THE WATER-ENERGY-CARBON-LAND NEXUS: OPTIMISING THE BECCS SUPPLY CHAIN

Solène Chiquier[a], Mathilde Fajardy[a,b], Niall Mac Dowell[a,b]
a) Centre for Environmental Policy, Imperial College London
b) Centre for Process Systems Engineering, Imperial College London
niall@imperial.ac.uk

Key Words: BECCS, biomass supply chain, land use, water use, optimisation

Negative Emissions Technologies (NETs) are necessary to meet the climate change targets identified at the 2015 Paris COP. In particular, Bioenergy with CO_2 Capture and Storage (BECCS) is being put forth as a key mitigation option to decarbonise the atmosphere in most IPCC AR5 scenarios (IPCC, 2014). Incurring high emissions through biomass supply chain and competing with land and water, BECCS sustainability and carbon negativity has been shown to be greatly dependent on the conditions – feedstock production, processing, transport and conversion – of its deployment (Fajardy and Mac Dowell, 2017).

In this contribution, we present a biomass supply chain optimization framework, implemented in the AIMMS software, based on a BECCS whole-systems model. This model calculates the carbon, energy, water and land intensity associated with biomass production, processing, transport and conversion in a 500 MW UK based BECCS power plant, for a range of biomass feedstock, either energy dedicated crops – miscanthus, switchgrass, willow or agricultural residues – wheat straw, importing regions and land types. This last parameter is particularly significant as it accounts for the impact of direct and indirect land use change and hence plays a decisive role in the determination of BECCS carbon break-even time.

Given an UK annual CO_2 removal target and constrained amount of arable land per importing region, the optimal combination of feedstocks, importing regions and land types is determined to minimize either water or land use. Regardless of the criteria which is being minimised, marginal land is found to be the optimal choice, as it is associated with very limited land use changes.

Finally, the choice of the resource to be conserved drives the biomass and region selection. For example, when minimizing BECCS water use, wheat straw is prioritised over other feedstocks. However, when minimizing the land use, miscanthus is preferred because of its relatively high yield.

Overall, we conclude that given an annual carbon removal target and constrained amount of arable lands, the resources aimed to be preserved – arable land or fresh water – will have profound implications on the potential feedstocks and supply chains for BECCS.

References

Fajardy, M., & Mac Dowell, N. (2017). Can BECCS deliver sustainable and resource efficient negative emissions? *Energy Environ. Sci.* https://doi.org/10.1039/C7EE00465F

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