BIOREFINING : PREPARING FOR THE PERFECT STORM

Professor Robert Edwards, Chief Scientist, The Food and Environment Research Agency.

With news from Russia that grain harvests may be some 30% lower than expected due to drought and an associated export ban on cereals likely, we seem a step closer to Professor Sir John Beddington's perfect storm of global food, fuel and water shortages by 2030.

As plant scientists are mobilized to meet the challenges of increasing crop production, we are constantly faced with the debate over food Vs. fuel. In terms of energy, we know we have to move from a world running on the photosynthetic products of ancient sunlight to one where we are part of the ambient carbon cycle. We also know that unless your country is blessed with spare growing capacity, that in the current agronomic model, biofuel crops are bound to compete with food production. But what if we could efficiently use crops for both food and non-food uses?

Consider this scenario. As the last of the grain trucks depart our farms for the granaries the business of the secondary harvest begins with the residual straw in the form of pellets fed into silos and wetted with water containing degrading enzymes. After a week, the syrupy liquid extract, full of sugars, is pumped into waiting tankers and the solid residue retained by the farmer for soil conditioning or energy production by combustion. Meanwhile the liquid extract is fermented into a range of simple precursor chemicals at regional centres prior to national distribution to the chemical and fuel industries.

This is the world of biorefining, where biomass is used as an alternative to oil to provide us with the liquid fuels and chemicals we need to operate a modern society. Furthermore it is not a new vision. In the 1930s agricultural chemists fearful of our growing dependence on fossil fuels had already proposed the large scale use of plants as alternative chemical feed-stocks and termed the science 'chemurgy'. Now some 70 years later we have made significant progress in realising their ambitions for chemurgy, though in terms of competing with the near atom efficiencies of chemical refining we still have a long way to go to make biorefining a commercially sustainable industry.

By examining the scenario above and the proposed use of wheat straw as a chemical feedstock we can identify some of these challenges.

THE STARTING MATERIAL

While the straw is rich in sugars, their ability to be released into forms which can be usefully fermented is limited by other chemical constituents present and the complexity of the polymerized matrix they need to be extracted from. Unlocking these sugars from plant cell walls (lignocellulose) using sustainable biological processing is currently the subject of multi billion dollar investments in the private and public sectors around the word. As an alternative, chemical processing of lignocellulose is possible, though the plant required is expensive, energy intensive and unlikely to be deployed at multiple small sites.

TRANSPORTATION

Unlike crude oil, in terms of energy 'density' straw is bulky and energetically expensive to transport. It therefore makes sense to process the biomass to a more energy intensive form prior to shipment from its site of production; hence the bioprocessing of the straw to a more easily shippable liquid form on site. Ultimately it may be possible to both digest and ferment plant material in a single process, though that would require the generation of effectively novel microbes through techniques such as synthetic biology. For the purposes of the scenario presented here it is instead proposed that the outputs of primary processing on the farm would be the nutrients required for secondary fermentation at a regional hub.

AGRICULTURAL SUSTAINABILITY

Though straw is of secondary importance to grain, it still has a great value to agronomy and some of its carbon and nutrient value needs to be retained on the farm. In effect, crop utilisation in countries like the UK is already very efficient and diverting biomass for industrial processing would need some careful environmental evaluation.

BIOREFINED PRODUCTS

The outputs of biorefining need to be compatible with the needs of the chemical industries which have been built up around oil refining for decades. This is where the ability to engineer metabolic pathways in microbes to produce chemicals which are entry points into existing chemical processes is vital.

By identifying these challenges we can immediately see that the science of biorefining requires inputs from the public and private sectors at levels ranging from the international to regional. At the higher level, biorefining needs concerted science and technology programmes integrating the disciplines of plant breeding, microbiology, enzymology and chemical engineering. In the UK this level of organisation is provided through the BBSRC's 'Integrated Biorefining Research and Technology Club' (IBTI), in a partnership with UK-based industries. At the regional level, biorefining has the capability of addressing the local needs of farmers and food processors with the ability to fine tune the processes to the needs of the available biomass or waste stream.

Working at both the national and regional level, the Food and Environment Research Agency (Fera) has identified biorefining as a key area for development in partnership with public and private sectors and one which complements its existing science capability. For example, its work with seed breeders could be usefully developed to look at new traits for feed-stock use in biorefining, while its analytical services would help develop efficient processing technologies for the wide diversity of plant materials used by the food industry. The agency would also be able to provide expertise in environmental impacts of this new industry. Whatever the inputs, importantly in a rapidly changing world organisations such as Fera need to be able to flexibly partner with Universities and industry to develop new technologies such as biorefining which address national needs in food security and environmental sustainability as we draw closer to the storm ahead.

RUSSIA: MODERNISATION THROUGH SCIENCE AND INNOVATION

Dr. Julia Knights,
First Secretary, Science and Innovation (S&I), British Embassy, Moscow

Russia is taking many positive steps towards modernising its innovation infrastructure and strong opportunities for UK industry, consultancy and research collaborations exist.

This year the UK Science and Innovation Network (SIN), funded jointly by FCO and BIS with a remit to cover international science and innovation, set up a new section within the British Embassy in Moscow to capitalise on recent opportunities for the UK in research and industry collaboration with Russia.

President Medvedev's Commission of "Modernisation and Technological Development of Russia's Economy" set up in May provides one of the major opportunities for the UK. £211 million is available this year for technological breakthroughs in five themes: energy efficiency, nuclear, space and communications, energy efficiency, medical and information technology (including supercomputers).

A £3.23 billion energy efficient innovation city named "Skolkovo" dubbed "Russia's Silicon Valley" by the Russian media, will act as a testing ground for new economic policies to stimulate commercialisation of scientific research through the Commission's five themes. International architects have been invited to design for the masterplan project worth over £90 million covering 380 ha of