UKERC G8 GLENEAGLES 2005 dti

G8 Workshop on Energy Research and Innovation

11-12 May, Oxford, UK

"Improving Collaboration on Clean Energy"

CHAIRMAN'S REPORT

Energy science and technology managers, researchers and other interested individuals from the G8 plus five developing nations (Brazil, China, India, Mexico, South Africa) discussed ways to improve collaboration on clean energy at a two-day workshop in Oxford on 11-12 May 2005. The workshop was a follow-up to the initial meeting in Washington, DC in April 2004 on implementing the Evian Action Plan that committed G8 nations and their research organisations to convene to compare and link programmes and priorities on clean energy.

This technical workshop was convened to stimulate ideas for making energy research and innovation more effective and to encourage closer working relationships.

Existing cooperation to advance clean coal technologies and carbon capture and sequestration (e.g., Carbon Sequestration Leadership Forum), hydrogen technologies, (e.g., International Partnership for the Hydrogen Economy), renewable energy and energy efficiency (e.g., REEEP, REN 21, MEDREP) and nuclear energy (e.g., GEN IV Global International Forum and International Thermonuclear Experimental Reactor), is established and operational. The existing partnerships include some key developing countries and complement the spectrum of energy technologies being progressed through the International Energy Agency (IEA).

The workshop participants made the following observations and recommendations with respect to energy research and innovation, to be put forward for consideration by the Governments of the participating countries.

The workshop participants from G8 countries recognised the pressing need to meet growing global energy demand whilst addressing the challenges of energy security, air pollution and climate change. Developing country participants highlighted the importance of poverty alleviation, economic development and the need for solutions amenable to their needs.

A separate document (the *Workshop Summary Report*) put forward for the Governments of the participating countries to consider, records the observations and recommendations made by workshop delegates. This Chairman's report records, in more detail, the outcomes of the workshops, which gave rise to the observations and recommendations (the latter are shown in italics below).

The key points from the overview session presentations are at Annex A and the conclusions of the breakout sessions on both days are recorded in Annexes B and C.

1. *A range of international networks in developed and developing countries already exist for information sharing and collaboration. Participants did not wish to propose additional international structures.*

Detail: David Irving's independent review of the current status of international energy research programmes and priorities drew on completed country proformas supplemented by IEA country reviews and the synthesis prepared by France following the Evian Summit. The review was presented to the workshop. It concluded that whilst all countries supported the principle of international collaboration there was no appetite for new structures or organisations. This was confirmed in workshop discussions.

2. *There was a widely perceived need to improve current arrangements for collaboration among developed and developing countries. Examples of areas where greater co-operation would be beneficial included: fossil-based systems, carbon capture and storage, solar PV, electricity networks, energy storage, bio-energy, built environment, distributed generation, transport and systems approaches to energy. Bio-energy was cited as an area in which developing countries had experience - although still faced challenges - that developed countries did not. The Italian government alerted participants to its forthcoming International Workshop on Bio-energy in Rome on 14th June 2005.*

Detail: The breakout group on international research capacity identified a number of steps that could be taken to strengthen the current arrangements for collaboration:

- An expectation that participating countries would define the benefits of the collaboration prior to initiating projects.
- More assistance to developing countries with generating data and developing their expertise in the generation of data.
- Encouragement, where appropriate, for developed countries to help developing countries with the methodologies to develop roadmaps in technological areas specific to their needs.

- Encouragement for national research programmes to make international cooperation an integral part of programmes.
- Recognition that regional cooperation between developing countries spreads appropriate technology and expertise and can enhance the capacity to participate in partnerships with developed countries.

3. *There were broad similarities in outlook among all participants in the workshop, along with some differences in perspective based on different national circumstances and levels of development. Participants agreed on the importance of environmental considerations, on the need for secure and affordable energy supplies to power economic growth and development and on the need to avoid increased energy capacity leading to negative long-term legacies. Participants* ***recommended*** *that participating countries continue to work together to explore these shared objectives, analyse further the needs of developing countries and propose solutions for enhancing participation in existing networks. How best to progress this was not fully agreed, although a number of countries saw value in a further meeting.*

Detail: Although there were many similarities in the research priorities identified by developed and developing countries, the focus of these priorities also differed in important ways. For developing countries, increasing access to energy and supplying energy to meet rapidly rising demand were the key drivers, while in developed countries the focus was predominantly on environmental issues and security of supply.

The workshop identified four key rationales for research priorities:

- Affordable energy for all – particularly for developing countries
- Environment
- Economic efficiency
- Security of energy supply

The emphasis on each varied between countries and regions. The priorities potentially conflicted and the challenge was to devise solutions that could satisfy all of them.

The presentation from Dr Maithel of TERI, The Energy and Resources institute, India, pressed for the priorities of the developing countries to be included in the global energy research agenda.

Together with research on new technologies, there was a need for research focused on developing products, based on current technologies, to fulfil the needs of the developing countries. The current arrangements for networking and collaboration between G8 countries and developing countries in energy research were inadequate and new innovative models were needed. An example of a very successful project had been the Swiss Agency for Development and Cooperation/TERI project to develop clean technology packages for energy intensive small and micro enterprises.

4. *A range of international networks in developed and developing countries already exist and are seen to be working well but were often not widely known beyond their participants. The workshop participants saw a need to raise awareness of the networks, their participants and their activities, preferably through the compilation and publication of a network inventory, which could facilitate better interaction.*

The discussion in the breakout group examining existing networks revealed a wide range already operating in developed and developing countries. Awareness of these networks however was often limited to those in which a country participated. There was no complete picture. The group defined networks as "any mechanism through which collaboration can occur." An inventory of all existing networks appropriately publicised would widen knowledge and understanding and help facilitate collaborative efforts. Any inventory should be comprehensive and include the role of business networks and the research carried out by industry on a multi-national basis. The group thought that the IEA was well placed to take forward action on an inventory.

Before any new instrument was designed it was important to identify the tasks. Once this had been done the chances of making use of an existing network or building on an existing network would be assessed. There was broad agreement in this breakout group that the IEA could be asked to convene a meeting between developed and developing countries.

From the business viewpoint there was still a long way to go to coordinate publicly funded programmes within a nation state never mind between states. There were funding and policy gaps at key points in the innovation chain and a need for bold new policy frameworks.

A further suggestion was that a forum specifically for developing countries to share experience and learn from each other could be useful.

5. *The IEA's valuable networking role and its ongoing technology programme was acknowledged. Participants* ***recommended*** *that the IEA raises the visibility of its activities and reinforces links with the international business community and developing countries. This was seen as a responsibility that IEA shares with its member Governments.*

Detail: The IEA model was time-tested and provided a basis for developing new collaboration initiatives. The workshop recognised the range and scope and accumulated expertise of the IEA and the importance of making best use of the IEA's technology programmes, analysis, products, new initiatives and networks.

The workshop thought there was scope however to raise the profile of the IEA. Business, for example, had little or no involvement with the IEA. The IEA was receptive to developing its services, within its resource constraints, recognising that it needed to evolve. It wanted to increase access to its networks and would like to raise the profile of the Agency. The IEA suggested that its members in Working Groups and Implementing Agreements could assist here. It wished to improve the linkages between developed and developing countries, was very willing to be part of the solution and looked forward to working with G8.

6. *Participants saw benefit to all nations of an increase in the shared knowledge base regarding decision tools (e.g., roadmaps, scenarios) for planning and prioritising research activities. They also saw benefit, especially in developing countries, of sharing experience in assessing and evaluating the impact of research programmes.*

Detail: The review of energy research programmes and priorities identified some common features and problems. Most countries tended to have a plethora of agencies and close co-ordination between programmes was essential. Importance was attached to the involvement of industry in the design of programmes. There should be clear strategies, with roadmaps, milestones and evaluation to permit full accountability. A balance needed to be struck between flexibility to adapt to changing circumstances and sufficient continuity for projects to make progress.

The breakout group on designing national research programmes identified the following needs:

- Shared knowledge of scenarios (backcasting, forecasting, roadmaps etc) and methodology to allow for better design of research activities at a national level. This could be through the provision of a virtual network, as part of an existing organisation, but it needed to integrate those producing the scenarios and the users. It was necessary to bring together and exchange in a transparent way the methods and schemes used to evaluate research activities as well as identifying the limitations. The design of research should have an overarching framework/strategy which included energy policy, sustainability, and social aspects.

- In all countries, but particularly developing nations, there was a need for increased assessment and accountability of funding resources, but finding measures to assess accountability was hard. All countries would benefit from shared experience in this area through sharing existing assessment procedures. All countries had regular review programmes in place.

- All nations would benefit from an increase in the shared knowledge base through access to scenarios, backcasting, forecasting, roadmaps and evaluation processes. This would suit the establishment of a virtual network. The IPCC might provide a source for scenarios or the IEA could consider establishing a framework for the sharing of scenarios and contact details.

- A network to allow for an exchange of experience between research institutes and research managers on issues of evaluation etc would be useful. This would be at a 'local' level and could provide a valuable continuing resource.

7. *Participants acknowledged the importance and challenge of effectively advancing technology beyond the research and development phase.*

- Participants identified that the deployment of new technology required significant increase of scale or size of projects beyond that used during laboratory research of new technologies. They acknowledged that new research challenges associated with this increase in scale may arise during the deployment stage. Additionally, participants recognised that there can be problems in obtaining financing for initial deployments as the technology is frequently at a pre-commercial viability stage, where private sector support is difficult to secure.

- Participants noted the desirability, in principle, of international demonstration projects which would help to share knowledge and accelerate deployment. However, they also acknowledged a number of practical issues that need to be addressed. These included siting projects and the capacity of countries to exploit the results. Attendees expressed a desire to see an improved framework based on existing international partnership programmes for taking forward international demonstration projects, which would address these challenges. This could usefully take account of existing and already planned demonstration projects with a view to moving towards a more coherent network of further improvements in international demonstrations.

The break-out group on innovation and the exploitation of R&D came forward with some interesting observations. Though some issues were generic to all deployment and commercialisation of technologies, the energy sector had some very specific characteristics. (i) scale: there had been very few energy innovations that had emerged from small benchtop demonstrations – energy had to be scaled up to massive sizes; (ii) capital intervention – high levels of investment were needed to get energy technologies to market; (iii) the length of time (often decades) it took to reach commercialisation; (iv) the very complex web of intellectual property rights that can be created and which may impede collaboration; (v) the energy industry's huge existing infrastructure and market. This in total is a massive challenge.

Research should be outcome/solution oriented, rather than focused on the promotion of a particular technology. Continuity and long term planning were crucial, and only government was in a position to provide the necessary framework. As energy innovation was characterised by a long gestation period there had to be confidence that the financial and commercial environments were there for the long term.

The stakeholders were many and varied and not naturally cohesive, but big infrastructure projects needed full commitment from all those involved or affected. An informed market place was important; if a new technology was to succeed, effective education/information programmes were essential. Fiscal measures were important and needed to be cleverly designed - not simply subsidies which carried the risk of industrial dependency. Any subsidy system needed a clear exit strategy from the start.

The following issues were discussed in the course of the workshop:

- International norms and standards had an important role to play in encouraging progress and providing a conducive environment for R&D. There was broad support for further work in this area.

- Real concern about the 'valley of death/muddle in the middle' between technical feasibility and commercial viability. There was interest in a broader framework for analysing induced technological change on the lines of the recommendations in IPCC's cross-cutting report. Demonstration of technological feasibility was not enough. To compete in the marketplace the technology had to operate with a reasonable return on investment, at a predictable cost, with adequate personnel available to manage the facility, minimal likelihood of operational or regulatory surprises and widespread public acceptance. It was essential to recognise early on any factors that could inhibit large-scale deployment. Characteristics that were trivial at the small scale could become extremely important at the large scale.

- Full advantage should be taken of the emergence of new instruments to support energy research e.g. more venture capital, the shift of funding around public/private. For innovation to occur, it was necessary for governments to provide long-term vision and a stable policy framework.

- Innovation was not restricted to technology. Innovation was needed also in regulatory and economic policy, market structures and management practices. Some important innovations might be around trading of carbon, improved trading of energy, ensuring "market prices" were paid for energy including external environmental costs. There was scope for innovation in the relationship between the public and private sectors, with the possibility of public/private partnerships and privatisation.

8. *The workshop participants recognised the need to develop human capital able to undertake research development and demonstration into clean energy technologies in both developed and developing countries, preferably using existing networks and initiatives such as exchange and scholarship/fellowship arrangements.*

During the break-out group discussions the importance of maintaining and developing the skilled human capital to progress clean energy research and development was highlighted by most countries.

In the developing countries the increasing need for energy provision meant the demand for skilled resource was increasing, while in some developed countries it was commented that fewer young people were choosing energy technology as a career option so when current experts retired there was a possibility of insufficient trained replacements being available. To support the other recommendations of the workshop on future collaboration, and the training efforts in both developed and developing countries it was believed that the greater use of existing mechanisms to facilitate researcher exchanges, and international scholarships and fellowships should be actively encouraged.

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ANNEX A

Summary of Session 1 overview presentations

1. Energy Research Programmes and Priorities: David Irving

The draft review paper draws on the completed country proformas, post Evian material and IEA data. Prepared by an independent consultant its purpose was to inform and stimulate discussion and the views expressed were not necessarily those of HMG or UKERC.

Key messages were:

- All countries had a plethora of agencies and close co-ordination between programmes was essential. Industry should be involved in designing programmes. There should be clear strategies, with roadmaps, milestones and evaluation to permit full accountability. A balance needed to be struck between flexibility to adapt to changing circumstances and sufficient continuity for projects to make progress.

- The principle of international collaboration in energy R&D is widely supported, but there is no appetite for new structures or organisations.

- There may be signs that countries are not finding sufficient benefit to proactively pursue greater and deeper collaboration.

- There does not seem to any significant attempt to involve the researchers in emerging countries in either the design of programmes or in collaborative research.

2. Overview of IEA's Energy Technology Programme: Graham Campbell

The goals, structures, programmes and activities of the IEA were described.

The closing observations:

- Urged that best use be made of IEA's technology programmes, analysis, products, new initiatives, and networks.

- The IEA model is time-tested, a basis for developing new collaboration initiatives

- IEA Ministers have emphasised publicly their support for clean technologies

- The IEA is open to further development; it must evolve. It wants to offer support, within resources.

3. Technological advance: creating large scale solutions: Gerald Stokes

The IPCC cross-cutting report is in preparation and will provide a useful guide. Between technical feasibility and commercial viability is the 'muddle in the middle'. To address this problem a more cross cutting assessment tool is required:

- Demonstration of technological feasibility is not enough. The technology must also compete in the marketplace (i.e. the technology can be successfully operated with a reasonable return on investment, at a predictable cost, adequate personnel are available to manage the facility, there is minimal likelihood of operational or regulatory surprises and there is widespread public acceptance).

- The factors that might inhibit large scale deployment are recognised early on. Characteristics that are trivial for small scale may be extremely important for large scale. This is a very big issue.

3. A perspective from the Developing Countries: Sameer Maithel

Describing the drivers and the consequential research priorities in the sectors of residential and services, transport, industrial and the power sector in the developing countries, the presentation emphasised the significant differences between these and the drivers and priorities in G8 countries. A key driver for developing countries was the need to improve access to electricity and modern energy services.

The presentation pressed for the priorities of the developing countries to be included in the global energy research agenda. Together with research on new technologies, the research needed to focus on developing products, based on current technologies, to fulfil the needs of the developing countries. The current arrangements for networking and collaboration between G8 countries and developing countries in energy research were inadequate and new innovative models were needed. An example had been the very successful Swiss Agency for Development and Cooperation/TERI project to develop clean technology packages for energy intensive small and micro enterprises.

4. A business perspective: Ian Stephenson

The presenter referred to the wider context: energy supply and security was rising up the agendas of governments and business worldwide; climate change was a reality and it posed a huge global challenge; a greater awareness by governments and businesses of the impact of climate change and the likelihood that this would fall disproportionately upon developing countries.

From the business viewpoint there was still a long way to go to coordinate publicly funded programmes within a nation state never mind between states. There were funding and policy gaps at key points in the innovation chain and a need for bold new policy frameworks. Enlightened businesses were playing their part and two examples of products developed by Johnson Matthey (AquaCat and Amoxis-Hybrid) were described in some detail.

The Carbon Trust was an innovative development by the UK government. It helped organisations reduce carbon emissions and encouraged the development of low carbon technologies. It sought to harness the power and resources of the private sector through imaginative use of public funding, concentrating on where it could make a difference using supported R&D, technology acceleration, incubators and harnessing venture capital. A particular focus was the pre-commercial demonstration phase.

ANNEX B

Record of the conclusions of Day 1 break-out sessions on programmes, priorities and research capacity

Group 1: Rationale, priorities and needs of national programmes

Priorities: The group agreed with the analysis provided in the background paper 'Energy research programmes and priorities'. The principal common research priorities were identified as: energy efficiency, renewable technologies, carbon capture and storage, improved fossil fuel usage, and research into hydrogen and fuel cells. Some countries also prioritised nuclear fusion, nuclear fission, biomass, non-conventional sources of fossil fuel, and energy storage. There was agreement that energy issues did not figure sufficiently prominently in transport research.

Although there were many similarities in the research priorities identified by the developed and developing country, the focus of these priorities also differed in important ways. For developing countries, increasing access to energy and supplying energy to meet rapidly rising demand were the key drivers, while in developed countries the focus was predominantly on environmental issues and security of supply.

Rationale: The group essentially supported the findings of the 'Energy research programmes and priorities' paper. The four key rationales for research priorities were identified as:

- Affordable energy for all – particularly for developing countries
- Environment
- Economic efficiency
- Security of energy supply

The emphasis on each varied between countries and region. The priorities potentially conflict and the challenge was to devise solutions that can satisfy all of them.

Innovation was important. There were different types of innovation: on technology, regulatory and economic policy, market structures and management practices. Technology innovation was required in many areas, with different countries having different priorities. Key areas identified included: renewables, energy storage, aviation, new nuclear, increasing efficiency, hybrid technologies, off-grid solutions. Some of the most important innovations could be around trading of carbon, improved trading of energy, ensuring "market prices" were paid for energy, including external environmental costs.

There was scope also for innovation in the relationship between the public and private sectors, with interest from some group members in public/private partnerships and privatisation. For innovation to occur, governments needed to provide a long-term vision and a stable policy framework.

Group 2: Designing national research programmes

The group identified the following 3 key points:

1. Provide shared knowledge of scenarios (backcasting, forecasting, roadmaps etc) and methodology and distribute them to allow for better design of research activities at a national level. This could be through the provision of a virtual network as part of an existing organisation. Needs to integrate people who produce the scenarios and the users of them.

2. Bring together and exchange in a transparent way the methods and schemes used to evaluate research activities as well as identifying their limitations.

3. The design of research should have an overarching framework/strategy which included energy policy, sustainability, and social aspects.

Summary:

- There is a large measure of commonality in the drivers of energy research and development but these may be conflicting. Common drivers were security, sustainability, and access for developing countries, economic competitiveness, and employment possibilities. Drivers in developing countries could be in conflict with a need for immediate provision of energy and longer term aims.

- During the past decade there has been increasing involvement of stakeholders including industry and public officials in the development of energy policy and roadmaps.

- In all countries, but particularly developing nations, there was a need for increased assessment and accountability of funding resources but finding measures to assess accountability was hard. All countries would benefit from shared experience in this area through the sharing of existing assessment procedures. All countries have existing regular review programmes.

- A trend was for governments to consider various time horizons (short-medium and long term roadmaps) with an increased emphasis on a timescale of 30+ years. The definition of long term varied considerably.

- All nations would benefit from an increase in the shared knowledge base of nations through access to scenarios, backcasting, forecasting, roadmaps and evaluation processes. This would suit the establishment of a virtual network but there was an aversion to the creation of new bodies. The IPCC could be a source for scenarios and/or the IEA could establish a framework for the sharing of scenarios and contact details.

- There is a need when designing research initiatives to consider them in the wider context of energy policy, sustainability and the social implications.

Group 3: Innovation and the exploitation of R&D

The group considered:

- Existing links between R&D and innovation programmes

- Networking arrangements for connecting the business and research communities

- Means for improving links between R&D and innovation programmes with a view to accelerating the exploitation of promising energy technologies

The discussion covered the fact that some issues are generic to all deployment and commercialisation of technologies, but that some things are characteristic to the energy sector. The first is about scale: there have been very few real energy innovations that have sprung from small benchtop demonstrations – energy needs to be scaled up to massive sizes. The second is about capital intervention – the amounts of investment needed to get energy technologies to the market. The third is the time it takes to get to commercialisation – doesn't happen in six month timescales as can do elsewhere, but can take decades. The fourth point is that that can create a very complex web of intellectual property rights which can hamper willingness to collaborate. The last point is that the energy industry has a huge existing infrastructure and market that needs to be overcome/altered – a massive challenge.

Research then – should be outcome/solutions oriented, rather than promoting a particular technology. To do this, a faith in continuity and long term planning are crucial, but only government can provide this framework. They are often not inclined to, but researchers should push in that direction. As mentioned, a characteristic of energy innovation is that it takes a long time to get from start to finish – need reassurance that financial and commercial environments will still be appropriate when get to the end point.

The stakeholders in this area are many and varied, and don't often come together naturally, but big infrastructure issues need full commitment from all. One aspect of this is the importance of informed market place – if a new technology is going to have a chance of success, there needs to be work on education/information and ensuring people understand the risks and advantages – not simply a price/weight comparison, but an understanding of the externalities that may not affect performance of the product, but make all the difference to the environment. Finally – fiscal measures are important and should be clever in design – not just subsidies e.g. pence per kwh. Subsidies were discussed, especially the risk of industrial dependence on these subsidies where they cannot exist independently of them – need clear exit strategies before embarking.

Countries need energy policies to provide continuity for certainty and growth. They will not be able to develop a first class industry without that.

Group 4: International Research Capacity

The group identified the following as important:

- Participating countries should clearly define the benefits of collaboration prior to initiating projects.

- Assistance to developing countries to generate data, and to develop expertise in the generation of data, in order to facilitate collaboration.

- Where appropriate, developed countries should help developing countries with the methodologies required to develop roadmaps in technological areas specific to their needs. This work would help identify the potential areas for collaboration.

- International cooperation should be an integral part of national research programmes.

- S&T collaboration is a long-term effort and it requires:
  - political commitment to ensure continued collaboration;
  - continued long-term funding to ensure long-term collaboration and maximise benefit.

- There is a need to recognise the difference between:
  - intra-developed country collaboration;
  - developed/developing country collaboration.

- Regional cooperation between developing countries spreads appropriate technology and expertise and can enhance the capacity to participate in partnerships with developed countries.

Group 5: Making use of existing networks

The group shared information about existing networks which revealed many existing networks operating in developed and developing countries. The group agreed that the priority was to identify tasks before designing any new networks or instruments. This might reveal a requirement for a new network or a structure which made better use of existing networks.

The group examined a number of options including a new workshop to clarify needs. There was broad agreement that the IEA could be asked to convene a meeting between developed and developing countries to take this forward.

The goal should be the development and diffusion of sustainable energy solutions that contribute to the reduction of greenhouse gas emissions and the alleviation of poverty. As these are global problems, they cannot be separated. The instruments that will achieve these goals need further elaboration to achieve the defined objective. To make progress the group proposed the identification of a more complete understanding/inventory of existing networks. Once these networks and their characteristics were known more consideration could be given to how they might be linked better and what need, if any, there was to create a new network.

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ANNEX C

Record of the conclusions of Day 2 technology break-out sessions

Group 1 - Fossil based systems

Against a background of different country priorities – energy, security, environment, poverty alleviation and local/national/international emissions issues – a broad-based open strategy was needed which embraced a range of clean fossil fuel/fuel systems and encompassed:

- fuel flexibility, recognising and facilitating the link to hydrogen;
- a twin track approach – efficiency improvements as the basis of working towards zero emissions;
- the importance of 'capture ready' approach;
- not just CO2 but also other emissions;
- maximum effect at minimum cost;
- complementary demonstrations worldwide recognising the link to hydrogen production.

Incentives were needed to overcome the incremental costs and capital requirements to accelerate the deployment of new technologies, particularly in the developing countries.

The development of the required human capital in both developed and developing countries should be facilitated using existing networks and initiatives and recognising the importance of continuity of support. Bilateral and multilateral arrangements for staff exchanges should be encouraged.

Group 2 - Carbon capture and Storage (CCS)

Definition: capture of CO2 from large single point industrial sources of CO2, followed by compression and injection of large volume of pure CO2 into the earth's crust at least 800m below the surface, but not more than 2km due to the prohibitive cost of CO2 compression.

Geological targets: easy options were saline aquifiers, hydrocarbon fields More problematic options were coal beds, mineral, e.g. basalt, serpentine.

For the foreseeable future fossil fuels would remain the primary world energy source. CCS was one of the key technologies that could deliver the necessary reductions in emissions and a diverse transport fuel supply in the

longer term. The infrastructure could be achieved within the next few decades. Although the cost of converting existing plants might be too high because of distance from the carbon storage site, new plants should be designed and built in geographical areas which allowed for CCS.

Major demonstration projects in Canada, Norway and Algeria were showing great promise in practicality, safety and stable long term storage capacity. Existing international collaborations and networking were well established and mature. In the science and engineering community they were functional.

Key issues:

- Cost was an issue for widespread commercial development of carbon capture and storage at large point sources, such as power plants, cement works, steel works, chemical plants, synthetic fuel plants and hydrogen production facilities.

- A need for further research and monitoring of demonstration storage sites – e.g. degree of CO2 leakage, operating characteristics.

- A need for large scale integrated demonstration projects with power plants.

- A need to relax the requirements of purity of CO2 to reduce cost and allow power plants leeway. It was necessary to understand the geological interaction with impure CO2 and the amount of leeway.

- Outreach was crucial – currently there was a lack of public outreach and public demonstration programmes.

- There were some intellectual property issues on the capture side.

- There was a need for incentives from government to encourage CCS and an appropriate stable regulatory framework covering liability, safety, security and long-term storage was essential for public and commercial acceptance.

- The barriers for carbon capture were primarily technical and for carbon storage they were legal/regulatory.

The following actions would assist:

- Mapping of geological storage capacity would help with strategic planning of energy infrastructure. This was particularly relevant for emerging economies.

- Improving linkages between developed countries and emerging economies. E.g. CSLF, IEA Clean Coal Centre, FP7 and IPCC.

- Large-scale integrated demonstration projects in the power generation sector.

- More public outreach work.

Group 3 - Networks

Challenges identified:

- Ageing networks – finding a balance between replacing or managing old networks.
- Load issues: meeting load growth (especially with electrification programmes in developing countries) versus mature systems which can be tuned and also changes in the type of load e.g. moves to digital systems and power quality.
- Distributed generation – to accommodate wind, PV and small scale/local generation.
- Intermittency problems - especially on islands.
- The effects of liberalisation with a need for clarity around policies and tools.
- Long-distance transmission – both the technical challenge and the issue of continental-scale networks.

Tools identified:

- Policy tools affecting reliability, investment levels and types of network (rural, urban, developing, developed).
- Interconnection.
- Storage.
- New network technologies (e.g. fault current limiters) within the network.
- Micro-grids.
- Demand side measures.

Conclusions reached:

- There was the issue of developed countries with mature networks versus developing countries undergoing electrification. However developing electrification could be split into rural electrification versus urban load management.

- Networks existed which could be extended: the EU technology platform (EU, USA and Japan) could be used for G8/developed countries/mature networks. This examined broad issues – policy, research and regulation. The IEA Implementing Agreements (IA) provided a mechanism to focus on specific technology issues. It might be possible to identify parts of existing IAs which it would be better to consider in the proposed Transmission and Distribution IA.

- Some technologies were well developed but not mature because of the barriers to their application. There was potential for developing demonstrator projects to further examine application of selected technologies. There might be potential for expanding micro-grids into national systems.

- The issue of who potentially could solve problems/remove barriers needed to be addressed before decisions were made on incentives to stimulate development.

Group 4: Biomass and biofuels

A full exchange of information identified some of the barriers to progress in the main feedstock to product thread areas:

A: Crops – starch and sugar – fermentation – ethanol
Technology well known and not a barrier
Barrier is the price of oil – needs to be financially sensible
Improvement of membrane distillation
Process approach to minimising carbon emissions
Increase efficiency CHP
Use of gasification to give more options for markets for products.
Increase ratio carbon from ethanol and carbon used to produce ethanol –
Better understanding of life cycle cost.

B: Waste oils or crops – lipids – transesterfication – biodiesel (bi product glycerol)
Need new feed stocks –security of supply an issue
Maximise efficiency

C: Waste and crop residue trees and crops - lignocellulosics (general biomass) – combustion – heat and power
Emission control.
Scale – making combustion (bigger) gasification suitable for smaller scale
Engine technology currently being developed where biomass is just one of the fuels for the engines.
Diesel engine development.
Small scale clean solid fuel combustion - residue issues.
Problem of gasifying and then transporting

Key conclusions:

- A range of 'feedstock-to-product' threads have been or are being developed to address opportunities for biomass use in heat and power generation, transportation fuels, etc. Countries are developing different fuels in different ways. These provide many new opportunities for environmental benefits, renewable energy supply, and economic development. The drivers for these vary significantly between developed and developing nations. Developing countries with a primary focus on alleviating poverty are looking for the assistance of the developed nations to adapt existing technologies to local needs. On the other hand, other nations are focused on reducing cost and increasing efficiency of biomass conversion technologies.

- International workshops are required to address the needs of developing nations wishing to address poverty and to develop a strategy for technology transfer and implementation between all countries. The International Workshop on Bio-energy in Rome on 14th June 2005 could help to move towards this goal.

- The sustainability of bioenergy uptake should be explored and evaluated from a systems analysis / product lifecycle point of view and needs to consider issues of policy, land-use change, climate impact, socio-economic implications, and biodiversity.

Group 5 - Photovoltaics

The group briefly considered all solar energy technologies, including solar thermal electricity, heating and cooling, in addition to PV. It was decided to focus discussion on PV. The Group also discussed the merits of a demonstration large-scale PV solar power station.

In 2004 for the first time 1 GW of energy was produced. By 2030 it was believed that there would be 1000GW installed peak capacity worldwide.

The key challenges facing solar PV in developing and developed countries were identified as including:

- Reducing costs for cells and modules by increasing efficiencies, reducing material consumption, developing low-cost, high-throughput processing, large area module production and new cell concepts.

- Reducing costs for integrated system and optimising implementation through building integrated PV, inverters and resolving grid-connection issues (e.g. intermittency) and resolving storage (e.g. batteries) issues.

Recommendations:

- Raise the profile**:** Solar PV technologies needed a higher profile in view of their important role in future energy systems. The technology had some unique characteristics that were particularly important in the longer-term, such as use in remote power applications (especially important in developing countries) and distributed generation networks (e.g. developed countries). Raising the profile of PV also required an understanding of the comparative advantages of PV over other renewable technologies (e.g. biomass).

- Networking and collaborative research**:** There was a broad consensus that a joint-research project might look at the major challenges facing PV. A G8 plus 5 Working Group, set up through an existing structure like the IEA, might be the best vehicle to take this forward.

Group 6 - Built environment

Technological challenges/barriers to implementing technology included:

- A need to raise awareness and increase the information available to consumers.
- Cheap energy supplies removed the incentive to reduce consumption even when cost effective means were available – behaviour needed to change.
- Design considerations and energy efficiency could conflict.
- The technology should be more accessible, including training for installers, and more affordable, particularly for developing countries.
- Some reluctance by power companies to accommodate energy from distributed generation.

Existing mechanisms to encourage the technology included:

- Building standards and legislation.
- Raising consumer awareness e.g. invoices to consumers with information on energy use, pre payment cards.
- Measurement tools e.g. Germany's 'energy passport', Japan's air quality measures.

Actions that could be taken included:

- Mechanisms at international level to share technology and best practice and learn from mistakes.
- A mechanism to address the information gap between the international level and the local level.
- Improving awareness and access to information for consumers, backed by regulation and an appropriate enforcement system.

- Metering consumption.
- Trading mechanisms to encourage energy efficiency.
- There could be an annual review of what countries had done to introduce integrated policy actions in order to share experience.

Conclusion: The technology was available, but a major thrust was required in the area of information dissemination and implementation. Work was needed:

- To develop the appropriate technological solutions for the mass market, and different situations to facilitate implementation.
- To address the problem that whilst knowledge transfer happened amongst the international academic research community it was not happening between them and local level practitioners.
- To look at what was not working i.e. bad practice as well as good practice.

There was a need to establish what was required to facilitate implementation of the existing technologies e.g. information dissemination, procurement opportunities, standards, strategy development etc.

Scenarios were a useful method for evaluating possible options and quantifying the results.

Group 7 - Surface Transport

1. The common issues identified were secure mobility (included congestion, fuel supply/availability and cost, condition of the infrastructure), protection for the environment and public health (the effects at global and local level) and safety. There was a consensus over general issues but recognition that problems manifested themselves in different ways depending on the level of development. Different countries would rank these issues in a different order.

2. The challenges covered different disciplines and all required further research. The topics identified included technology (e.g. hydrogen, fuel cell), infrastructure (e.g. cultivation, distribution, etc.), policy (e.g. harmonisation of regulation), economics (e.g. employment, balance of payments). There was a split between developed and developing nations in capacity and priorities: with a focus on hydrogen in developed countries, and an interest biofuel across all countries (with strong expertise in Brazil).

3. A synthesis of the discussion identified different instruments for addressing issues:

    - the role of a network should be defined and the function and effectiveness of existing networks should be surveyed and matched against the definition. If any matches were found they should be co-ordinated. The danger of network fatigue was recognised. It was proposed that the IEA be asked to take on this task.

    - The maturity of research in different areas should be assessed. Hydrogen and fuel cells were still in need of continued support for basic technological research. Biofuels was seen as near to global delivery and already a major component of the fuel mix in some countries. There was no agreement over the style of research and disciplines that should be included, but it was agreed that the priority should be development and deployment rather than basic technological research. Apart from technology there was a need for research on aspects of policy, economics, sociology, agriculture etc.

    - Discussion focused on hydrogen and biofuels but the wider topics of energy conversion efficiency, demand management and mass transport were touched upon and their importance recognised as possibly providing the means for a step change or the key to future solutions.

A general observation made in plenary was that energy issues had not figured sufficiently prominently in transport research.