

Scotland's Energy & Environment: The Technological & Social Challenges

A Discussion Forum at
SNH Battleby Centre, near Perth

30 May 2007

Organised by

Edinburgh Consortium for Rural Research
and United Kingdom Energy Research
Centre



UKERC



in association with

Aberdeen Research Consortium and Scottish Natural Heritage
with sponsorship by the Scottish Executive



SCOTTISH EXECUTIVE

Notes

SCOTTISH ENERGY FORUM PROGRAMME 30 MAY 2007

08:45 Registration

09:10 Welcome: Chris Browitt, Edinburgh Consortium for Rural Research

09:15 Keynote Lecture-The Energy Challenges: Jim Skea, UK Energy Res Centre

Session 1: Nuclear, Oil, Gas, Coal

Chair: Chris Browitt, Edinburgh Consortium for Rural Research

10:00 Fossil Fuels and Nuclear: What is their Energy Future?: Stuart Haszeldine, Edinburgh University

10:30 Discussion

10:50 Coffee/Tea

Session 2: Wind: Onshore and Offshore

Chair: Luke Reade, Edinburgh University

11:10 Wind Technology: Bill Leithead, Strathclyde University

11:30 Interactions between Birds and Wind Farms: Rowena Langston, RSPB

11:50 Social Aspects of Wind Farms: Claire Haggett, Newcastle University

12:10 Discussion

12:30 Lunch

Session 3: Marine

Chair: Paul Mitchell, Aberdeen University

13:40 Emerging Marine Energy Technologies: Robin Wallace, Edinburgh University

14:00 Socio-economic and Environmental Impacts: Sandy Kerr, Heriot-Watt University, Orkney

14:20 Discussion

Session 4 Biomass/Biofuels

Chair: Paul Mitchell, Aberdeen University

14:40 Biomass to Butanol Distribution: Martin Tangney, Napier University

15:00 Biomass/Biofuels in the Environment and Communities: Nicholas Gubbins and Kevin Dickson, Highlands & Islands Community Energy Company

15:20 Discussion

15:40 Coffee/Tea

Session 5 Solar/ PV and Hydro

Chair: Chris Browitt, Edinburgh Consortium for Rural Research

16:00 Prospects for Photo-Voltaics in the UK: David Infield, Loughborough Univ

16:20 From Hydro to Energy Company: Keith MacLean, Scottish and Southern Energy

16:50 Discussion

17:30-18:30 Reception

Notes

Opening Session
Chair: Chris Browitt, Edinburgh Consortium for Rural Research

Welcome

Chris Browitt, Edinburgh Consortium for Rural Research

This Scottish Energy Forum will cover traditional and renewable energy technologies on the supply side, and will have a particular focus on their environmental and social impacts. We need renewables in the face of climate change and its inevitable impact of at least a 2C rise by 2050; otherwise, the impact will be considerably greater. Much of the technology is already available, leaving the potential barriers to implementation in the environmental and social issues. It is here that insufficient understanding, research and data exist, and, therefore, where the main debate must lie to assist rapid take-up, acceptance and ownership by our communities. Lessons learnt in these fields will benefit the export success of our emerging renewables industry. In his opening keynote address, Jim Skea, Research Director of the UK Energy Research Centre, will ensure that the demand side is not neglected given the potential prospect of a large environmental saving there. Each of the 5 sessions: Oil and Gas/Coal/Nuclear; Wind Onshore/Offshore; Marine; Biomass/Biofuels; Solar/Hydro, will comprise a summary of the technologies and a presentation on environmental/social issues together with a discussion. These contributions are enhanced by sponsors, speakers and delegates from further afield whom we particularly welcome; their time input and their expertise is very much appreciated. I draw your attention to their logos which appear on the front cover of this abstract volume. On your behalf, I would like to give a particular thank you to SNH for provision of their Battleby Conference facilities, and to the Renewables & Consents Policy Unit of the Scottish Executive for their direct sponsorship.

The Energy Challenges

Jim Skea, UK Energy Research Centre

The two most pressing challenges in the energy sector are securing deep cuts in greenhouse gas emissions in the coming decades and ensuring the reliability of energy supplies. Worldwide it is expected that demand for fossil fuels, including oil, expand. Without action, carbon dioxide emissions will continue to rise rapidly. Although the era of cheap oil is probably over, more expensive (and more environmentally damaging) sources of liquid hydrocarbons are available, such as the tar sands in Alberta Canada. Meanwhile, the UK is on the point of losing its self-sufficiency in both oil and gas, implying that positive steps will be required to maintain diversity and hence security of supply.

Technologically speaking, the four broad approaches for addressing these challenges lie in energy saving, capturing and storing the carbon associated with fossil fuel use, nuclear power and renewables. Recent work by the International Energy Agency suggests that energy saving could make the largest contribution, but a portfolio of approaches will be needed. The precise mix of measures will depend on how climate change and supply security are prioritised, though many actions will help address both challenges. As well as the application of technology, lifestyle changes may also be needed if climate change ambitions are to be met.

There has been considerable progress in developing new policies in the energy sector. The EU's new energy policy for Europe specifies ambitious, legally binding targets for renewable energy. Across the EU, 20% of energy demand (not just electricity) should come from renewable sources by 2020. This target has yet to be allocated among the Member States. In the UK, the Energy White Paper released in May envisages some innovative new measures to tackle energy demand, reform of the renewables obligation, a carbon capture and storage competition and measures to remove barriers to investment in new nuclear power stations.

Session 1: Nuclear, Oil, Gas, Coal

Chair: Chris Browitt, Edinburgh Consortium for Rural Research

Fossil Fuels and Nuclear: What is their Energy Future?: *Stuart Haszeldine, Edinburgh University*

The future of Scottish energy supply is frequently discussed in terms of a revolution in renewable energies. Do "traditional" energy sources have a role to play, and if so what? The present mix of Scottish electricity and of all-energy will be outlined. Energy for transport and for heat appear much more difficult issues than electricity generation. Constraints on the prognosed resource supply of coal, oil and gas will be summarized. The planned lifetime of present electricity generation plant, fuelled by gas coal and nuclear, is compared to historical needs for electricity supply. Future growth rate in renewable supplies is compared to timescales of delivery for traditional generation. Options for low carbon futures with nuclear new-build, and with carbon capture from centralized coal and gas plant, will be discussed and some Scottish advantages and disadvantages of each suggested. This appears to point to a set of choices required now to balance risk of non-delivery against risk of public unacceptability, and risk of missing CO2 reduction requirements.

Session 2: Wind: Onshore and Offshore
Chair: Luke Reade, University of Edinburgh

Wind Technology

Bill Leithead, Strathclyde University

From its rebirth in the early 1980s, the rate of development of Wind Energy has been dramatic. The size of the wind turbines has increased rapidly from a rated power of 100kW or less to 5MW. Today other than Hydropower, it is the most important of the renewable sources of power. The large-scale exploitation of Wind Energy was pioneered in Europe by Denmark, Germany and Spain. Although the wind resource in the UK is very substantial, particularly in Scotland, its exploitation in the UK has been slow with the first wind installed only in 1990. However, the pace of development is now increasing and wind turbines are becoming a familiar presence in the countryside. The UK Government has adopted ambitious targets for renewable energy of 20% from wind by 2020. Much of this, by necessity, must be met by wind energy. For this potential to be fully realised, many challenges will need to be met. Nevertheless wind energy will, very likely, become increasingly important over the next two decades. An overview of wind technology, from the extraction of energy from the wind to its incorporation into the electricity supply network, is presented. In addition, the improvement in the technology over last two decades and the prospects for offshore deployment will be discussed.

Interactions between Birds and Wind Farms:

Rowena Langston, RSPB

The main sources of impacts for birds that may arise from wind farms are: collision with turbines, disturbance displacement, barriers to movement, and habitat loss or change. There is a high degree of species and site specificity to impacts. Not all birds are equally affected and effects at one site may not be replicated at another site. Generally, direct habitat loss or change is not a problem. However, where sensitive habitats are involved, e.g. some peatland habitats, there may be a much larger impact zone than that occupied by the turbines and associated structures such as roads. Even where effects of individual wind farms may be minimal, there may be greater cumulative effects associated with multiple wind farms and other developments. For example, the increased energy demand necessitated by flying around, instead of through, a wind farm for a migrating duck may be inconsequential or readily compensated for, but if similar detours are made at various points along the migratory flyway, there may be cumulative energetic consequences reducing fitness and survival. Similar effects can arise as a result of disturbance displacement from wind farms, as this equates to effective habitat loss. The consequences of such displacement will depend upon the bird's investment in that location and the availability of suitable alternatives of equivalent quality. Collision has a direct effect on mortality and even small increases in death rate may be significant for species of generally long-lived birds that have inherently low reproductive rates, notably so when their populations are small. There are two levels of concern, for the conservation objectives of Natura 2000 sites (EU Birds & Habitats Directives), for which there are legal obligations for their protection, and for the effect on population size for individual species. Changes that lead to reduced breeding productivity or reduced survival will ultimately lead to population decline, unless density-dependent responses

occur to compensate for losses. Furthermore, there may be a time lag before any declines manifest themselves. The importance of location in minimising the likelihood of adverse impacts highlights the value of site selection and strategic planning. Good baseline data, monitoring, research, and consultation are all essential requirements for responsible wind energy development. Long-term studies are needed, at least on a sample of sites, to permit the distinction to be made between any short-term and long-term effects.

Social Aspects of Wind Farms

Claire Haggett, Newcastle University

Never has there been greater concern about where our energy will come from; yet at a time when renewable energy could be coming to the fore, wind farms are often met with vocal and vociferous public resistance. Moreover, this resistance is effective, with developments regularly refused planning permission directly because of the extent and strength of public opposition.

This presentation will present a synthesis of the research on opposition to wind farms, and report on the latest, multi-disciplinary, work on this issue. It will argue that opposition has to be understood, rather than just overcome or dismissed. Indeed, efforts made to overcome opposition are likely to be unsuccessful and incite further antagonism if they do not understand or address the roots of that opposition. This presentation will highlight research on some of the motivations for protest, and discuss the impact these have had on several case studies (both on- and off-shore). It will then suggest possible lessons from this research, and will give examples of where new ways of working have been implemented, leading to more successful scenarios for the future.

Session 3: Marine
Chair: Paul Mitchell, Aberdeen University

Emerging Marine Energy Technologies
Robin Wallace, Edinburgh University

This talk will describe the nature and extent of the marine energy resources around Scotland and give an overview of the status of the technology and infrastructure that can harness and deliver them. It will highlight some remaining challenges and ongoing research that addresses them.

Socio-economic and Environmental Impacts
Sandy Kerr, International Centre for Island Technology, Heriot-Watt University, Orkney

Twenty years ago commercial wind technology was being refined with prototype large-scale devices installed in Orkney. Today the marine energy sector is at a similar stage. Again Orkney is playing a key role with some of the world's first full-scale marine energy converters (MECs) being tested at the European Marine Energy Centre. Most R&D activity focuses on narrow technical issues: energy capture, hydrodynamics, moorings, grid connections etc.

Looking at the onshore wind sector today we can see that technical issues are no longer the focus of attention. Key issues include environmental impact, stakeholder conflict, and issues of ownership and the distribution of incomes. Furthermore there is a planning system that has failed to take a strategic national approach and relies on often, uncoordinated, case by case, region by region, decision making.

The evolution of the marine energy sector is likely to follow a similar path to that of onshore wind. The prediction and monitoring of environmental effects of MECs presents major challenges. The recently published Scottish Marine Renewables SEA has highlighted gaps in baseline environmental data. Not only is baseline data often missing but acquiring it can be time consuming, and expensive. There is now a need to prioritise effort around the most significant gaps in environmental data. There is also a need to develop cost efficient monitoring techniques, together with modelling techniques, which can help us predict environmental change.

The Scottish Executive has two interests in marine renewables: addressing climate change and economic development. A successful marine energy industry has potential to create wealth and employment. However manufacturing will probably be based around existing engineering facilities. Employment opportunities for rural communities may centre on servicing and maintenance. There is also potential for localised clusters of R&D and service sector activity.

Other economic benefits for rural communities will depend on the scope for rental payments and/or the ownership of developments. In the case of onshore wind this is a source of conflict. At the moment there are few opportunities for local communities to secure 'rent' from the energy in the marine environment that surrounds them.

Finally the nature of rights of access to the sea and its resources must be addressed. The effects of closed areas around marine energy farms needs to be considered. In particular a dialogue needs to be established with the fishing community. This fragmented stakeholder group has strongly resisted exclusion from sea areas in the past and similar exclusions around marine energy development may result in conflict.

The marine energy sector (developers, regulators and academia) can learn much from the development of onshore wind. The successful development of marine energy resources requires early work to address gaps in our understanding of environmental effect and the conflicts that may arise from this new industry.

Session 4: Biomass/Biofuels
Chair: Paul Mitchell, Aberdeen University

Biomass to Butanol Distribution

Martin Tangney, School of Life Sciences, Napier University

There are few subjects as topical as global warming and the associated importance of reducing carbon emissions. In this respect the development of the biofuel industry is recognised as key - as evident by a number of recent government directives, including the UK Road Transport Fuels Obligation (RTFO), which requires that 5% of the UK's transport fuel comes from a renewable source by 2010, while the EU has decreed that biofuels should account for 5.75% of total fuel sales by 2010 and 10% by 2020. This has stimulated a global race to internationalise biofuels which, unlike petrol, are CO₂ neutral and do not contribute to global warming. Although biofuel production in the EU is currently low these recent directives on renewable energy dictate that the expansion of this industry is inevitable. Hence, the development of a competitive UK industry is both critical and imminent, with butanol production being a potential key to this success. Butanol is now recognised as an extremely important second generation biofuel and is considered superior to ethanol due to its higher calorific value (ie more energy), lower vapour pressure (allowing easier storage and transportation) and the fact that it can be blended at relatively higher concentrations with petrol. A further advantage of butanol as a biofuel is that in contrast to ethanol it can be blended with (bio)diesel.

An obvious route to large scale butanol production is via industrial fermentation. Microbial fermentations have long been established as biotechnological processes, whereby the available carbon in a (cheap) starting substrate is metabolised by a micro-organism and converted into a more valuable end product – as, for example, the bioconversion by yeast of the sugar in grape juice into alcohol in wine. The industrial acetone/butanol/ethanol (ABE) fermentation by solventogenic species of the anaerobic Genus *Clostridium* was once one of the largest biotechnology processes in the world. Its decline since the 1950's was due to an inability to compete with the petrochemical industry, largely as a consequence of increasing substrate costs and the relative inefficiency of bioconversion of substrate to product. However, as oil resources are finite and with the current general interest in renewable resources, attention has once again turned to the ABE process – and, in particular, to its immense potential in the microbial production of butanol.

The large scale industrial production of bio-butanol using clostridia will depend on a number of critical factors, not least of which is the identification and development of a cost-effective fermentation feedstock. There is also a distinct need to develop a more comprehensive understanding of the technology and the biology of the process – and indeed using contemporary technologies, such as genomics and molecular biology, fundamental biological activities of clostridia, such as the uptake and metabolism of specific carbon sources, are currently under investigation. In the light of unprecedented support for research in this area, there is genuine optimism that such work will spawn the scientific advances that will underpin butanol/biofuel production in the UK and beyond.

Biomass/Biofuels in the Environment and Communities

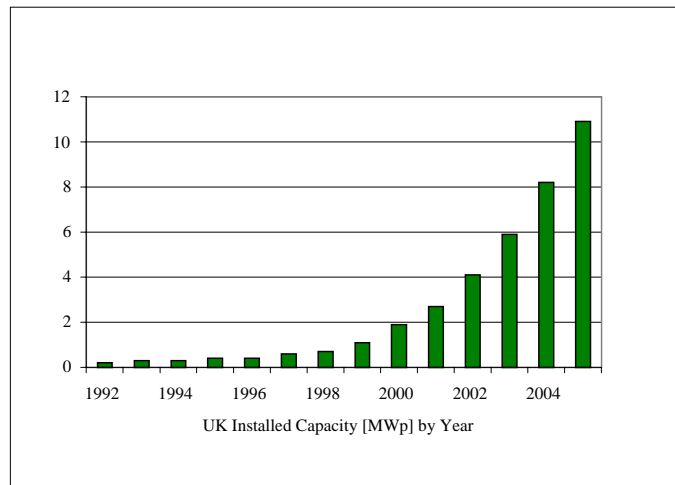
Nicholas Gubbins and Kevin Dickson, Highlands & Islands Community Energy Company

Traditional centralised energy supply options are limited in rural areas with increased costs and high emissions. HICEC have worked extensively to identify, install and monitor renewable energy options for community usage. Biomass can offer low carbon heating and power with reduced costs and increased local economic activity. Barriers do remain and the development of supply and demand must be considered together with HICEC undertaking measures to encourage local production for distributed demand. Biodiesel solutions are also under review with demand growing greatly and scalable production possible.

Session 5: Solar/ PV and Hydro
Chair: Chris Browitt, Edinburgh Consortium for Rural Research

Prospects for Photo-Voltaics in the UK
David Infield, Loughborough University

Photovoltaics (PV for short) is experiencing rapid growth world wide with year on year increases in manufactured volume exceeding 30% over a number of years. The UK is not yet fully engaged in this process, perhaps in part because radiation levels are somewhat lower than in some other countries, but also reflecting only modest Government commitment. Nevertheless, the prospects in the UK are good. There is an excellent research base in the fundamental materials science, a growing capability in device fabrication and characterisation, and a strong commercial sector concerned with the design and manufacture of advanced materials processing technology. And, despite the present low level of installed PV capacity in the UK (around 10 MW in 2005), growth rates are respectable, see figure below.



PV system costs remain high and even with Government grants, this presents a serious impediment to market growth. Research aimed at significant cost reduction is critical at this stage. The UK Energy Research Centre (UKERC) has recently completed a research road-mapping exercise to help the funding agencies determine research priorities and to refine their research and development programmes accordingly. The context for the research road map is an assumption that the UK wishes to provide 3% of its electricity requirement from PV systems by 2030. This is an ambitious but realistic target and would involve installation rates no higher than those already demonstrated in Germany for example.

A draft of this road map can be viewed at the UKERC web site (www.ukerc.ac.uk). The presentation will outline the process by which the road map was developed and highlight key findings.

From Hydro to Energy Company

Keith MacLean, Scottish and Southern Energy

The presentation will outline how the Hydro Board has evolved into Scottish and Southern Energy taking with it a continuing strong emphasis on its traditional renewable supply system but engaging, also, in new generation technology development. The move from the public into the private sector has demanded the change from being an electricity provider to becoming an energy service company. The new strategy and philosophy embraces not only advances across the spectrum in energy generation but encompasses the challenges of how to make a success out of helping customers use less energy, and balancing the need to address climate change while ensuring security of supply.

Bio-Details of Speakers

Jim Skea, UK Energy Research Centre

Professor Jim Skea was Director of PSI from November 1998 to September 2004, and is now Research Director at the United Kingdom Energy Research Centre (UKERC). He was previously Director of the Economic and Social Research Council's Global Environmental Change Programme and a Professorial Fellow at SPRU (Science and Technology Policy Research), University of Sussex. His main research interests are: energy/environmental policies; sustainable development; climate change; environmental regulation and technical change; and business and environment issues more generally.

Stuart Haszeldine, Edinburgh University

Professor Stuart Haszeldine is a geologist at the University of Edinburgh. He undertook PhD research on UK coal deposits, then gained 25 years' experience working with subsurface information from large basin-scale to local field-scale structures in the North Sea hydrocarbon extraction fields and in radioactive waste disposal. He has worked extensively with oil and gas companies and, more recently, with power generators and engineering contractors. Since 2005 he has helped to create the UK's largest University group, between Edinburgh, Heriot-Watt and BGS, examining CO₂ storage geoscience. Collaborations also exist with the UK Energy Research Centre, and the UK Carbon Capture and Storage Consortium.

Bill Leithead, Strathclyde University

Professor Bill Leithead is the Director of the Industrial Control Centre at the University of Strathclyde. He has been involved in wind energy since 1988, and the wind energy research group, which he established at the University of Strathclyde, has an international reputation for its work in the dynamic analysis and control of wind turbines. The Group has strong links with industry and has assisted with the design of control systems for several commercial machines. He is the Chair of the UK Government-funded SuperGen-V Wind Energy Technologies research programme, and is the UK Board member of the European Wind Energy Academy.

Rowena Langston, RSPB

Dr Rowena Langston has spent over 18 years as a conservation scientist following post doctorate research on shorebirds. Most of this time she has have worked for the Royal Society for the Protection of Birds (RSPB) and the British Trust for Ornithology. Her current role for the RSPB is primarily as an ornithological consultant to conservation and policy colleagues at the RSPB, and in an advisory role on several working groups involving government departments and industry on a range of issues; notably, renewable energy, possible impacts on birds, and monitoring and research advice.

Claire Haggett, Newcastle University

Dr Claire Haggett is Lecturer in Sustainable Development at Newcastle University. She specialises in a range of energy issues, including understanding opposition to renewable energy, and the wider implications of its implementation on people, communities, and landscapes. Claire is a sociologist by training, and is formally of the Home Office (Research and Statistics Directorate) in London. She is now involved with the management of several ongoing multi-disciplinary research projects, and is concerned to link research and practice, making research both useful and useable. She regularly presents at a range of international conferences for social scientists, natural scientists and practitioners, and publishes in both well respected academic journals and specialist policy and industry publications.

Robin Wallace, Edinburgh University

Dr Robin Wallace is Head of The Institute for Energy Systems in the School of Engineering and Electronics where his research interests include marine energy and network integration of distributed renewable energy generation. He is Principal Investigator of the EPSRC SuperGen Marine Energy Research Consortium and a Co-Director of the UK Energy Research Centre with responsibility for the theme Future Sources of Energy.

Sandy Kerr, International Centre for Island Technology, Heriot-Watt University, Orkney

Dr Sandy Kerr is a lecturer based at Heriot-Watt University's International Centre for Island Technology (ICIT) in Orkney. He teaches on MSc courses in Renewable Energy Development, Energy Studies and Marine Resource Management. Originally trained in Land Economics, and after a period working as a valuation surveyor, he moved to ICIT in 1993. His research has focussed on the interaction between environmental and economic systems within the context of marine and island resource management. His PhD examined the sustainable development of small island communities and this remains a principle interest. Other research interests include aspects of planning, environmental economics and stakeholder conflict in the marine environment

Martin Tangney, School of Life Sciences, Napier University

Dr Martin Tangney, is Fellow of the Higher Education Authority (FHEA), who has nearly 20 years research experience in the molecular biology, genetics and physiology of industrial Gram positive bacteria. He is an internationally recognised expert in carbohydrate utilisation and gene regulation in solventogenic clostridia. He graduated with a First Class honours degree from University College Cork, Ireland, and did an MSc in Genetics at Trinity College Dublin before taking up an EU fellowship to carry out his PhD at the Heriot-Watt University in Edinburgh. He subsequently worked in industry for several years as a gene technologist for Novo Nordisk A/S (now Novozymes), Copenhagen, where he won the scientist of the year award in the biotechnology division. He was later re-located to the Finish National Health Institute in Helsinki to head up a Novo task group. Dr Tangney returned to academia as a senior Post Doctoral fellow at the Heriot-Watt before taking up his current position as a lecturer in the School of Life Sciences at Napier University Edinburgh. He has research collaborations with industrial

and academic groups, both nationally and internationally. His current research is heavily focused on biofuel development -in particular the production of butanol by solventogenic species of clostridia - and he is Director of the Biofuel Research Centre. He has published extensively in leading scientific journals as well as being an inventor on several patents. Dr Tangney has hosted national and international scientific meetings and workshops, including the prestigious international conference on solventogenic clostridia Clostridium VIII held in Edinburgh in 2004. Dr Tangney is a former consultant to Novozymes, Denmark and is currently a scientific advisor to the board of Green Biologics Ltd. He serves on the committee of TechLink UK-Ireland and is the meetings convenor for the Scottish Microbiology Society.

Nicholas Gubbins, Highlands & Islands Community Energy Company

Nicholas Gubbins is the Chief Executive of the Highlands & Islands Community Energy Company (HICEC), and was formally head of Community Regeneration at Highlands and Islands Enterprise. Prior to that, he worked for Scottish Natural Heritage in a number of locations in Scotland. He has managed a wide range of community development and environmental projects and programmes and was responsible for the establishment and direction of HIE's community energy unit, the predecessor to HICEC.

Kevin Dickson, Highlands & Islands Community Energy Company

Kevin Dickson is HICEC's South of Scotland officer, covering everywhere outwith the Highlands and Islands. He is responsible for assisting renewable energy projects applying to the Big Lottery's Growing Community Assets scheme and helping to develop several community owned income generation schemes. Other aspects of his work include the development of district heating schemes in association with registered social landlords, and measures to stimulate biomass supply in rural areas.

David Infield, Loughborough University

Dr David Infield has been Director of CREST (Centre for Renewable Energy Systems Technology) at Loughborough University since founding the centre in 1993, and is Professor of Renewable Energy Systems with the Department of Electronic and Electrical Engineering. Following a PhD, he joined, in 1978, the Building Services Research and Information Association (BSRIA), Bracknell, UK, to work on solar thermal systems. Then, from 1981 to 1993 he was with the Energy Research Unit at Rutherford Appleton Laboratory, Oxfordshire, where he was manager of the EPSRC Universities' Wind Test Site.

For over five years he was Programme Director for CREST's world leading MSc programme in Renewable Energy Systems Technology (see www.crestuk.org) and co-managed the new European Masters programme in Renewable Energy with the EUREC Agency in Brussels.

He now has over 20 years research experience in renewable energy technology and his current research, which is focussed on the electrical integration of wind and photovoltaic generators, is funded by the EU, the UK's DTI and EPSRC, and by industry. He also has a specific interest in building integrated photovoltaics (BIPV) and the more speculative area of building integrated wind. He has published over 100 papers on renewable

energy; he is a member of the EPSRC College, represents the UK on a number of international committees, and regularly referees for the leading journals.

He currently leads the PV topic within the UKERC Future Energy Sources theme and is also a co-director of the EPSRC Supergen Programme on Highly Distributed Generation.

Keith MacLean, Scottish and Southern Energy

Since completing graduate and postgraduate studies in Chemistry at Heriot-Watt and Hamburg Universities, Keith MacLean joined SSE in 1994 following a career in Germany and Scotland working in Research & Development and Business Management. At SSE he has worked in a number of areas of the core energy business and was also responsible for starting up and running its telecoms business from 1997 to 2004.

In 2004, he was appointed Head of Sustainable Development, and is responsible for energy and environmental policy, public affairs and for ensuring that SSE carries out its internal and external activities in a sustainable manner and takes a balanced view on the economic, environmental and social elements of its work.

Outside SSE, he is a member of the Executive of the Micropower Council as well as Director on the Boards of the Scottish Renewables Forum (SRF) and the British Wind Energy Association (BWEA). In 2006, he also took over as Chairman of the Board at the UK Business Council for Sustainable Energy (UKBCSE).

In addition to this trade association activity, he also serves on a number of government bodies, including the DTI's Transmission Working Group as well as the Scottish Executive's Environmental Advisory Forum on Renewable Energy (which considers planning issues relating to renewable energy and the supporting infrastructure), and on the Forum for Renewable Energy Development in Scotland – a joint government and industry group set up to deal with all issues relating to the achievement of the Executive's renewable energy strategy.

Notes

Edinburgh Consortium for Rural Research

ECRR is a consortium of 25 organisations working in basic and applied research relating to rural and coastal affairs. Its members are active in farming, forestry, aquaculture, landscape, natural heritage, energy and the environment, and have a network of bases that span the whole of Scotland. Research interests are focused within the UK and internationally, particularly in developing countries. For members' details, please visit www.ecrr.org.uk.

United Kingdom Energy Research Centre

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. The Centre was established in 2004 following a recommendation from the 2002 review of energy initiated by Sir David King, the UK Government's Chief Scientific Advisor. It is a central part of the £28 million cross-Research Council programme, Towards a Sustainable Energy Economy (TSEC), funded by ESPRC, NERC and ESRC. For further details visit www.ukerc.ac.uk

Aberdeen Research Consortium

The role of the ARC is to co-ordinate the research activities of the universities and research institutes in the Aberdeen area, to exploit and optimise research potential and to add value to that provided by individual institutions. Details of its 9 member organisations can be found at www.aberdeenrescon.ac.uk. ARC includes among its specific objectives; increasing external funding, attracting high quality researchers, raising profile, and commercially exploiting research.

Scottish Natural Heritage

SNH is a Scottish government body with responsibility for Scotland's natural heritage. SNH promotes its care and improvement, responsible enjoyment, greater understanding and appreciation, and its sustainable use now and for future generations. For further details visit www.snh.org.uk.