



# **SUPERGEN WORKSHOP 2006**

## Workshop Report

9-10 May 2006, St Hugh's College, Oxford

Edited by:

Jane Palmer, UK Energy Research Centre Meeting Place

**Event organised and sponsored by:**



UK Energy Research Centre

## **THE UK ENERGY RESEARCH CENTRE MEETING PLACE**

The UK Energy Research Centre's mission is to be the UK's pre-eminent centre of research, and source of authoritative information and leadership, on sustainable energy systems. UKERC undertakes world-class research addressing whole-systems aspects of energy supply and use, while developing and maintaining the means to enable cohesive UK research in energy.

A key supporting function of UKERC is the Meeting Place, based in Oxford, which aims to bring together members of the UK energy community and overseas experts from different disciplines, to learn, identify problems, develop solutions and further the energy debate.

## **SUPERGEN**

The SUPERGEN initiative is a large, collaborative programme of research based on the assembly of research consortia which tackle the large challenges of sustainable power generation and supply. The Engineering and Physical Sciences Research Council (EPSRC) has earmarked £25 million of funding for the initiative over a five year programme. The first SUPERGEN consortia started to operate in 2003.

## **CORE ORGANISING TEAM**

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## Workshop Background

Following on from the first SUPERGEN workshop held in June 2005, on 9 and 10 May 2006, the UK Energy Research Centre convened a second workshop bringing together representatives from the 13 SUPERGEN consortia.

The aims of the meeting were to:

- reflect on progress and experience gained within the consortia over the last three years
- discuss the renewals process for the four SUPERGEN 1 consortia;
- introduce the four new SUPERGEN 5 consortia; and
- provide opportunities for networking between consortia.

The meeting had three elements:

- update presentations from EPSRC and UKERC summarising recent developments
- overview presentations from each of the new SUPERGEN 5 consortia
- thematic break-out groups focusing on a range of issues: SUPERGEN renewals, bridging across consortia, co-ordinating bio-energy research, rapid assessment of new materials and materials selection, cross-cutting socio-economic issues, integration of renewables and consequences for the supply system, the role of scenarios as integration tools and transport fuels

The agenda, a list of participants and presentations from the workshop are available on the UKERC website (<http://www.ukerc.ac.uk/content/view/93/187>). Summaries of each of the plenary sessions and break-out groups are set out below.

## Tuesday 9<sup>th</sup> May 2006

### **Update on Research Council's Energy Programme – Andrew Davies, EPSRC**

#### *Research Council Energy Programme*

- Research Council Energy Programme (RCEP) is a cross-RC programme bringing together both individual RC and cross-council research monies – essentially gearing against themselves to increase funds available
- RCEP has a stronger focus on the applied side, with the fundamental science feeding in via the responsive mode. Neil Bateman (EPSRC) has responsibility to make better links between science and applied technologies
- In order to establish what resources were going into energy research, EPSRC had been re-coding its grants records. This had provided an opportunity to tidy up portfolios
- Large proportion of funds towards fusion – this includes both infrastructure as well as research
- Appointing a Senior Research Fellow in late summer (the appointment of Nigel Brandon of Imperial College was subsequently announced)
- EPSRC are open to suggestions in terms of linking fundamental science to the research portfolio
- CCLRC is trying to highlight the energy activities within facilities better
- All RC have some kind of involvement with Supergen
- Socio-economic issues Interested in developing an over-arching socio-economic framework across Supergen consortia and other research council funded programmes e.g. TSEC. Needs to be an exchange of knowledge across disciplines, increasing awareness about benefits and limitations of different methods. Under Supergen, the socio-economic aspects could be incorporated via bridging funding or renewals process

- International linkages: consortia can apply to EPSRC for additional resources for international activity. EPSRC also has some specific funds ear-marked for international activities. May also be funds for international links under ERA-NET
- Developing countries – RC happy to support researchers from developing countries to visit the UK e.g. as visiting fellows, but will not support foreign groups abroad in their own country
- 'Energy & equity' theme will be led by ESRC but funded jointly under the RCEP, so aim to be interdisciplinary
- 'Public attitudes to nuclear' theme had originally been intended to be covered by the Keep Nuclear Option Open consortium, but this had ended up focusing only on the science. There was a need for more interdisciplinary approaches.
- Responsive mode: Amount funded remains the same but EPSRC would like to see more proposals related to energy being submitted – open to proposals at any time in any area, including fusion. People possibly discouraged by lack of success in past, but success rates have improved and are now on a par with those under managed programmes. Being part of a consortia should be presented as a strength under responsive mode if appropriate but a link is not a necessary prerequisite to apply under responsive mode
- Transport & energy: recognised as an area of weakness and therefore a priority. Sustainable Urban Environments (SUE) programme is looking to take this forward but unlikely this will happen until the next comprehensive spending review. ESRC and DfT will be funding a virtual transport centre which will consider ideas on a case by case basis

#### *Plenary discussion*

- Consortium agreement template is helpful but would like something more authoritative from the Research Councils
- Need a statement from Research Councils to state that the project will go ahead even if the Consortium Agreement isn't signed so that delays don't impact negatively on the project (i.e. delayed start cutting into time available for research)
- Advice from existing consortia and an aide memoir for Universities in terms of how the finance works would be helpful – good to gather collective knowledge
- One option for encouraging universities to move more quickly is for the Research Councils not to release funding until the Consortium Agreement is signed

#### **Update on the UK Energy Research Centre – Jim Skea, UKERC**

- The new Energy Research Partnership is now looking at how energy research is currently structured in UK and what the priorities might be
- Office of Science and Innovation now the DTI's Innovation Group (which runs the Technology Programme), as well as RCUK, potentially providing a closer link between industry research and the RC streams
- R&D being considered under the Energy Review. The IEA has also been assessing R&D as part of its wider in-depth review of UK energy policy
- UKERC Studentships: the quality of applications had improved in 2006, with greater understanding of interdisciplinarity and a wider range of disciplinary combinations
- Meeting Place developed as a function rather than a physical place. Presently developing research hotel proposals and looking to bring more international visitors to UK
- Road-maps: systematic review of existing review maps to identify where gaps are, in conjunction with Rutherford Appleton. Using objective benchmarks such as methods and architecture rather than rating in terms of quality. Safeguards are important to ensure that there is a broad base for the development of roadmaps to keep them balanced and prevent bias towards a particular interest group – important to include industry.

- Aim is to provide access to all info relating to energy R&D through the research landscape tool – using IEA nomenclature to make widely compatible and linking to sources outside of UKERC & research council programmes to make comprehensive. One major omission at present is upstream fossil fuels.
- Research Atlas coverage is greater than just research council funded programmes – will include Framework 7 but is mainly public sector. Have started exploratory conversations with BP to ask if they would be willing to release information at a general level – delicate issue in relation to IP. New road maps are being developed using a collaborative process to address this issue
- Utility of Atlas – aiming to be user led rather than software led – want to avoid lack of use (as happened under the Sustainable Development Research Network). Unclear at present if research council and Government interest in this information is transient or more durable. If there is a broad user base, it will require work to keep up to date
- Atlas not intended to form an accountancy style function (e.g. to provide detail on how much has been spent on what each year) – aim is to identify the broad shape of the funding portfolio

#### **UKERC Energy Data Centre – Geoff Dutton, Rutherford Appleton Laboratory**

- Important to ensure the quality of the data – collection process is based on the techniques developed by the British Atmospheric Centre protocols and present focus is on data from UKERC themes, as reliable sources. Will need to scope and cost options for taking in data more widely
- Different research councils have different traditions in terms of the way in which they manage data
- Industry sources are problematic – difficult to know when to trust these
- Protocols for data collection are important to ensure that data is comparable – currently based on BAC template, but certain aspects related to energy will require specific protocols which will be considered as centre develops
- Possibility to set up restricted access to certain data sets

## Presentations from the new SUPERGEN 5 Consortia

#### **Biological Fuel Cells – Bob Slade, University of Surrey**

- Interacts with other consortia e.g. biomass, fuel cells
- Management structure: Industry club has been set up as non-financial, with industrial members able to nominate representatives to sit on the Steering Group. Steering Group can provide advice to executive committee.

#### **Energy Infrastructure (AMPerES) – Simon Rowland, University of Manchester**

- Particular overlaps with Supergens 1, 3 and 5
- Using 'red-amber-green' approach to flag what hasn't been done to industrialists and management
- Want to identify and learn from best practice and problems identified by existing consortia
- Key aspects to obtaining industry funding: call for interest occurred at the right time as well as aggressive marketing by the academic partners and re-shaping of work packages to meet industry requirements to have clear deliverables within 2 years.

- IP issues were not a major challenge – worked hard at modifying expectations of Network Operators – also helped by the fact that they are not manufacturing companies. Only have ownership of a small percentage of the outputs.

### **Wind Energy Technologies** – *Bill Leithead, University of Strathclyde*

- Project management board made up of four academics and two industrial partners: E.ON and Garrard Hassan
- Remit is to focus on technology – public acceptability and socio-economic aspects not currently being addressed
- Main focus is on offshore wind – faces different issues in terms of planning and public acceptability
- Estimates of impacts on costs per kWh are not part of the work programme
- Possible opportunity to carry out action research on public acceptability issues rather than through retrospective case studies

### **Energy Storage** – *Peter Hall, University of Strathclyde*

- Central remit is to scale up devices and make as efficient as possible but need interaction with other consortia to establish where these sit: clear links with SUPERGEN 1
- Dynamics of operation being addressed at systems level – relevant to product development

## **Plenary Discussion**

### *Experience from within existing consortia*

- One option: PV consortium (SUPERGEN 2) got the Consortium Agreement signed within six weeks – circulated it first to the universities to give them opportunity to comment early on and then circulated to industry partners. One industry partner chose not to sign but was still able to interact with an option to join the management team at a later stage so it didn't hold the whole process up.
- PV group actively managed the process by collecting letters of support from people outside consortia with specific skills to bring them in under responsive mode, although not always successful
- Another option is to have Consortium Agreement signed just by the academic partners (as in SUPERGEN 3 Distributed Systems)
- In SUPERGEN 1 Marine, placing a liaison officer from research administration into the project team made a big difference to how paperwork was dealt with

### *Consortia partner selection*

- Ideally need to be up front and transparent in partner selection criteria to avoid issues with e.g. IP at a later stage – set expectations early in the process to ensure that partners are clear about what is involved. SG3 is now in position where two of the industry partners are not bringing their technical IP to the project because it was the only way to go forward
- Industry partners also need to recognise that academic partners have other demands on their time – also educational establishments
- Clarity from EPSRC was requested regarding how consortia are constituted and that consortium members do not always choose their partners. A more structured team selection process would be helpful – based on past experience, EPSRC would now avoid picking consortium members
- Clarity around how the principal investigator (PI) system works – the distinction between the PI and management role is not always clear. Management arrangements are different across consortia although all generally working

- EPSRC deliberately distance themselves from IP issues since this could absorb a lot of time and money – instead the aim is to keep flexibility to prevent lots of stakeholders dropping out
- EPSRC to consider stricter conditions, for example, impose a three month deadline by which time the Consortium Agreement has to be signed otherwise no longer a partner
- EPSRC to provide a model Consortium Agreement and guidance on best practice.
- Doctoral Training Account (DTA) funding: EU students were now covered by this scheme. The scheme may be stopped in the future – Research Councils might prefer to fund studentships directly associated with projects

## Breakout Sessions

### **SUPERGEN Renewals process** – *Andrew Davies, EPSRC*

- Two alternatives proposed – a competitive process with a limited success rate or a core-plus model with core funding available to all consortia but competitive bidding for additional funds
- In August 2006, the first four consortia will submit their annual report and business plan for future - EPSRC to provide a detailed structure of what it expects to see provided. Document to be of similar length to the original submissions, with no limit set on length
- Two-stage process: to be peer reviewed by a small panel outside of UK academia who will be asked to comment on scientific quality and management structure
- 'Plus' projects to look at expanding the scope of consortia and/or linking other consortia together
- Still in consultation mode on renewals process, encouraging feedback from Supergen community. Aim is to finalise by mid-June
- AD to put together a document outlining the key lessons learnt from past experience with stipulations for future and will update presentation in light of discussion in the breakout session, to go on UKERC website

### **Bridging across consortia: developing mechanism** – *Jim Skea, UKERC*

- Jim Skea highlighted the actions and recommendations from last years SG, pointing out that only about 10% were followed through – largely due to it not being clear as who was to take them forward.
- There is the need for better communication within Supergen, in order for people to know what is going on elsewhere. Need to improve the basic communication between the consortia; people need to be able to find their way around.
- The EPSRC energy website has links to the Supergen consortia (<http://www.epsrc.ac.uk/ResearchFunding/Programmes/Energy/Funding/SUPERGEN/default.htm>) but it still needs the right pointers. The contact person for each consortium should be mentioned. There are also concerns over a lack of broad knowledge of what's happening elsewhere, because there is a lack of information on the websites – consortia need to make good websites themselves.
- A structure is needed to apply for bridging activity funds rather than only e-mailing EPSRC. There is the need for more "carrot and stick" mechanisms from EPSRC to give the right incentives to make the bridging happen. The application procedures for funds should be made more flexible; UKERC could help on that.
- There should be some networking activities to make sure that people working in this field meet up regularly - the UKERC Meeting Place could possibly be used.
- More events are needed in order to raise people's eyes from their own research, such as conference-type events, 1-day hot-spot meetings and/or annual

conferences. These could be developed in the context of the NERN (National Energy Research Network).

- Boundaries – keep loose connections with TSEC, RCEP, and ensure it is inclusive to people outside of SG

## Wednesday 10<sup>th</sup> May 2006

### International Linkages

#### **UK Energy Research Centre – Jim Skea, UKERC**

- G8 was a major highlight last year, building good international linkages, including foreign office and overseas councillors. Event generated further events and opportunities e.g. Italian Clean Coal workshop which highlighted a greater need for bilateral links between countries for participation within EU programmes

#### **Engineering & Physical Sciences Research Council – Andrew Davies, EPSRC**

- International aspect in energy is becoming a bigger component with the appointment of the senior research fellow: a UK ambassador for energy at the international level
- Also trying to establish different ways of working with the EU – want to make it an easier route for UK researchers and hopes to build on the current pilot scheme in bio-energy
- Research councils also have the visiting fellowship scheme, overseas travel grants and framework programmes

#### **International Partnership for a Hydrogen Economy (IPHE) – Peter Edwards, Oxford University**

- IPHE takes a top down approach with high input from research community
- Given more power than IEA implementation agreements (which have been criticised for not engaging developing countries e.g. China, Russia, India)
- UK input is through IEA tasks and annexes

### **Discussion**

- There are difficulties in accessing IEA programmes since this has to be via government departments – often low priority with only a small team to deal with. If there is a solid academic case for being involved then EPSRC can liaise with the Government
- Important to have UK involvement (either academic or industrial) at an early stage of the framework in order to influence at a strategic level
- EPSRC keen to help research community to get more involved with Framework 6 e.g. through travel grants. Want to be flexible in providing support at the EU level
- Senior research fellow will have an over-seeing role, keeping aware of what is happening at an international level, including the Framework programme. Will have a complementary role to the UKERC and will report-back through the

UKERC. First task will be to go out into the research community and identify the resource gaps where effort should be focused

- Explicit resourcing is important e.g. time and resources for networking specifically allocated under UKERC – e.g. Meeting Place
- EPSRC want to see the international aspect strengthened within Supergen, both for new consortia and those coming up for renewal

## Breakout Sessions

**Co-ordinating bio-energy research** – *chaired by and notes by Paul Upham, University of Manchester*

- A wide range of disciplines were represented in the group: agronomists, agri-engineering, bio-fuel cells, marine energy storage, engineering reliability, genetics/biochemistry, micro-biology, thermal conversion, hydrogen and wastewater treatment, planning, impact assessment, sociology
- The challenge is how to bring such a range together and make the links between consortia
- There are a considerable number of research programmes related to bioenergy e.g. TSEC-Biosys, RELU, SUE, SHEC, UKERC, Supergen – how do we develop links between these?
- There are thematic links between programmes e.g. hydrogen, bio-refineries, social aspects, as well as many others – best to position such links in the 'plus' bids as part of SUPERGEN renewals or under responsive mode for smaller projects
- UKERC can potentially help facilitate links but intellectual energy is within consortia

**Rapid assessment of new materials and materials selection** – *chaired by Stuart Irvine, University of Wales Bangor; notes by Ken Durose, Durham University*

### 1. Current issues and approaches

- *Need for a digest of resources.* i.e. a survey of the resources available in characterisation and processing
- *Focus on published materials.* Current working practice tends to focus on published materials rather than to investigate new materials. Projects funded on the energy ticket are often delivery focussed whereas new materials work is higher risk and more appropriate for responsive mode funding.
- *High throughput methods* are used in other fields e.g. catalysis, biomedical, but there are few if any energy materials related projects in the UK.
- *Modelling and materials simulation* – computational methods of materials screening are used in materials science – there is an opportunity for the materials community here
- *Usual sequence for materials development* is i) synthesis of a material, ii) characterisation of the material and then iii) fabrication of a device, the functionality of which is an indication of success.
- *Reference samples and calibration standards* are an important part of materials work. There is scope to co-ordinate this, to manage duplication and to collaborate internationally.

### 2. Examples of need for rapid assessment/development of energy materials

- *Transparent conductors* for photovoltaic devices. Need high transparency and high conductivity. Direct use in both thin-film and in organic solar devices
- *Catalysis for H<sub>2</sub> dissociation* – base metal replacements for platinum
- *New materials for H<sub>2</sub> storage*
- *Materials aging issues* – e.g. dielectric properties or super-capacitors
- *Also recognised as an issue*
  - lifetime testing – online condition monitoring

### 3. New approaches

- *Computational methods for new materials screening* – ab-initio methods (density functional theory). This is used to calculate band structure, give band gap sequences etc. The methods are developing significantly. For example, the CASTEP software is now capable of dealing with multinary compounds.
- *High throughput testing and optimisation. Combinatorial methods.* The approach is to deposit many compositions or test pieces on a single substrate and to use automated testing to screen the samples. It is essential to test for the parameters that are relevant to the actual functionality of the material that is to be used in applications. (E.g. Oxygen diffusion, optical transparency, conductivity etc). Such methods are used in catalysis and medical applications, but there is scope to see them used in energy materials.
- *Statistical methods, Taguchi methods and experimental design.* Not new methods, but penetration into all areas of energy materials is not complete.
- *For testing materials with distinctive applications in mind,* testing the actual functionality may require new characterisation methods or new approaches.
  - Magnetic resonance imaging of porous solids – a high resolution method
  - In-situ testing
  - Outsourcing of analysis to specialist suppliers rather than buying all equipment in-house.

### 4. What limits our progress?

- *Limited resources* within our own institutions
- *Information about materials resources.* We need to know what resources are available in other institutions. See
- *Access.* Need to simplify getting access to resources in other institutions
- *Usage of national resources.* Are we using resources such as the RAL instrument pool optimally?
- *Human resources* – where there is apparatus in a particular laboratory there is not always the human resource to make it available for other users from outside.
- *Training in materials engineering* – materials departments are closing nationally – there are long term issues for the subject
- *Typical project profile* supports work with outcomes on the two – three year timescale. Work with longer timescales is discouraged by the present fitting of projects into the typical timescales

### **Cross-cutting socio-economic issues** – chaired by and notes by Rob Flynn, University of Salford

- merit in overarching approach on SE issues across consortia rather than embedding within individual consortia
- consensus that substantive SE work progresses best within specific individual consortia, but also valuable to identify common approaches, share methodologies and develop networks – so concentrate on individual consortia initially
- Identified three topic areas where cross-consortia activity should be prioritised:

1. economic modelling and costing – bringing together engineers, economists & scientists in a systems approach
  2. social acceptability and process for public engagement – learn from different sectors about methods used for engagement – developing common framework, compare and contrast methods and processes in different consortia
  3. impact assessment, planning and regulatory issues across different sectors – bring together
- General agreement to investigate prospects of designing joint work packages as part of each consortium's core activity connected with some or all of these three topic areas at the renewal of Supergen 1 consortia
  - AD comment – SE activities through core is v positive approach
  - LCA and carbon trading are implicitly assumed in areas 1 and 3.
  - There is a spectrum of 'soft' issues which individual consortia would have to refine depending on relevance.
  - EPSRC are supportive of cross-consortium approach in the core package – requires some kind of executive management steering to bring about – could do something in time for August (proposal deadline) across four consortia – lead needs to be from within consortia

**Integration of renewables and consequences for the supply system – chaired by and notes by Graeme Burt, University of Strathclyde**

The consideration of integration requirements is multifaceted and covers many challenges:

- The power interface, including power electronics
- Metering and policy
- Market issues
- Protection and control – appropriateness of transmission solutions at distribution levels questionable; fault ride through requirements
- Generation profile and storage – network impact may present a requirement for storage at a local level (on the generation site) or at a strategic level (network services provision). These applications would impact on electrolyser design.
- Infrastructure and investment
- Regulation and options for reinforcement – distributed energy resources or network capacity.

It was recognised that a number of the above aspects are significantly influenced by the nature of the renewable penetration – will it be achieved through fewer large installations or through many smaller installations. For example, regarding the power electronic interfaces, technical challenges remain for both large and small installations in terms of both materials issues and control algorithms.

It was recognised that while Supergen 1 FNT, Supergen 3 HDPS, and Supergen 5 Infrastructure clearly deal with network issues, the device technologies consortia should also take these into consideration. The latter would clearly have a more local focus, but the options considered for devices and their interfaces would impact on cost and scheme efficiency. The achievement of network-desirable characteristics could have a favourable impact on scheme economics.

Consideration was then given to areas of exposure and need, and the following were discussed:

- Availability of data and models – UKERC's energy data centre initiative should support this
- Power electronics – new effort required. Possible impact on transport applications also.

- Protection and control – new effort required.
- Education and exchange regarding network interface issues – a Supergen workshop may help this and in particular inform the device technologies consortia
- Economic assessment – both device and network elements to be included. Again aided by better exchange across consortia.
- Integrated energy systems with storage – including economic impact supports appropriate focus for research effort in terms of size and location.

**Role of scenarios as integration tools** – chaired by and notes by Paul Ekins, Policy Studies Institute

Paul Ekins introduced a session on the role of scenarios as integration tools, by outlining the purpose of scenarios (ways of characterising and stimulating thought about different futures, rather than predictions or forecasts), and giving some examples of scenarios that had been produced in recent UK work in the areas of energy and climate change.

It emerged in discussion that there was a clear perceived relationship between scenarios and *roadmapping*, which was a major activity being undertaken by the various themes in UKERC, and *modelling*, which was being undertaken in a number of ways by Supergen consortia.

On modelling one research challenge was to understand the differences between, and ways of integrating, very detailed (e.g. the WASP electricity network model) and more aggregate (e.g. MARKAL) technology models, on the one hand, and technology models with different kinds of economic (e.g. computable general equilibrium, or econometric) models, on the other. This was perceived as one possible of cross-consortium cooperation.

In respect of roadmaps, one possible integrating research task was the comparison of different roadmaps of different energy technologies, to see what the common elements were, with a view to informing decision-makers about what decisions would close off options for which technologies, and when such decisions might need to be made.

Joint consideration of models and roadmaps were both ways of considering how the different elements of the energy system being considered by Supergen consortia might be undertaken, with a view to drawing out complementarities, synergies, or mutual incompatibilities. Examples mentioned were hydrogen and electricity systems; hydrogen and different liquid transport fuels; and hydrogen, electricity and DME (di-methyl ether), which was said to be a 'complete' low-carbon energy solution (provided, of course, that the fuels were all derived from non-carbon sources or the carbon was sequestered).

This of course opened up the rather ambitious research possibility of seeking integration of roadmaps and scenarios right across all the Supergen consortia (and, potentially, the UKERC themes as well, not least to bring in the demand side).

However, it was recognised that a pragmatic way to proceed would be to have some common integrating work packages of this kind with the four Supergen 1 consortia that were up for renewal, and to engage in networking with the others, putting in extra bids for research grants as and when the time seemed right.

**Transport fuels** – chaired by and notes by Iain Donnison, Institute of Grassland and Environmental Research

Participants attended this session from Bioenergy, Hydrogen, Highly distributed power and Marine consortia with interests in public perception, stakeholder consultation,

thermal and biological conversion, combustion, gasification, engine reliability, crop production and crop quality impact on conversion efficiency.

A large number of renewable transport fuels are possible and were discussed from fuels capable of use in internal combustion engines and derived from biomass (including primary and synthetic fuels such as diesel, ethanol, methanol, hydrogen, dimethyl ether, methane, hythane, Fischer-Tropsch derived fuels, and fast pyrolysis derived bio-oil), to potential future fuels such as hydrogen derived from a number of sources including biomass and electrolysis. The value of backward compatible fuels was discussed as was the potential of hythane as an intermediate fuel before a hydrogen future. Electric cars were discussed but although generative breaking technology was seen as promising, fully electric cars were seen as of limited potential primarily because of storage (battery) difficulties. Most technologies could be made more environmentally beneficial by combining with carbon sequestration.

Crops can be grown for transport fuels as well as biomass for heat and power. However biomass and biofuel crops are at present of different types with annual crops being grown for transport and perennial crops such as *Miscanthus* and willow for power. For example currently biodiesel and bioethanol are being or will be produced in the UK from oil seed rape, sugar beet and cereal grain. However these first generation fuels will be replaced by perennial crops, exploiting technologies such as lignocelulosic conversion, with far superior carbon and energy balances requiring much lower energy and fertilizer inputs. A range of crops were advocated to expand the range of environments and land types available in the UK to provide biomass and biofuel feedstocks. Advantages of a UK biofuel industry, compared to imports of oil, gas or biomass, were security of supply for the nation and for business models. However there would be a need to make maximum use of land for competing demands of food, energy, transport and other non-food uses.

#### **What SUPERGEN research is of direct relevance to transport?**

A number of areas of potential relevance were identified including:

- Biological derived hydrogen
- Conversion of biomass to carbon based fuels
- Thermal conversion from biomass to hydrogen
- Upgrade of biomass, particularly oils, by hydrogen
- Use of hydrogen as an energy vector
- Bio-oil for boats and possibly other types of transport.

#### **How can and should SUPERGEN interact with transport?**

An opportunity was clearly seen for a cross consortia work package on the production and utilisation of hydrogen in the SUPERGEN renewal process between the Bioenergy, Hydrogen and Marine consortia. Given the flexibility of hydrogen this would apply to both power and transport sectors. Hydrogen was seen as a potential energy vector derived from wind and marine installations mounted in locations distant from main centres of population and energy use. It was stressed that there should be a clear distinction between hydrogen and renewable hydrogen.

#### **How much overlap is there of SUPERGEN with transport?**

It was believed that the power and transport research communities are different but there is definitely overlap of some researchers and research interests. This was primarily in the area of hydrogen but also in factors affecting biomass conversion efficiencies and the issue of competing land resources.

## Plenary Conclusions and Actions

*Jim Skea, UKERC*

- Research community now has a clearer idea about progress In Supergen 5, although Supergen 5 is not so well aware of what is being done in Supergen 1-4
- Greater clarity about renewals process
- Identified where gaps are for bridging opportunities and identified ways of dealing with these gaps to encourage linkages within Supergen
- Support for another meeting next year, although will aim to finish at lunchtime on second day
- Andrew Davies and Jim Skea to identify where responsibilities for action lie and establish process for taking these forward

*Andrew Davies, EPSRC*

- Will set up a discussion board to continue renewals process discussion
- will modify renewals process presentations – put this up on web to show how thinking has evolved
- Feedback from consortia welcomed