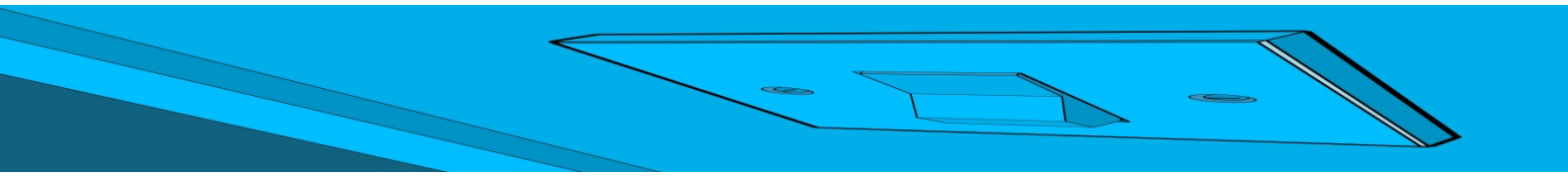

UKERC

UK ENERGY RESEARCH CENTRE

DEVELOPING A BIOENERGY ROADMAP FOR THE UK

Bioenergy research roadmap workshop, April 2007

Working Paper

REF: UKERC/WP/ESM/2007/017

Professor Gail Taylor, UK Energy Research Centre

Event Organised and Sponsored by:

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THE UK ENERGY RESEARCH CENTRE

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Environmental Sustainability is a research and networking theme within UKERC. The over-arching goal of Environmental Sustainability is to develop and demonstrate an approach that can be used to appraise consistently the relationships between the environment and all fuel cycles.

Executive Summary

This workshop brought together a wide range of individuals and organisation with an interest in bioenergy for heat, power and liquid transport. This included researchers from universities and research institutes, Government Research Councils, Government Departments, stakeholders from industry and others. The meeting was convened to begin the process of developing a UK Bioenergy Research Roadmap, which will be completed before the end of 2007.

The aims of the workshop were:

- To prioritise research activity and overcome the gaps in knowledge in bioenergy
- To influence research funding strategies in energy research.
- To encourage closer collaboration between academic research groups and technology developers
- To seek funding for collaborative research from Research Councils, DTI, DEFRA, Carbon Trust EU, etc.
- To establish partnerships with the outside the existing bioenergy research community
- Create the Research Roadmap for bioenergy to 2020 and 2050.

These aims were largely met. The first day was spent defining why a roadmap was needed and what our vision for the roadmap would be as follows:

"In order to realise the substantial potential of bioenergy to help bring about the transition to a sustainable low-carbon economy, a roadmap is required to inform and guide research. The roadmap will enable the science community, and those who shape the direction of science, to identify gaps, prioritise funding and unlock the unique potential of the bio-based economy."

It was agreed that the UK context included climate change and sustainability drivers and not only energy security and in this respect, the focus of bioenergy roadmapping in the UK was different to that in some other nations.

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Introduction – setting the context

Session 1: Background

In the last few years a large number of roadmaps and action plans dealing with bioenergy research, development and deployment have been published from across the world including from the EU, USA, Canada and Australia. Although of value, they miss the particular context of the UK. Our agricultural landscape is complex but limited and the way in which UK-sourced and imported feedstock may be deployed for the competing requirements of heat, power and liquid fuel is not easily resolved. On the one hand the energy balance of heat and power may be much better than that for liquid biofuels, but on the other hand, few alternatives for liquid biofuel are available, in contrast to renewable sources of heat and power. All of this highlights the complexity of this area and suggests that such a discussion meeting is timely and will produce valuable output that captures the interdisciplinary requirements of this topic.

In the UK we have no research roadmap and the main aim of this meeting is to bring together a wide range of stakeholders – researchers, research funders, policy-makers and industry representatives, to identify roadmap priorities for the UK. Our conclusions will be evidence-based and our hope is that our output will be a document that helps to guide the UK Research Councils and other UK agencies to 2020, ensuring bioenergy is considered in a holistic way. Our research roadmap will be published by UKERC and used as a high-level document, adding to roadmaps being produced in other areas including photovoltaic, wave and tidal energy.

Introduction to UKERC and the roadmapping process

Presentation of framework document [UKERC working paper on developing a bioenergy roadmap], *Gail Taylor, Southampton University*

The presentation began by setting out the purpose of the UK Energy Research Centre, including its mission, research and coordinating role. Gail explained how the research programmes and functions of the UKERC are distributed across the UK, with headquarters in London.

The aims of this workshop were:

- To prioritise research activity and overcome the gaps in knowledge in bioenergy
- To influence research funding strategies in energy research.
- To encourage closer collaboration between academic research groups and technology developers
- To seek funding for collaborative research from Research Councils, DTI, DEFRA, Carbon Trust EU, etc.

To establish partnerships with the outside the existing bioenergy research community
Create the Research Roadmap for bioenergy to 2020 (2050)

It was hoped that the output of the meeting would produce a clear shared view on research priorities, an agreed method of working and schedule, a framework document with bullet pointed headings; an agreed process to take this forward to a final document; and action points.

However, this workshop would not: discuss and write the detailed roadmap; discuss details of research requirements and priorities; or identify funding mechanisms to deliver the roadmap.

An important input into the research roadmap is the UKERC bioenergy research landscape. This document was published in November last year and peer-reviewed during the first quarter of this year. It is available to view at: http://ukerc.rl.ac.uk/Landscapes/Bioenergy.pdf. It was updated in September 2007 and will be updated every six months in future. A draft framework for the bioenergy research roadmap was circulated to workshop participants before the workshop. The output of this workshop will produce a second draft of this document by the end of 2007. The document will then be circulated widely to interested stakeholders with a final version being produced early in 2008

Session 2: Setting the UK context

Presentation of framework document, *Gail Taylor, Southampton University*

In 2004, Biomass accounted for more than 80% of renewable power generation in the UK, with landfill gas and municipal waste combustion dominating (DTI). However, only 1 % of heat supply is from bioenergy and 1.5 % of electricity from biomass. The Carbon Trust estimates that this may realistically rise to 7 % of supply. The UK also has a large biomass resource (~ 30 M tonnes yr^{-1}) that is largely under-utilised. There are only approximately 10,000 ha of energy crops in a 17 M ha landscape. Further, considerable energy is lost as 'waste' in wood and other lignocellulosic resources and in food wastes.

Indeed, an increased contribution from the bioenergy sector is expected considering the UK policy context which is defined by some important targets:

- Energy White paper
  - 10% of supply from renewables by 2010
  - 20 % of supply from renewables by 2020
- CO_2 emissions reduction and Stern Review
  - 60% reduction from 1990 emission by 2050
- EU Biofuels directive
  - 5.75 % replacement of liquid transport fuels by 2010 rising to a 10% commitment by 2020. Meeting this target with a supply of sustainable feedstock for liquid transportation fuels remains challenging.

To achieve these targets, the UK's complex regulatory and policy framework may need to be simplified. The recent Biomass Task Force report (2005) made over 40 recommendations to overcome some of this complexity and the Government has now replied with initiatives such as the new Energy Crop Scheme and the Capital Grants Project, but these in general have been slow to develop and out-of-step with industrial requirements and momentum.

- There are other activities and studies that also form part of the UK context:

- March 2006 – BBSRC publishes report 'Bioenergy Research Review'
- April 2006 – Biomass Action Plan – EU
- May 2006 – 2030 EU Roadmap for biofuels – EU
- June 2006 – US DOE Roadmap for Bioenergy following Dec 2005 meeting
- June 2006 – BP announces £250 M Bioenergy Centre at Berkeley and Illinois
- July 2006 – Office of Science and Innovation – Foresight Horizon Scanning
  Biomass for Heat and Power
  Biomass for biofuels and the biorefinery concept
- September 2006 – UKERC Research Atlas for UK Bioenergy published

On a positive note, considerable investment has found its way to the bioenergy research community. Some £17 million has been invested into basic and strategic research since 2006: TSEC; RELU; SUPERGEN; GINs; SUE; and CARBON VISION. To add to this there is also a £20million BBSRC initiative and the SUPERGEN BIOMASS II programme (& EU projects). 19 research organisations have been identified as active in this area. The major players and research programmes are represented by the Figure below (use updated version). Gail stressed that there is a pressing need to bring this research together.

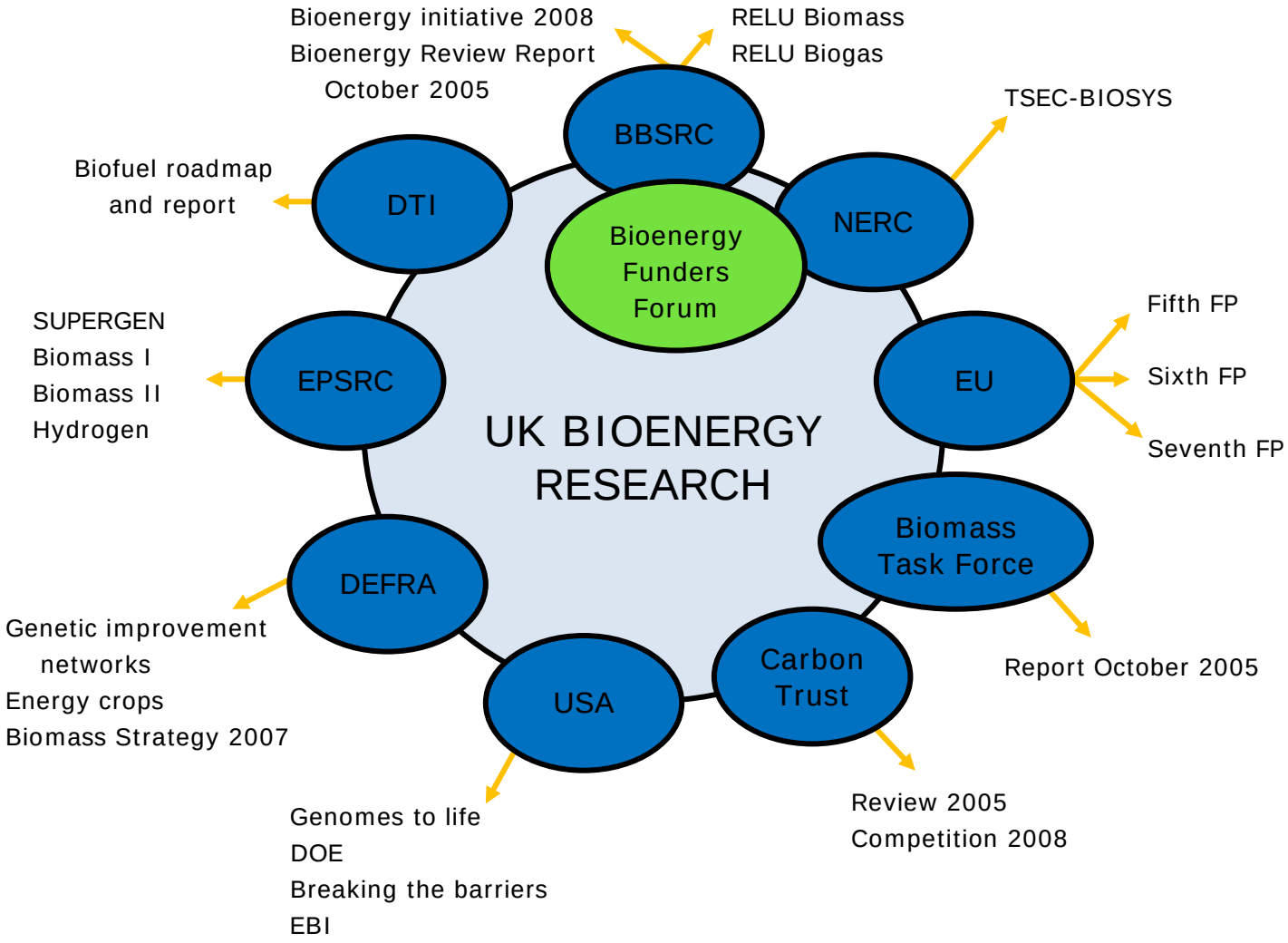

Figure 1: The Research Landscape Bioenergy- http://ukerc.rl.ac.uk/EPL0304.html

On the commercial side there is £87million available for applied research (DTI technologies dominate) and nine groups have been identified as active in this area – less than for fundamental and strategic research, reflecting UK commitment to science and a weakness in technology transfer linked to commercial developments. Some £67.7million has been allocated to development and demonstration. Industry 'pull' has been providing deployments – there are 18 or more new developments of various sizes in the UK. Gail closed her presentation by sharing a list of key challenges and science advances in for UK bioenergy.

Discussion

There was a comment that the roadmap document should not be viewed as a single end product but rather as a process where the content is revisited and updated as necessary. There was mention of the US approach which drills down so deep and identifies milestones and outputs. The UK approach will probably be quite different – the UK roadmap needs to hold the community in good stead but should incorporate flexibility to allow for a changing policy context. Another participant thought the a critical role for the roadmap would be to identify choices and options, particularly as industry and investors are keen for certainty. At the same time there needs to be allowance for uncertainty and contingency. It can also be argued that strategic research is about identifying goals and getting there alongside a timeline. Science is indeed to open up choices and identify uncertainties. Should this roadmap incorporate political judgements regarding technology forcing decisions? Indeed the US bioenergy roadmap is technology driven with limited attention to environmental sustainability. This cannot be the case in the UK.

Some vital context setting issues (which the US debate will not pick up on), were identified, including ecosystem services, Millennium Ecosystem Assessment, sustainability, EU policy documents, UK policy documents and knowledge transfer within the UK and to other countries, perhaps where biomass feedstock is being exploited.

Sustainability and land-use was identified as a key context setter for the UK, where strategic Government steer was required on what land-use priorities would be and how this could be achieved. We need insight into whether the UK has a competitive advantage or not, for example, the UK doesn't have a competitive advantage for primary growing and primary processing. It may be worthwhile to gather science on the economics of relevant industries and to find out how the UK could or does have a competitive edge - this could open up a different set of issues.

There was some discussion on picking winners. There was little support for picking winners – an approach adopted by the US. It was suggested that it may be more sensible to identify clear losers rather than clear winners. It was also pointed out that the UK is good on discovery of technologies but not so good on their exploitation – knowledge and technologies currently exist which could be better exploited.

Setting the context: Breakout session

The group worked in four parallel syndicates. Each was asked to address a different question, as indicated below. The groups then rotated so they could assess and add to

the output of the other groups. Through this method the groups were quickly able to establish consensus on the outputs. Group A required extra time to drill down on the issues.

In plenary, the participants discussed each of the group outputs and areas of conflict or confusion were discussed and resolved. Some outstanding issues were discussed on Day 2, the output of which is captured in this section below.

GROUP A - Will the UK bioenergy roadmap be useful? Why or why not? If so, who is the target audience?

Should we have a roadmap?
Yes, as long as it is insightful, useful and comprehensive. Good for future-proofing. Target audience important.

Why?

- to bring about a joined up, coordinated, holistic and coherent UK research community view; built bottom-up (not like USA model – top down focused on technology for fuel security), by the bioenergy community.
- to shape policy and inform decision makers; to ensure policy is consistent with state-of-the-art technical and scientific understanding
- to highlight knowledge gaps in order to target funding
- to set out principles by which research should be directed and funded
- to provide the iterative process that this field requires and a forum for debate between researchers, funders and policy makers

For whom? (UK focused)

- research community
- policy makers
- regulators: Environment Agency
- investors in research
- investors in development (stimulate integrated thinking)
- government funding bodies (EPSRC; NERC; BBSRC. CT; Defra; DFID; DTI)
- general public
- farmers, foresters, engineers

Process?

1) Better to make use of what we've already got – how far can we get in the UK with what we already have available. We need an inventory of what's available:
   - Anaerobic digestion
   - Waste
   - Combustion (fermentation, gasification, pyrolysis etc)
2) How to use our resources for biofuels to maximise value from use of land
3) For whom? Think of how the roadmap will be used and target individuals/groups with power to change.
4) Improve what we have

5) If we can't satisfy the targets with what we have then start to look outside at new/international options

There was considerable discussion on the purpose of the research roadmap and also who owns it, maintains it and uses it. The participants worked in small groups to consider these particular questions in more detail. The outputs of three groups are set out below in the table.

	Owners	**Maintenance**	**Users**
A	Hi-level e.g. DTI, ERP	UKERC in annual consultation with RCs, research community and industry	Policy –makers; research funders
B	Research community in consultation with others	UKERC	RCs, Gvt Depts, ERP, ETI, Bionernergy Funders Forum
C	Research community	UKERC	Direct: research community; research funders Indirect: policy-makers; investors

Participants discussed the above group outputs and concluded a roadmap would be a positive contribution and should aim to provide a coherent view of bioenergy. The roadmap should be based on a set of principles, including sustainability, and should provide a robust yet flexible framework that is free from prescriptive detail. The roadmap should not focus on picking winners, but rather provide options. Users would be high-level policy officials, research funders and investors. Indeed the research community would also make use of the document. There was agreement that the owner should be the research community, and that UKERC should have the task of developing and maintaining it in consultation with the research community. It was also recognised that some key expertise (especially engineering) was missing from the workshop and that these experts should be consulted when developing the roadmap and included in further meetings (see list in the Appendix).

Discussion followed on the way that the roadmap could be used and what could be done to maximise its impact. The Energy Technologies Institute should be taking shape over summer and the Bioenergy Funders Forum has no roadmap; need to make the most of opportunities to maximise the impact of the biomass strategy and the UKERC roadmap.

Based on the output above, the following mission statement was developed and agreed by participants:

"In order to realise the substantial potential of bioenergy to help bring about the transition to a sustainable low-carbon economy, a roadmap is required to inform and guide research. The roadmap will enable the science community,

and those who shape the direction of science, to identify gaps, prioritise funding and unlock the unique potential of the bio-based economy."

GROUP B - What's happening in the world (e.g. politics, socio-economics) to drive increase of deployment and use of bioenergy? What are the 5 most important global considerations?

1) *Climate Change*
   - reduce greenhouse gas emissions
   - meeting government targets
   - pollution control
   - sea level rise, flooding and other climate change effects (e.g. movement of populations)
   - carbon emissions trading
   - crop adaptation – changing pest and disease distribution
   - economics – Stern Report

2) *Energy Security and Supply*
   - decline in fossil fuel
   - geopolitics of fossil fuels – geographical locations
   - meeting renewables targets: electricity; road fuel
   - aviation fuels
   - international trading
   - oil prices
   - demand
   - tension/conflict between nations' energy security and overall environmental good
   - global fuel poverty issues

3) *Flexibility of the bioeconomy*
   - not intermittent
   - several markets: energy and food
   - electricity, heat, fuels, chemicals
   - not many changes needed in farm management (arable crops)
   - disruptive technologies

4) *Development (including social and economic)*
   - social change and popular drivers
   - UK rural diversification
   - new technology opportunities
   - international development opportunities
   - equitable transfer of knowledge of IP globally
   - EU bioeconomy, knowledge economy (expertise)
   - leading by example (e.g. certification, commitments, obligations)
   - CAP reform

5) *Environmental Sustainability (how much of a driver at this point?)*

- global trade issues
- crop mix
- ecosystem services (provision of water, protection of water sources)
- atmospheric pollution control
- biodiversity
- millennium ecosystem targets
- cultural landscapes
- competition for land (e.g. food vs fuel)
- mitigation potential of biological systems
- global responsibility and credit

A brainstorm on constraints and limitations produced the following output:

- public perception (CO_2 doesn't matter)
- research capacity (people, facilities)
- land resource
- showstoppers (maybe 2050; GM?)
- climate change and the environment (food , water)
- lack of confidence and momentum
- lack of commitment from policy and regulation
- R&D co-locates with major markets (e.g. GM)

GROUP C - What topics should the UK roadmap consider or cover and what are the boundaries?

Structure:

The group considered the overall structure of the roadmap and graphically set out a chain comprising three categories: feedstock production (supply chain); conversion; use. Also feeding into conversion are: microbiology; better [reduced?) costs; biorefineries (other outputs), carriers; and enhancement of energy yield. There is also a feedback loop from use to feedstock production. Improving biological input was identified as an aspect of feedstock production.

Other comments related to the fact that the roadmap should not be too narrow or wholly focussed on the UK. The roadmap should also branch out from traditional areas (e.g. include marine) and should certainly consider the whole supply chain from molecular engineering to emissions.

Scale:

- all scales from domestic heat to bio-refineries
- geographical (research/development/deployment)
- timescale
- application

Topics:

- resource availability
- sustainability: carbon and energy balance; economic; society; environment

- waste: landfill; non waste – unused – nomenclature
- public acceptability (planning, NIMBYism)
- environment: impacts; capacity
- basic science/technological developments/application
- all research elements that would be needed in a 2050 bioeconomy:
    - social impacts
    - economics
    - diversity
- Consideration of radical disruptive technologies

Needs:

- vision statement (providing flexibility)
- generic research questions
- short term issues (focused)/longer term needs
- value added
- demonstration

Boundaries:

- should be broad rather than attempting to pick a few winners at this stage
- set of principles that guide a self-organising effort from the UK research community (we don't know the 'right' answer yet) but we know what a good one would look like

The group suggested the following matrix as a useful way of setting out topics and boundaries:

	Sustainability – GHG balance	Waste	Environment	Public acceptance	Basic science and technology	Use deployment
Feedstock development						
Feedstock production						
Conversion technologies						
etc						

GROUP D - What should the roadmap not consider?

The roadmap should not:

- include an analysis of the total investment required – but it could indicate the level of investment required (low/med/high)
- not compare different carbon reduction renewable technologies – but it could state the uniqueness of the bioenergy contribution and could define the methodology/tool to make comparison

- Consider targets (e.g. set aside). This is the role of the policy-maker not the roadmap. However, the roadmap could provide information on limitations, potential etc.. Presentation of targets/timeframes is important e.g. use a date range, not absolute dates
- Consider technologies and benefits for developing countries if there is no benefit to the UK; or if there is a strong case to include such information/analysis, then it should be subject to prioritisation.
- rank/rate research
- Consider technologies/areas which are already commercial, unless value can be added. The roadmap could consider application of commercial technologies in the UK context. The roadmap should fully engage industrialists along the chain
- make assertions regarding the impact on UK security of energy supply but it should consider security of energy supply as a driver and as part of the UK context

Session 3: Bioenergy timeline– what will it look like?

Participants were asked to brainstorm ideas for what the bioenergy sector should look like by 2010, 2020 and 2050. The ideas are listed in the appendix. The discussion and key observations that followed this activity are outlined below.

2010:

The following themes emerged from the brainstorming session:

- Training and research capacity
- International/regulatory issues
- Public understanding
- Deployment and targets
- Decentralisation
- Fundamental underpinning science (restricted to bioscience)

The participants made the following observations on the above output:

- UK currently constrained by infrastructure/grid which will prevent decentralisation of energy supply by 2010 – more realistic as a deliverable by 2050
- 2010 – or 3 yrs – is a short timeframe for mobilisation of science community
- Role of science with respect to informing policy? Science informs evidence based policy.
- Output highlighted more interest in end-points than capacity to deliver – however, Day 2 focuses on research requirements and gaps.
- Inevitable lock-in as regards short term policy and science objectives for 2010
- Group output demonstrated a biological focus and omission of other relevant disciplines
- Land target of 40,000 hectares of perennial energy crops is not realistic by 2010. However, number of hectares is increasing significantly year on year.

2020:

The ideas put forward by the participants were clustered into the following themes:

- Land use, policy and target issues
- Markets, demonstration and deployment (large)
- Commercial activity
- Agricultural practices
- Crop development
- UK energy supply (decentralisation)
- Sustainability
- Standards

Outliers:

- Public understanding
- High risk technologies

The participants reflected on the above output and made the following comments:

- Different categories for 2010 and 2020, in particular movement from training/skills category in 2010 to deployment/commercialisation by 2020 with implicit assumption that skills base and capacity is adequate, in place and maintained.
- Post-Kyoto process key driver. Assumed that CO2 price is a key driver in 2020 as 2010 prices too low.
- Large grouping of agricultural production/development. However, recognised there are some omissions e.g. landfill; sewage; fermentation.
- Output short on scientific breakthroughs by 2020?
- Bioethanol – obsolete or lock-in?
- Perhaps a need for a workshop on future technology issues

2050:

The following themes emerged from the ideas generated by participants:

- Biorefineries and a bio-economy
- Sustainable approach
- Climate change targets
- Biofuel deployment
- Energy crops (GM)
- Innovative basic science
- Decentralisation

After considering the output above, the participants made the following observations:

- Bio-based economy is a significant feature.
- However, new global and UK context (e.g. population size; population movement and distribution; new technologies in all fields). New drivers in 2050 e.g. water shortages.
- Land currently productive will not be in future e.g. southern Europe. Land not currently productive will be e.g. parts of Russia.
- Idea of presenting social vision of economy to the public with a view to obtaining public acceptance. Presentation of vision would be important e.g. lifestyle choice

and engagement or survival/inevitable pathways. Govt likely to take 'survival' route? Would a vision be about enabling supply chains to deliver lifestyle choices?

- In 2050 greater awareness of food versus energy land use limitations with priority for food.
- What is the role of science with respect to providing solutions to complex problems?
- 2050 difficult to make statements/opinions as totally different context and 2020 within current science/policy time horizon whereas 2050 too long term.
- US already laying down investment for biobased economy in 2050 – UK behind? However, US is goal-orientated and putting all eggs in one basket which is not necessarily the right way or most economically effective approach.
- Likely that predominance of other economies such as China and India will be important. China can incorporate bioenergy development as part of sustainable modernisation.

Session 4: Identifying Research Gaps

Participants were asked to identify possible research gaps and a summary of output is given below:

- Plant improvement (all crops)*
  - yield
  - conversion efficiency
  - sustainability
  - new crops (including marine)
  - GM
  - Disease/stress resistance (climate change related)
- Public perception
  - GM
  - Scale
  - Compatibility of crops, landscape and sustainability
  - Credibility
  - Transport/logistics
  - Engagement/education
- Microbial conversion processes (novel routes)
- Membranes
- Cell walls
- Enzymes
- Microbial conversion for energy carriers e.g. biomass to give hydrogen and methane
- Conversion technologies, e.g.
  - thermochemical
  - syngas clean-up – gasification
  - scale down to liquids – scale
  - chemical engineering applications
- Scaling of biogeneration
- Modelling*

  - Whole systems modelling
  - lifecycle; process design
  - climate change impacts; integration different technologies
- Automotive application of biofuels
  - characteristics fuel
  - optimisation
- Environmental sustainability *
  - land use
  - lifecycle
  - biodiversity
  - water icc
  - global context
  - ecosystem service
- Biomass resource (waste)
- Carbon/energy balances
- Economic and socio-economics
- Pre-processing, e.g. pyrolysis

The groups then agreed which five areas were the most important. Participants split into five small groups to consider these topics in more detail, focussing on the following: state of play; what should we be doing; opportunities; limitations.

GROUP A – Uptake of bioenergy technologies

1) State of play
   - limited representation at workshop
   - there is research into uptake of clean technology (e.g. Univ Sussex) but little is specific to bioenergy
   - energy demand
   - development/impact of new markets (e.g. microgeneration)
   - innovation trajectory
   - economic tools for LCA and multi-criteria analyses

2) Opportunities
   - Harnessing marketing concepts/research
   - analysis of barriers to uptake
     i) regulation
     ii) public perception
     iii) awareness/education
   - How to integrate bioenergy potential into the larger picture
     i) Utopic versus pessimistic impetus
     ii) Are we talking about technology or bioeconomy? (Framing)
   - Perception s of environmental sustainability
     i) Process of public learning and engagement
   - Regulation and policy
     i) How regulatory frameworks can act as drivers/barriers

ii) Unforeseen consequences of policy positions
iii) Research into carbon trading systems

- Fostering innovation
  i) Specificity of incentives
  ii) Modelling f innovation trajectories
  iii) New technologies to market – LINKING
  iv) Specific to UK context (advantages)
- Skills base
  i) Perception of biology/engineering/bioenergy
  ii) Training (modelling) required and incentives
  iii) Career progression paths
  iv) Personal wealth creation (UK spinout companies)

GROUP B – feedstock supply

1) State of play
   - UK expertise in miscanthus and willow and poplar, but relatively low funding aimed at doubling yield
     i) Strong fundamental biology and plant science; Gaps – microbial technology

2) What should we be doing?
   - development of poplar, reed energy grass and switchgrass in the UK
   - slow – no large scale investment in genomics, tools available but money needed
   - development of propagation tools to reduce establishment costs
     i) compatibility with environmental objectives
     ii) climate change impacts (2 sites)
   - Energy crops with global change (CO_2 conc.)
   - watching brief on marine options
   - Anaerobic digestion from silage
     i) Other feedstocks for co-digestion – suitability
   - modelling of optimal land use tool – including market forces
     i) efficient use of UK land for energy and food
     ii) strategic needs e.g. transport fuels

3) Opportunities
   - harnessing the fundamental developments in plant science for bioenergy crops and applying models, transitional research
   - options (Japanese knotweed)
   - consequences of diverting agricultural co-products
     i) on other markets (e.g. animal field)
   - feeding through to a range of options – e.g. designer plants

4) Tools missing
   - genomics and high throughput biology
   - Sequencing: should we do it or leave to the US?
   - Trialling system (multi-site)

5) Constraints and limitations
   - public perception (CO_2 doesn't matter)
   - research capacity (people, facilities)
   - land resource
   - Showstoppers (maybe 2050; GM?)
   - climate change and the environment (food , water)
   - lack of confidence and momentum
   - lack of commitment from policy and regulation
   - R&D co-locates with major markets (re GM)

GROUP C – Conversion technologies

	Domestic	Industry	Utility
Heat	X Equipment available, not economic	Economics – where low cost fuel is available	x
Power	X	Yes – Demo: early deployment where feedstock is available	Yes – Co-fire dedicated; landfill gas; sewage sludge; CHP limited. Subsidy ROCs, Free fuel
Fuel/processing	Niche: chopping; chipping; bio-diesel - oil	Yes – Pellets; chips; bio-diesel; vegetable oil	Yes – bio-diesel; bio-ethanol; milling

Opportunities, tools and resources:

	Domestic	Industry	Utility
Heat	Capital cost; public understanding; distance heating infrastructure	Increasing uptake; highlight opportunities	CHP
Power	Technologies not developed; capital cost	Technological improvements; grid infrastructure; incentives	Reduce fuel cost, waste and residues, dedicated technologies
Fuel/processing	Novel solutions: micro wave; milling	Microgrid	2nd generation transport fuels, biorefineries; smaller scale transport fuel/tech; syngas clear-up

GROUP D - Environmental Sustainability

Definition: To exploit today without compromising the future? But not status quo and recovery time

1) *State of play*
   - Millennium Ecosystem Assessment
   - Britain (N Europe) data-rich (e.g. Countryside Survey)
   - Ecosystem goods and services
   - Climate change impacts
     i) Integrated (soil, hydrology, biodiversity etc
     ii) Whole system (beyond bioenergy)
     iii) LCA
     iv) Comparative assessments
     v) Issues
        a. scale
        b. representativeness
        c. sensing technologies
        d. integrated research platform
        e. modelling
        f. rare extreme events
        g. valuation

2) *What should we be doing?*
   - More effort in existing research
   - Integration – land use/conservation
   - Research capacity building
   - Public resistant to change
   - Questions
     i) Do we understand the science?
     ii) Do we understand the application of science?
     iii) Can we forecast future scenarios?
     iv) Can we make effective assessments?
   - Link local/regional/national/global
   - Tools
     i) LCA
     ii) Carbon footprinting
     iii) Non-linear modelling
     iv) EIA
   - raise profile
     i) US
     ii) Research
     iii) Government

GROUP E – Modelling

1) State of play
   - Fragmented
   - Multiplicity

2) Targets – common platform
   - integrate across length/scale

3) Opportunities
   - Predictive science e.g. conversion efficiencies; climate change effects
   - Hypothesis testing/forming
   - Research progress – acceleration
   - Scenario testing to input into policy

4) Limitations
   - People
   - Modelling platforms (integrative)
   - Quantitative data

Session 5: Workshop wrap-up

The wrap-up discussion gave rise to a number of ideas, particularly relating to next steps that should be taken:

- Run 1-day workshops
  - presentation of roadmap summary
  - involve all necessary disciplines and end users
  - invite international experts

- Timeliness – take into account:
  - New docs
    i) DTI tech scanning
    ii) Defra document
  - Timetable
    i) Late 2007 draft
    ii) Report workshop asap
    iii) Volunteers
  - Annual meeting on bioenergy
    i) experts – parallel groups
    ii) wider involvement (avoid overlap (Supergen, BERN)
    iii) focus on research/science
    iv) could link with an annual review of the roadmap

Some comments relating to the content of the map were put forward:

- Develop definition of 'sustainability' more in the preamble

- Matrix of: pure; applied etc….useful for inclusion across bioenergy chain
- Defra output on funding matrix available shortly
- Timeline would be better presented as short, medium, long or with date ranges rather than using fixed years such as 2010, 2020 and 2050

Meeting Agenda

Bioenergy research roadmap workshop

25th -26th April 2007, St Hugh's College, Oxford.

A two-day workshop to bring together a wide range of stakeholders – researchers, research funders, policy-makers and industry representatives -to identify bioenergy research roadmap priorities for the UK with a view to establishing a common document as the UK Bioenergy Research Roadmap up to 2020 that reflects the needs of the bioenergy community.

AGENDA

Tuesday 24th April

19:30 *Welcome drinks and dinner at St Hugh's College Drinks and dinner at St Hugh's College (pre-dinner drinks in small SCR and dinner in the Boardroom)*

Wednesday 25th April

From 8:30 Registration

Session 1: Welcome and introductions

9:00 Welcome and introductions

Session 2: Setting the context

10:00 Presentation of framework document
Gail Taylor, Southampton University

11:00 *Refreshment break*

11:30 Breakout session A: UK roadmap context

Questions to be considered by breakout groups:

1) Will the UK bioenergy roadmap be useful and if so, who is the target audience?
2) What are the global considerations? What's happening in the world (e.g. politics, socio-economics) to drive increase of deployment and use of bioenergy?
3) What should the UK roadmap consider or cover and what are the boundaries? (e.g. feedstocks; conversion technologies; end-uses; imports; environmental sustainability; social-science; ethics; public perceptions….).

13:00 *Lunch*

14:00 Breakout session B: Key drivers

Questions for the breakout groups:

1) What are the major drivers for the UK (e.g. climate change, energy security)?

2) What are the limitations for the UK?
3) Can or should we identify winners for the UK (e.g. bioethanol?)

Session 3: Bioenergy timeline – what will it look like?

15:00 Bioenergy timeline -metaplan What should we be aiming for by 2010, 2020, 2050?

15:30 *Refreshment break*

16:00 Discussion of issues raised by metaplan

Session 4: Summing up

17:00 Plenary wrap-up and review of Day 1

17:30 Close

19:00 *Drinks and dinner at St Hugh's College (pre-dinner drinks in small SCR and dinner in the Boardroom)*

Thursday 26th April

Session 5: Review

09:00 Introduction to Day 2

Session 6: Research gaps and priorities

09:30 Break out session C -Research gaps and priorities

Questions for the breakout groups:
1) Where are the gaps?
2) How do we set priorities?

11:00 *Refreshment break*

11:30 Plenary discussion on research gaps and priorities

Session 7: Summing up

12:00 Plenary summing up, action points and way forward

12:30 *Closing Lunch*

LIST OF ATTENDEES

Name		Organisation
Ian	Shield	Rothamsted Research
Gail	Taylor	University of Southampton
Les	Firbank	Institute of Grassland and Environmental Research
Gillian	Alker	TV Energy and TV Bioenergy Coppice
Richard	Murphy	Imperial College London
Robert	Trezona	Carbon Trust
Katherine	Bass	Defra
Philip	Lowe	RELU, Newcastle University
Charles	Banks	University of Southampton
Iain	Donnison	IGER
Ben	Goh	E.ON UK Power Technology
Debbie	Harding	BBSRC
Ian	Tubby	Forest Research/Biomass Energy Centre
Geoff	Hogan	Biomass Enregy Centre
Benedict	Gove	Natural England
Emma	Frow	ESRC Genomics Policy and Research Forum
Jenny	Jones	Leeds University
Lamb	Chris	John Innes Centre
Phil	Wigge	John Innes Centre
David	Howard	CEH
Neil	Bateman	EPSRC
Chris	Baker	NERC

APPENDIX

1. Inclusion of all stakeholders

Suggested names:
The Porter Alliance, Imperial College
Richard Dinsdale – Glamorgan (H2 from biomass)
Mike Theodorou – IGER (Annaerobic microbial)
Richard Morris – JIC (Modelling)
Other scientists involved in conversion technologies

2. Bioenergy timelines 2010, 2020 and 2050

<u>What should we be aiming for be 2010</u>

Ideas from group:

Training and research capacity

- research alliance with China, India, Brazil, Argentina
- bioenergy an exciting career destination for top talent
- coordinated UK research activity
- coordinated and focused bioenergy research community
- research framework for low carbon economy with integrated funding solution
- Integration of bioenergy research strategy from policy which feeds to researchers
- Started development of research tools to enable translational research
- Interdisciplinary bioenergy advanced training programmes
- Vibrant, coherent bioenergy research community
- Recognised world research leadership in several key areas

International/regulatory issues

- Consistent government policies and grants
- No conversion of primary rainforest to biomass plantations (or leakage)
- Understanding of carbon products versus waste

Public understanding

- public acceptance of GM
- increased public awareness of biomass fuels and conversion technologies
- high level of public understanding of bioenergy
- increasing consumer awareness and purchase of alternative energies

Deployment and targets

- wide demo of 2nd generation bio-transport fuels
- RTFO met (5%) from UK bio fuel plant capacity
- 20,000 ha of energy crops
- 40,000 ha f perennial energy crops

Decentralisation

- regional energy strategies within the UK
- small scale mixed fuel CHP systems (for homes)
- consistent, sustained non-competitive grant funding to support small/medium scale local biomass heat (& CHP) and the biomass fuel supply chain
- create use and incentives for anaerobic digestion

Fundamental underpinning science (restricted to bioscience)

- models for competition for land and natural resources (especially water) and the data and tools to do so
- agreed protocols for environmental and sustainability assessments
- clarity in thinking about: British science strengths and potentials; the viability, potential and trade-offs between different technological options
- genome sequences for energy crops
- metagenomics initiative : bio-inspired sampling
-]transformation systems for bioenergy crops
- Systems biology better tools bioenergy crops
- Faster breeding pipelines: willow; poplar; miscanthus
- Biology of systems: plant; field; region; global
- Crop traits for bioenergy initiative: perenniality; rhizomes etc
- Long term environmental research platform for bioenergy cropping systems
- C5-c6 butanol microbes

What should we be aiming for by 2020?

Ideas from group:

Land use, policy and target issues

- 50,000 ha energy crops
- 20tn/ha biomass crops
- 100,000 ha of perennial energy crops
- Set aside land use for bioenergy sustainable
- 5% UK energy from biomass (all forms)
- 10% of UK energy from bio sources
- 30% renewable electricity; 20% renewable heat; 10% renewable transport fuels

Markets, demonstration and deployment (large)

- decentralised power generation
- all new small/medium CHP power plants in UK are biomass/biogas fed
- Demonstration/research biorefineries to study the potential for high value bio products to subsidise biofuel production
- Dedicated biomass IGCC plants for production of electricity/heat
- Co-firing on advanced coal plant
- Synthetic biology deployment of novel microbial conversions
- Production of bio-synthetic natural gas
- Breakthrough technologies in FT from biomass
- Functioning biorefineries

- Development and early deployment of a bio-aviation fuel
- Biomass to aviation fuel (mass market)
- 2 to 3 large commercial second-generation biofuel plants, 2 syn-diesel, 1 ligno-ethanol plant

Commercial activity

- emerging new major bioenergy companies
  - 10 world leading UK companies commercialising IP from UK research
- Effective markets for carbon, N, natural resources.

Agricultural practices

- agriculture more than self-sufficient in bioenergy
- mixed and cache cropping (maintaining soil carbon)

Crop development

- new crop varieties with higher yields and more sustainable higher conversion
- new bioenergy crops improved
- designer plants for novel biomaterials
- short rotation forestry producing IS and
- Science: optimised breeding program for biofuels; microbiology: lignocelluloses conversion; GM crops; clear commitment to long term funding
- UK is major player in bioenergy research and industry
- Predictive science-based crop breeding
- Domestication of new bioenergy crops
- Improved water us efficient crops

Sustainability

- sustainable liquid biofuel crops
- reduce carbon footprint to 2 planet economy
- practicable process to stabilise climate
- reduction in energy use per capita

Standards

- a global sustainability standard for bioenergy especially biofuels
- assurance/certification for bioenergy crops
- international standard centres for innovation and development in bioenergy

UK energy supply (decentralisation)

- increased local production of CHP
- wide scale use of microgeneration
- real time energy supply demand systems – how much to plant, where etc
- consensus on positioning of bioenergy with respect to other
- UK renewable energy options

Better public understanding of issues surrounding bioenergy – which leads to better public acceptance of new technologies

Fundamental science that could be the basis of disruptive (transformative) technologies

What should we be aiming for by 2050?

Ideas from group:

2050

Biorefineries and a bio-economy

- Robust UK bio-energy economy
- Major shift to a bio-based economy
- Commercial scale biorefinery
- Combined production of bioenergy and high-value products for other industries (biorefineries)
- A systemic bioeconomy
- Biomass the major feedstock for the chemical industry

Sustainable approach

- sustainable provision of food, water and energy
- shifts in land use and new diseases and plants due to climate change
- better matching of fuels (form, production etc) with use
- energy self-sufficiency for an ageing rural population
- increased use of food and wood wastes from landfill to energy production
- sustainable use of agricultural environment

Climate change targets

- reducing overall UK energy demand
- > 5% of UK energy from bio sources
- Bioenergy making a significant contribution to UK GHG reduction
- UK exceeds 60% cut in GHGs due to worsening climate change
- Transport not dominating carbon emissions
- Reduce carbon footprint to 1 planet economy
- Stabilisation of global climate

Biofuel deployment

- biofuel seen as normal fuel source
- replacement of petrochemical feedstocks and to green plant/factories

Energy crops (GM)

- energy crops >25t/ha GM or non-GM
- large scale planting GM – step changing crops
- GM crops for max abiotic stress tolerance, yield, sustainability
- Designer plants
- Integration of plant biology with maths/engineering

Innovative basic science

- novel micro organisms deployed for energy purposes

- major contribution from UK science in establishing bio-energy in developing world
- artificial photosynthesis systems
- basic science feeding into new energy crop varieties

Potential to move towards widespread distribution heat networks