Sustainable Biofuels: Prospects and Challenges

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‘Apart from used chip fat, there is no such thing as a sustainable biofuel.’

...The European commission, by contrast, does have a plan, and it's a disaster. It recognises that "the oil dependence of the transport sector ... is one of the most serious problems of insecurity in energy supply that the EU faces". Partly in order to diversify fuel supplies, partly to cut greenhouse gas emissions, it has ordered the member states to ensure that by 2020 10% of the petroleum our cars burn must be replaced with biofuels. This won't solve peak oil, but it might at least put it into perspective by causing an even bigger problem.’
Biofuels study and report

- The study was launched on the 16th October 2006
  - Open call for evidence issued

- Participatory industry workshop held at Royal Society in London on 12th January 2007
  - Facilitated interaction with feedback fed directly into report development
  - Over 20 industries represented including agriculture, chemical, oil and vehicle sector representatives (UK and inter / multi-national)

- Report launched on the 14th January 2008
Working group membership

- **Chair**
  Professor John Pickett CBE FRS  
  Rothamsted Research

- **Working group**
  Professor Dennis Anderson  
  Centre for Environmental Policy, Imperial College London
  Professor Dianna Bowles OBE  
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Drivers and obstacles for bioenergy: conflicts and synergies are inevitable

Global / Regional
- Energy Security
- Climate Change
- Rural Development

Local / Consumer
- Usability / reliability
- Environment / health [inc air quality]
- Cost

Sustainability
What is driving biofuels?

UK Petrol Price (2007)
- Wholesale petrol = $15/GJ
- Pump purchase = $55/GJ

Zambia Petrol Price (March 2006)
- Wholesale petrol = $18/GJ
- Pump purchase = $44/GJ

Zambia projected ethanol production costs
- $16 to $38/GJ (no taxes)
  - C-molasses to straight juice used
  - Assumes no value for co-products e.g. electricity
Costs of oil provision to Africa?

- Estimated ‘oil expenditure’ for Africa = US$62 billion in 2006
- In Tanzania and Senegal c. 40% of foreign exchange earnings are spent on purchasing oil products
- Estimated ‘expenditure’ has tripled since 2002
- Consumption has increased by 10%

Based on BP 2007

Woods, 2007 (Burkina Faso)
Climate Change

- Biofuels can contribute to a meaningful reduction in greenhouse gas emissions but requires the development of highly efficient and integrated supply chains.
- Existing examples of biofuels programmes around the world starkly illustrate the range of greenhouse gas savings that can be realised.
  - Average Brazilian ethanol results in reductions of c 80% in greenhouse gas emissions, on a life cycle analysis, compared to petrol (Worldwatch Institute 2006).
  - US maize-based ethanol struggles to deliver reductions in greenhouse gas emissions of 10%.
  - UK- projected reductions in greenhouse gas emissions of anywhere between 10% and 80% could be delivered from wheat to ethanol (Woods & Bauen 2003).
- Current policy frameworks and subsidies for biofuels are not directed towards reducing greenhouse gas emissions, but rather provide incentives for national supply targets. As a result, there is currently no incentive to invest in the systems that would deliver low greenhouse gas biofuels.
Energy Security

- Global primary oil demand projected to grow 1.3% per year up to 2030
  - reaching 116mb/d (from 84mb/d in 2005),
  - transport sector accounting for most of this increased demand (IEA 2006).
- Much of the current demand for oil is met by OPEC; this has energy security implications especially if supply routes are disrupted.
- The surge of demand for oil from developing regions (China, India and Latin America in particular) + continued high demand from Europe & USA is continuing to drive oil prices higher.
- The current era of high oil prices has started to make biofuels, and other close to market alternative technologies, a realistic alternative.
- Virtually any degree of energy security can be achieved if countries are willing / able to pay for it. E.g. exploiting tar sands and oil shales to produce synthetic fuels.
  - Note: costs of producing synthetic fuels are high and are much more carbon intensive than for conventional oil fuels.
- Using unconventional energy resources could seriously compromise objectives to mitigate climate change.

- **Whether this trade-off between energy security and climate change mitigation is avoided by the production of biofuels will depend on how biofuels are produced and on developments right across the supply chain.**
Rural development

- Will biofuel production compromise food production and decrease the quality of life for the rural poor of the world?
- Biofuels could provide a part of the answer to this problem by diverting ‘surplus’ production to a new market whilst maintaining productive capacity.
- In many developing countries, rising food-based commodity prices will assist investment in agriculture and forestry which, in turn, will improve yields and production efficiencies.
- With careful implementation, the rural poor of these countries could be major beneficiaries of a new biofuel-inspired development dynamic.
- However, without specific intervention, the urban poor in developing countries will suffer as a result of increased food prices unless (i) economic prosperity rises as a whole, and; (ii) a reasonable amount of the value generated by biofuels is retained locally.
  - This is a critical component of understanding how to harness FDI beneficially

- We do not assess these issues in detail, but highlight the dangers of an overly simplistic food versus fuel debate when synergistic opportunities for food and fuel exist and should be maximised.
Balancing environmental, economic and social issues for sustainable biofuel development

**Environmental**
- Net emissions to air, water and land
- Climate change mitigation & adaptation
  - Inc GHGs
- Above and below-ground carbon balances
- Biodiversity
- Good agricultural practice & soil management
- Waste
- Direct & Indirect Land Use

**Social**
- LCA Social impacts
- health & safety
  - environmental quality
  - Labour conditions
- Welfare / happiness
- Equitable access to local resources
  - e.g. land tenure
  - Barriers

**Economic**
- Competitiveness
- Market breakthrough
- Incentives
- Barriers & Regulations
- Taxes
- IP rights and ownership
- Value chains and value retention

**Policy & Institutions**
- New policies & plans
- Directives
- Incentives
- Barriers
- Institutional capacity
- Technology neutral options

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Regional Strategic Drivers e.g. EU’s Lisbon Criteria
Overview of Biofuel Conversion Pathways

Solid Biomass
- Includes: Herbaceous Perennials (e.g. Miscanthus, switchgrass), Woody Perennials (Short rotation coppice e.g. willow, poplar), Straw and Forest Residues, Municipal Waste
- Sugar-rich crops: e.g. Wheat, Maize, Sugar Beet
- Oil crops: e.g. Rape (Canola), Oil Palm, Jatropha, etc. Also waste fats and oils
- Wet Biomass: e.g. cattle, pig and human manure

Sugar-rich crops

Thermochemical
- Gasification
- Pyrolysis
- Biooil
  - DME (Dimethyl Ether)
  - Methanol
  - F-Tropsch
  - Ethanol / Butanol
  - Diesel

Biological
- Fermentation
  - \( C_6 + C_5 \)
  - Yeast / Bacterial

Mechanical
- Extraction
- Esterification

Biological
- Anaerobic Digestion
- Biogas
  - \( CH_4 \)

Transport Fuels
- Electricity & / or Heat

Source: Revised from DG TREN (Maniatis, 2003; Woods, 2003)
Understanding supply chains and boundary issues

- Changes at one point in the supply and use chain have implications for other segments of the chain
Biofuel pathways- biomass and energy production

- Detailed site-specific assessments are needed to evaluate potentials
- Beware volumetric comparators
- Future biofuels may not be ethanol or methyl esters
UK- RTFO implications for E85 use in Somerset
Woods & Brown (2007; EU-BEST project data)

- ‘Worst case’ GHG savings between 53% to -25%
- Using ‘country level (conservative) default factors’ as defined by the UK-Renewable Transport Fuel’s Obligation Reporting Requirements (RFA, 2007)
Biorefineries

- A biorefinery concept based on integrated biological and thermal processing for transport fuels and chemicals
  - Such systems are already emerging
RS Biofuels Working Group Conclusions

A coherent approach will:

- avoid the unintended consequence of solving one problem at the expense of exacerbating another;
- see biofuels as part of a portfolio of approaches that also includes, for example, greater energy efficiency, electric vehicles, hydrogen and fuel cells, and fiscal incentives such as carbon pricing based on avoided greenhouse gas emissions;
- balance growth of feedstock against other uses of land;
- deploy an assessment of sustainability that encompasses the complete cycle from growth of the raw material to end-use irrespective of where each stage in the cycle takes place;
- commit to invest properly in the required R&D;
- provide aptly targeted fiscal incentives;
- develop a process for effective public engagement on biofuel issues.
Biological Mitigation Options and The Carbon Cycle (GtC)

C-cycle options:
1. Bigger
2. Un-balance (more down than up)
3. More efficient use of biomass flows
4. Fossil-fuel substitution
5. Protect major existing carbon stocks

Source: http://www.vitalgraphics.net/graphic.cfm?filename=climate2/large/11.jpg
THANK YOU!

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NILE
New & Improved Lignocellulosic Ethanol

IEA Task 40