Biorenewables, the bio-based economy and sustainability

This issue of Interface Focus is being used to introduce readers of Interface to research into the use of plants to supply mankind with renewable energy and material resources. This field is given the general name of biorenewables research, but over the past few years it has come to public attention through media coverage surrounding one type of biorenewable product, liquid biofuels. Biofuels research lies at a complex set of interfaces, where the worlds of research and innovation meet those of business and politics. This is a difficult arena in which to work at the best of times, but when the world is urgently seeking to develop truly sustainable energy resources to combat climate change, the quality of scientific advice will be at a premium. Mankind can ill afford to make mistakes in the technologies it pursues to reduce greenhouse gas emissions.

Because crops use photosynthesis to convert atmospheric CO₂ into the organic compounds that are used to generate biofuels, it appears that biofuels should be able to eliminate anthropogenic CO₂ emission from internal combustion engines. This simple idea has been at the heart of the arguments in favour of exploiting plant biomass for liquid fuel. Of course this picture is an oversimplification, since the complete process of generating the fuel is, in general, not free of greenhouse gas emissions. The promise of biofuels as a climate change mitigation technology, therefore, rests upon the technology’s ability to maintain very low levels of greenhouse gas emissions in its production.

Brazil has over 35 years of experience from its development of the science, technology and economics of sugar cane bioethanol production. Here, it is widely accepted that the process life cycle of the biofuel results in a sizeable reduction in greenhouse gas emissions with respect to petroleum fuel. In large part, the success of sugar cane ethanol rests on the productivity of the cane and the simplicity of the processing. Other sugar crops and starch crops can and have been used for alcohol-based fuels in other parts of the world, oil-bearing crops have been used to make biodiesel and scientists and technologists are now looking at ways to convert woody material into alcohols. (These technologies are described in two of the papers, i.e. Landeweerd et al. [1] and van Zyl et al. [2]) Some, but not all, of these fuels are calculated to produce lower greenhouse gas emissions than their petroleum equivalent. It is the potentially widespread production of biofuels with increased greenhouse gas emission that should be avoided, but can we identify these readily?

As is so often the case, this question is not an easy one to answer and many of the papers in this collection discuss the issues that scientists, engineers and economists are addressing to make good estimates. In particular, it has become evident over the past few years that there are significant and potentially long-term greenhouse gas emissions owing to the change in land use when biofuel feedstocks are planted. There are both direct effects to the planted land, e.g. owing to the release of stored carbon during tilling, and more subtly owing to the indirect effects of displacing agriculture for food. It is these land-use change effects that are at the heart of the so-called ‘food versus fuel’ debate. Land-use change and indirect land-use change are dominant themes in the articles in this issue, i.e. see the papers by Davis et al. [3], Nassar et al. [4], Khanna et al. [5] and Landeweerd et al. [1]. As will become evident to the reader, there are significant disparities in the literature in particular with regard to the measurement of indirect land-use change effects and these differences themselves, as published in the literature, are the subject of study in a paper by Michalopoulos et al. [6]. Much less attention has been paid to optimizing the entire process of biofuel production, where significant improvements in performance can be engineered as is described in the paper by Hosseini & Shah [7].

As with Brazil and other parts of South America, Africa has enormous potential for biofuel production that at present remains largely untapped. Given the political and socio-economic conditions found in much of Africa, there are fears that such developments will not serve the indigenous population well. Two papers, one by van Zyl et al. [2] and another by Watson & Diaz-Chavez [8], look at the technical, biological, agricultural, economic and social dimensions of biofuel production in Africa. The potential for cross benefits between food and fuel production, i.e. ‘food and fuel’ rather than food versus fuel, are evident in the agro-economic conditions of much of Africa. Both the Brazilian and African experience points to the use of satellite observation to define zones for agricultural and biofuels development and monitor land-use change effects.

The papers collected here span a number of continents and give some impression of the scope of activity in biofuels across the globe. The last paper in the collection, by Lynd et al. [9], is in fact a report on the activities of the Global Sustainable Bioenergy initiative, created by Professor Lynd in 2010. In that year, the Global Sustainable Bioenergy initiative ran a sequence of meeting in which scientific communities in five continents assembled to...
discuss the potential for sustainable biofuel production and the desirability (or otherwise) for their exploitation. In the previous year, the Global Biorenewable Research Society was founded under the chairmanship of one of this issue’s editors (LvdW) with an objective to publish papers that gave as impartial a view as possible on biorenewables research. In 2010, the Society ran a meeting at Chatham House to look at issues of land-use change, sponsored by the Energy Biosciences Institute at the Universities of Berkeley and Illinois (Urbana-Champaign), the Porter Institute at Imperial College and Chatham House itself. The papers by Davis et al. [3], Khanna et al. [5], Hosseini & Shah [7] and Watson & Diaz-Chavez [8] arose from the discussions and debates that were held then.

We hope that reading both the insights and in a number of cases the opinions of practicing biofuels researchers from a range of disciplines will both be interesting and stimulate further submissions in the field to *Journal of the Royal Society Interface*.

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REFERENCES


