. It includes maps of land types and availability, along with yield, cost and GHG emission maps for arable & energy crops, forestry & wastes. Many of the 82 resources can be bought, sold or disposed at the system boundary, CO_2 can be sequestered at CCS hubs, and biomass imports purchased at UK ports. The geography of the UK determines possible road, rail, canal, ship and pipeline networks and the impacts of their use, and data on techno-economics and build rates exist for 61 distinct conversion technologies.

This input data is combined with user choices regarding bioenergy demands (for electricity, heat, hydrogen, methane and transport biofuels), budget limits, GHG emission targets (often negative) and CO_2 prices, which includes soft-linking to other ETI models. The mixed-integer linear programming (MILP) model then optimises using the CPLEX MIP solver for a user-defined mix of economic, emissions and/or energy objectives, meeting the system requirements in each decade to 2050, and balancing resource flows in each of the 157 square cells across the UK.

Results

The ETI has recently published a set of Insights based on the analysis of several months of BVCM runs – these offer an example of the types of learnings that can be drawn from the model:

- Bioenergy with Carbon Capture and Storage remains the only credible, cost-effective route to deliver the negative emissions required to help the UK meet 2050 emission reduction targets
- The lowest emission pathways convert biomass to hydrogen and power, in preference to biomethane and biofuels; but local scale biomass heating can be important in the near-term
- Gasification is a key technology for developing the bioenergy sector
- Optimal locations for UK biomass production have been identified, based on trade-offs between energy crop yields, conversion plant locations, land resources and import capacities

BVCM is continuing to support decision-making around optimal land use, biomass utilisation and the impact of different technology improvements. The ETI and its members have already used the results of BVCM to help commission further research on pre-treatment technologies and biomass characterisation; and will continue using it to identify technologies with system-wide importance, and hence opportunities for technology acceleration.