

## ENERGY MANAGEMENT GROUP NEWSLETTER

### Introduction

Welcome to this 2005/06 edition of our newsletter, with reports of our meetings and articles on energy and climate change. We hope that you find these useful and interesting. As ever, if you wish to contribute any material to the newsletter or have any comments on its content please contact the group secretary, Yasmin Andrew ([Yasmin.Andrew@jet.uk](mailto:Yasmin.Andrew@jet.uk)). The next edition of the newsletter will be published in the Spring and the deadline for contributions is end of January.

### Bursaries

We should like to remind group members that they can apply for bursaries to contribute towards the cost of attending energy related seminars or conferences. To apply for a bursary please contact Yasmin Andrew ([Yasmin.Andrew@jet.uk](mailto:Yasmin.Andrew@jet.uk)) detailing the event you wish to attend, costs for which you are seeking support and reason for application (e.g. priority may be given to those not in employment or for whom travel costs are a particular obstacle for certain events).

### Energy Management Group Events 2005

A report of the meeting Energy: the Big Issues held on 25 October can be found at [http://groups.iop.org/EG/05/06/050624a\\_e.html](http://groups.iop.org/EG/05/06/050624a_e.html)

And the minutes from the Fourth Energy Management Group Annual General Meeting [http://groups.iop.org/EG/03/04/030403b\\_e\\_emgmin\\_AGM\\_2005Oct25.pdf](http://groups.iop.org/EG/03/04/030403b_e_emgmin_AGM_2005Oct25.pdf)

#### **Note from Peter Gill ([gill.pf@virgin.net](mailto:gill.pf@virgin.net))**

*The following article was first published in Geoscientist Volume 15 No. 7 18-19. It arose out of the work that Feroze Duggan undertook together with others from the IOP, ICE, IEE, GSoc., EI, RSC, UKERC and other bodies and individuals in the preparation of the important two and a half day conference "Challenges and Solutions: UK Energy to 2050".*

*Other papers published for the conference were:*

- BRYAN LOVELL on Energy demand, supply, and impact (March issue) <http://www.geolsoc.org.uk/pdfs/solutionslovell.pdf>

- Demand: SHAUN FITZGERALD on Managing demand (April issue) <http://www.geolsoc.org.uk/pdfs/solutionsfitzgerald.pdf>
- Supply: DAVID JENKINS on There's no fuel like an old fuel (May issue) <http://www.geolsoc.org.uk/pdfs/solutionsjenkins.pdf>
- Renewables: JEREMY LEGGETT on The future and renewable energy (September issue) <http://www.geolsoc.org.uk/pdfs/solutionsleggett.pdf>

## Nuclear Power: cul-de-sac or saving grace?

***Renewables technologies and energy efficiency gains need time to mature or be deployed and will not be able to meet all our energy needs. Nuclear power will be required too, as part of an integrated electricity generation policy,*** says Dr Feroze Duggan

UK electricity generating policy is at a crossroads where many inappropriate avenues, narrowing pathways and cul-de-sacs meet - and where we also see one bright highway that is currently being ignored – the nuclear option.

The 2003 Energy White Paper ([www.dti.gov.uk/energy/ourenergyfuture.pdf](http://www.dti.gov.uk/energy/ourenergyfuture.pdf)) envisaged a low carbon future with renewables and no new nuclear stations, unless required in future, to meet our carbon targets. Therefore a nuclear programme<sup>1</sup> underpinning this policy is a necessary precaution. Giving renewables a high profile is laudable; but on the ground, I believe our expectations are not likely to be met. We started too late, and we are making unrealistic demands on immature technologies in a short time.

Figure 1 shows nuclear generating capacity reducing, from 23% (2002) to zero (~2035). Both renewables and deployment of energy efficiency measures would have to grow phenomenally fast to fill this gap. To put it baldly, unless nuclear capacity is replaced, reductions in CO2 emissions will not be achieved.

Renewables output is intermittent (variable), depending on time of day, weather and seasons. In Figure 2 electricity demand is matched against energy generated by renewables.

As other studies have also suggested, renewable energy supplies are not in line with, and appear unable to meet, our fluctuating electricity demand throughout the year. Demand reduction by energy efficiency requires substantial cultural changes and is a slow process that will not be achieved in time. Furthermore, reliable electricity grids require that installed capacity exceed peak demand. Figure 3 charts this excess - which is reducing, falling from 27% (2001/2) to 20 % (2002/3).

The intermittency of renewables makes them unsuitable for replacing baseload generation. Continuous and reliable supplies require either new nuclear reactors, or fossil fuel plants. The latter option suffers two limitations: increased emissions, and depleting oil and gas output from ~2010-20. Once again, nuclear is indicated, to work alongside renewables. Fusion is still a few decades away<sup>2</sup>. Our reliance on nuclear power is inescapable - the necessary milestone decision will have to be made.

Unlike oil, gas and coal, uranium has no real value except in electricity generation. An objective evaluation considering capacity, cost, reliability, safety and environment<sup>3</sup> indicates that we need to re-start new nuclear build rapidly<sup>4,5</sup>.

A Europe-wide opinion survey found that nuclear power is publicly acceptable if the long-term nuclear waste management was safe<sup>6</sup>. Acceptance of nuclear within the UK has also increased<sup>7</sup>.

So can existing science & technology deliver safe longterm waste management? Technically a worldwide consensus exists<sup>5</sup>: risk of  $10^{-6}$  over  $10^6$  years to reduce radiation exposure from waste to natural background, with containment of vitrified (glassified) waste in heavy duty containers, in a multi-barrier engineered repository, in ubiquitous stable geosphere. Further options include shallow burial, the ability to retrieve and relocate, and phased repository closure.

**The empirical evidence is good:** radionuclides are constrained naturally by the geosphere, as in the “natural reactor” at Oklo. Ancient glass artefacts show virtually no degradation.

**The UK waste inventory:** replacing nuclear with new nuclear build only causes 10% increase<sup>5</sup> in total high and intermediate level wastes, and about 3% for low level. Anyway we can't walk away from the legacy inventory.

**Decommissioning:** dependent on adopted strategies, this costs between 0.6p – 0.13p /kWh. That figure is relatively static, so is not an “Achilles heel”.

**Cost:** Electricity is cheaper in France than in the UK because of that country's ~78% nuclear capacity. This saves French industry<sup>3</sup> £1bn/y. The Royal Academy of Engineering's study<sup>8</sup> shows nuclear new build is as cheap as for gas. Renewables are expensive, but we should not count the pennies until the technologies mature. Nuclear will allow time for that to happen, and for the deployment of energy efficiency measures.

Finally, despite safety improvements, public perception of nuclear energy does not match reality. The technological facts are coloured by their defence pedigree, the cold war, memories of nuclear power stations as state-sponsored virility symbols, and so on. Unsurprisingly this has left the public ill-informed, confused, and suspicious. Currently the public is likely to jump to extreme, invalid emotionally charged judgements about civil nuclear power.

The fact that the nuclear industry is one of the most regulated of all should inspire confidence, rather than suspicion. We also need sociological tools to understand and unblock these perceptions<sup>9</sup>.

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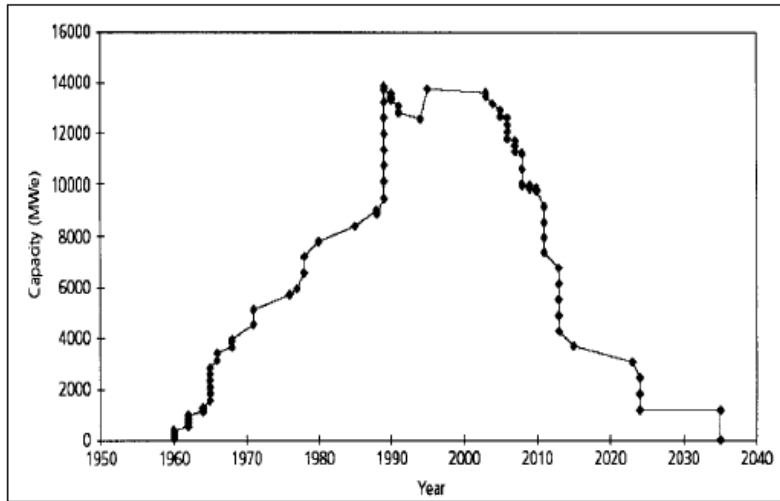


Figure 1. UK nuclear generating capacity - in the absence of new construction (Source: NAC and BNFL - Nuclear energy - the future climate 1999, Royal Society and Royal Academy of Engineering, fig. 12)

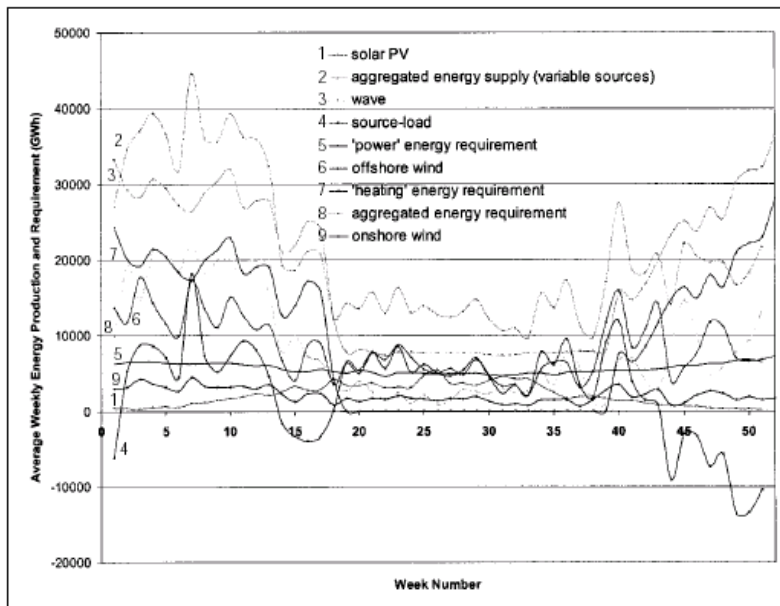


Figure 2. Average weekly energy production and requirement for UK Ca 2003 (From CREST University of Loughborough; Professor David Infield's presentation is at [http://groups.iop.org/EG/03/08/030812a\\_e.html](http://groups.iop.org/EG/03/08/030812a_e.html))

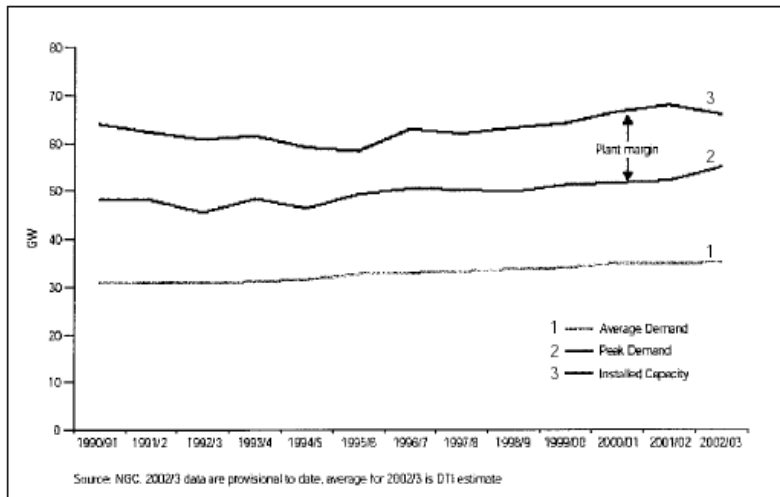


Figure 3. Installed Capacity and Electricity Demand, England and Wales (Energy White Paper, Our energy future - creating a low carbon economy, page 89 chart 6.1)

Note from Peter Gill ([gill.pf@virgin.net](mailto:gill.pf@virgin.net))

The following paper represents a distillation of views from the first two days of the “Challenges and Solutions Conference: UK Energy to 2050” It was presented by John Loughhead as input to the final session held at the Royal Society in London on November 10, 2005. It is regarded as an authoritative, multidisciplinary report which aims to provide the Government with a coherent, feasible solution to the acknowledged problem of the UK's looming Energy Gap.

IOP representation on the Organising Committee for the conference was by Tajinder Panesor, Feroze Duggan and myself. Feroze Duggan Chaired the Nuclear Sub Committee on which I also served. I was also a member of the Fossil Fuel Sub Committee Chaired by David Jenkins.

## How to plug the energy gap

Report written by John Loughhead, (Executive Director UK Energy Research Centre), with contributors from the *Energy Solutions Panel*, comprising John Loughhead (UKERC, report author) Richard Hardman (Solutions Conference Chair), Charles Curtis (University of Manchester, UK Nirex), David Jenkins (formerly BP), Feroze Duggan (Institute of Physics), Jeremy Leggett (SolarCentury), Martin Fry (Energy Institute) and Shaun Fitzgerald (BP Institute, Cambridge University); based on the consensus conference *UK Energy to 2050 – challenges & solutions 12-13 October 2005* [Note 5].

*The Report distils the conclusions of the meeting and is independent of all its sponsoring bodies*[Note 2].

## Executive Summary

Energy will inevitably become less available and more expensive than it has been for the last few decades. The change will be permanent. Adapting to this scenario while maintaining the UK's standard of living will require fundamental changes in the way we produce and use energy. All sources of energy will be required.

- **Fossil fuels** will remain our most important source for the next 50 years, despite a growing role for renewable energy. Clean systems, including carbon capture and storage, should be pursued urgently.
- **Nuclear fission energy** is a proven and reliable technology that will inevitably have a key role in a future clean energy mix.
- **Renewable energy sources** will play a growing role, but will require continued support in development and deployment if they are to match the cost levels of conventional systems.
- **Energy demand reduction** measures will be as important as generation technologies, and will require both technological and behavioural changes. Existing technology for energy efficiency is not fully exploited, and changing this is as important as new technology development.
- **Engagement of the public** in bringing about these changes is crucial, but requires more perceptive schemes that recognise the role energy plays in people's lives, and not based on arguments appealing to technical or economic rationality.
- **Industry and commerce** is prepared to play its role, but needs consistent incentive mechanisms given the absence of immediate market imperatives to change current practice.
- **Government** has the key role to play by providing consistent market signals, reinforced by structured and affordable incentives; implementing regulatory structures to bring about changes in the energy system, and taking responsibility for an effective engagement of the public in the process.
- **The market** alone will not deliver the aspirations of energy policy, and clear means to encourage the necessary changes are essential.

# Conference synopsis

## Introduction

A two-day conference was held in London in October 2005 to consider the challenges that the UK faces in ensuring a secure, affordable, and environmentally acceptable supply of energy in the period to 2050. Over the two days 150 delegates with personal expertise across the whole field of energy discussed these questions in a sequence of themed sessions, covering:

1. Demand
2. Nuclear
3. Fossil fuels
4. Renewables
5. Impact - social, cultural and political aspects

Each session addressed a pre-defined question; heard presentations from leading figures in energy identifying key issues and drivers, and ended with a facilitated debate.

This synopsis summarises the main points that arose, and the consequent policy and supply needs for the UK that we identified.

## General

Reducing carbon emissions will require simultaneous action on several aspects of the energy system to change the balance and technology of energy supply, means of energy distribution, underlying demand, and efficiency of usage.

The meeting felt that the well-known “wedge” approach proposed by Professor Rob Socolow of Princeton University demonstrated the inevitability of this if atmospheric carbon levels are to be held at acceptable levels, as well as being an effective means of articulating the problem.

### 1. Demand

*“Looking first to 2020, then to 2050, what will be the UK requirements for energy by type, and to what extent will energy efficiency and other measures curb trends in demand?”*

- Reducing demand through energy efficiency and other measures is an essential component of new measures.
- Encouragement of individuals and small enterprises to reduce demand is a key challenge.
- Government has a key leadership role to raise awareness of the need for local action and to ensure advice and support is available.
- Improving standards of energy usage in buildings and equipment needs legislation and enforcement at levels far beyond that which we have today. Fiscal incentives for reducing energy consumption will be needed, supported by improved information to individuals and households to enable them to understand the way they use energy.
- Existing energy efficiency technologies are under-exploited, and their wider application should be given the same priority as research and development in new technology.

Demand is a critical factor. The meeting believed that there is already considerable potential for reduction. Efficient use of energy must be pursued as a key element of the future energy mix, in parallel to supply aspects. The meeting was unanimous that, whatever new technologies might be developed in the 2050 timeframe, much could be done now by the further application of existing technologies to deliver substantive benefits by 2020. These include wider use of small-scale combined heat and power, or local renewable technologies such as wind in domestic and commercial premises, coupled with improved energy efficiency through improved building standards and wider adoption of low energy devices.

Changing the behaviour of individuals and the large number of small businesses will require active support and promotion by Government, since large organisations had generally made

substantial changes already. More demanding requirements for energy performance of buildings and equipment should be put in place, coupled with appropriate fiscal incentives to reward real improvements in energy use patterns and local renewable generation. Improved information to consumers, including more detailed information on energy bills, should be made available. Greater efforts should also be made to provide advice on how to reduce consumption - probably through the Energy Savings Trust.

## 2. Nuclear

*“What actions would need to be taken, and by whom, for the nuclear industry to generate economically competitive energy acceptable on safety and environmental grounds?”*

- Marked differences of opinion – arising largely from philosophy of approach - remain over whether nuclear should be considered as an option.
- Nuclear fission is now a mature technology with well-known construction and operating costs, and a good safety record.
- New nuclear build will almost certainly be required if the UK is to meet its emissions target; but active Government involvement will be essential to establish the regulatory and financial frameworks needed to enable it to proceed.
- Greater international collaboration on standards and design approvals would smooth the planning process and realise the full benefit of worldwide experience.
- Because the world design and supply capacity for nuclear power plants are limited, an early policy decision that translated into early orders would help the UK avoid potential future supply bottlenecks.
- Public confidence in any decision is critical and an open and transparent decision and consultation process essential.

Nuclear energy remains contentious, a fact reflected in the conference discussions. However the differences were primarily philosophical and demonstrated a certain lack of trust between pro- and anti-nuclear camps.

Presentations argued that current nuclear fission power generation is a mature technology with substantial international experience of safe operation. Experience over the last decade indicated that construction and operating costs are now well defined, if the latter are calculated on a conventional commercial basis. Debate over whether this basis is appropriate continues. The main source of uncertainty is the cost of disposing of nuclear waste and decommissioning nuclear plants – both being uncertain chiefly because there remains uncertainty in Government policy.

If new nuclear plants were built in the UK, our lack of indigenous design and supply capability would have a number of implications. While using designs already in service elsewhere (“off the shelf”) would mean lower costs, well-established operational procedures and greater certainty of performance, national licensing processes could inhibit their realisation. It is therefore important to explore the scope for international collaboration on standards, design approvals and related issues.

Even the international supply chain for nuclear plants has its limits, and timely build could be threatened if other operators happened to order new plant at the same time as the UK. For example, there are only two suppliers for the complex forged pressure vessels used in modern reactors; production lead-times of up to 10 years could be envisaged in the worst case.

Financing new plants poses further questions. Since their lifetime may be 80 years (from start of planning to end of decommissioning), investors might perceive considerable risk arising from possible policy changes over such a long period – over and above those arising from our already lengthy permissioning and licensing processes. Assuming that any new nuclear capacity would be privately financed, the meeting saw a clear need for a long-term, guaranteed regulatory regime within which secure investment decisions could be taken.

The meeting accepted that public opinion on nuclear power was mixed, with around half the population uncertain whether or not to support it. However, the planned retirement dates of existing nuclear plants mean that a decision about whether to replace them with new nuclear build must be taken soon, as the Government has already announced.

This debate must be conducted in an open and participative way, allowing genuine public concerns to be articulated and addressed. There is evidence that political perceptions of public concern may not be wholly accurate. Better efforts must be made by Government to understand public fears correctly. Any information used for this purpose must be objective, and generally accepted.

### 3. Fossil fuels

*“What part will each of the fossil fuels play (thro 2050)? – hence: What part could they play? What part should they play? How will this be decided? What will be the drivers?”*

- Fossil fuels will be the primary energy source over the next 50 years, especially for transport.
- An oil supply peak will occur within the timeframe, so the UK must plan for demand being constrained by supply, and high prices arising as much from geopolitical as technical and commercial factors.
- Natural gas supply will probably be unconstrained for most of this period, but as a net importer, the UK will need strategic storage or similar supply buffers.
- Coal is, and will probably remain, relatively cheap; developing means of using it cleanly, either directly or as a source of other vectors, should be a priority.
- As individual fossil fuels become supply-constrained we may need to prioritise their uses formally.
- In the absence of legislative constraints, fossil fuels will continue to dominate the market as a result of their convenience and compatibility with existing infrastructure and products. All expert commentators, such as the IEA and others, expect this dominance to continue through 2020 regardless of legislation.

Discussion focused on possible supply constraints due to technical, market and political factors. Oil will probably experience a supply peak within the timeframe considered, while natural gas will not.

#### **Oil**

Oil is primarily a transport issue. Although substantial additional resources are available for exploitation, a production peak should be expected within this time frame. Even if plenty of reserves are found, a production bottleneck is still likely in the short term because of three external factors: political access to reserves in the Middle East, political and perhaps technical difficulties with access in Arctic regions, and a likely shortage of personnel within oil companies who are qualified to spend the vast sums of money required to bring reserves on stream.

The timescale will depend much more on political than geological issues. We should therefore definitely plan for demand to be constrained by supply, with a consequent sustained high price, while recognising that reduced demand (either through price or carbon legislation) will extend the time at which a given rate of supply can be maintained.

The meeting noted that constraints in production capacity (as opposed to resource availability) should also be expected.

#### **Gas**

A global gas production peak within this timeframe is unlikely, although projection of historic growth rates suggest production constraints may arise around mid-century. For the UK, expanding Liquefied Natural Gas (LNG) re-gasification facilities would alleviate current concern about supply security from Russia; but this will also require expanding storage capacity. Gas to Liquid (GTL) technology provides a route to augmenting liquid supplies.

#### **Coal**

Ample coal supplies exist - at cost structures similar to today's. Supply sources are diverse and differ from those for gas. Moreover, a price increase of only \$10/tonne would effectively double the world's economic coal reserves. Maintaining the UK's coal-based generating capacity would therefore augment both diversity and security of electricity supply. Long-term,

coal can be used as a chemical source for methane, hydrogen and liquid fuels when conversion costs become economic.

Coal burning traditionally produces large emissions of carbon dioxide - which is why replacing coal by gas helped the UK to meet Kyoto targets. The only way that fossil fuels can contribute to easing the CO<sub>2</sub> emissions problem is by embracing cleaner technologies - for which there is a real cost (which is highest for coal relative to other fossil fuels). The alternative of carbon capture and storage is only proven and demonstrated *in principle* - no large scale plant is currently operational. It is likely, however, that the permissioning regime for a sequestration plant would be difficult; conceivably leading to the sorts of decadal delays familiar with nuclear power plants.

## 4. Renewables

*“How much of our total energy requirements can renewables be expected to provide, in light of the White Paper statement that the price of energy should allow us to maintain our competitive advantage as a nation?”*

- Renewable energy technologies could supply up to 40% of current demand by 2050.
- Development will require maintaining and reinforcing Government incentive schemes, covering both the generation technologies and changes in systems of energy supply and usage.
- Further cost reductions are probable, but not to the historically low levels produced by fossil fuels over recent years.

The meeting reviewed and debated a number of renewable technologies presently in service or development. It was the opinion of those directly involved in the business that large-scale renewables, specifically wind, bio-energy, and (to a lesser extent) marine energies, could potentially provide around 15% of current national demand by 2020, rising to 35–40% by 2050 if the newer technologies could be successfully developed and deployed. Distributed systems could provide additional energy for local use, although their contribution to remote demand would depend on substantive changes to the architecture of electricity networks.

Full exploitation of renewable energies also requires changes to the way energy systems are designed and used, adopting “fresh-start” thinking. The demonstration in Woking highlighted some of these including the use of local electricity grids for power sharing, and the more efficient energy design of buildings and processes.

The renewables industry believes that cost reductions to such systems can be achieved, but that incentives to encourage necessary development and stimulate demand management remain necessary. If such incentives are provided, the industry remains confident that the low-carbon energy supply envisaged in the White Paper is achievable by 2050. However, the Government’s current measures are insufficient to ensure this.

## 5. Impact

*“As we strive to meet the targets in the White Paper, how will the consequential changes in energy production and use be made culturally and politically acceptable in the UK?”*

- Public engagement has been poor to date, and the Government’s attempts to develop it have failed to recognise the way individuals interact with the energy system.
- For enterprises, real action has arisen only when appropriate incentives are in place - such as carbon trading.
- Future approaches will need to provide clear and consistent incentives that identify and engage with public and business alike.

The conference focused on two aspects: increasing efficiency of energy use, and means to reduce demand for energy.

There was a close relationship between discussion on these topics and that concerning energy demand. In particular, reducing demand by applying existing technologies was cited as an example of how opportunities to hand now are not currently being fully exploited.

Incentives to apply low-energy options, and public awareness of the impact of doing so as individuals, were still weak.

The meeting agreed that schemes to engage the public had been generally unsuccessful, and that the reason for this failure was the approach that had been taken. Many schemes used approaches based on economic or technical rationality; which may reflect how such decisions are taken within a technocracy, but which fail to take into account the real ways in which individuals made personal decisions about their daily lives. Changing public reaction substantially in the future will need more perceptive public engagement that recognises how individuals interact with the energy system.

Business and enterprise have responded to certain schemes - such as carbon trading. These have encouraged process-changes, leading to more efficient on-site energy generation and usage. However, clear and consistent incentive schemes are still needed to encourage the wider adoption of such measures.

## Notes

The report written by John Loughhead, (Executive Director, [UK Energy Research Centre](#)) is the result of a multidisciplinary consensus meeting between 150 scientific, technical, economic and sociological experts at Burlington House on October 12 and 13, under the auspices of The Geological Society of London [Note 1,5]. The meeting was co-sponsored by five sister societies and institutes [Note 2].

The Report distils the conclusions of the meeting and is independent of all its sponsoring bodies.

The report was published at the Royal Society in London on November 10, 2005 morning, where it will be presented before an Expert Panel, chaired by Lord Oxburgh KBE FRS [Note 3,4], immediate past Chairman of the House of Lords Science & Technology Committee, and an audience consisting of many who participated in the Burlington House sessions, invited guests and other interested parties [Note 4].

1. The Geological Society of London is a learned and professional body, of over 9000 Earth scientists with a remit to investigate, interpret, discuss, inform and advise on the nature and processes of the Earth, their practical importance to humanity, and, in the interests of the public, to promote professional excellence. Registered Charity No. 210161.
2. The Solutions Conference was co-sponsored by the Royal Society of Chemistry, the Institute of Physics, the Energy Institute, the Institution of Electrical Engineers and the Institution of Civil Engineers. Funding was also provided by the Natural Environment Research Council, Engineering and Physical Sciences Research Council, Economic and Social Research Council and Biotechnology and Biological Sciences Research Council.
3. In addition to its Chair Lord Oxburgh, the Expert Panel will include: The Lord Broers FRS FREng (President of the Royal Academy of Engineering, Chairman of the House of Lords Science & Technology Committee), Dr Vincent Cable MP (Lib. Dem. Shadow Chancellor), Rt. Hon. Bernard Jenkin MP (Con. Shadow Energy Minister), and Sir John Lawton CBE FRS (Chair of the Royal Commission on Environmental Pollution). Also present will be the *Energy Solutions Panel*, comprising John Loughhead (UKERC, report author) Richard Hardman (Solutions Conference Chair), Charles Curtis (University of Manchester, UK Nirex), David Jenkins (formerly BP), Feroze Duggan (Institute of Physics), Jeremy Leggett (SolarCentury), Martin Fry (Energy Institute) and Shaun Fitzgerald (BP Institute, Cambridge University).
4. For more details of this event go to <http://www.geolsoc.org.uk/template.cfm?name=Solutions2>
5. For details of the October two-day event go to <http://www.geolsoc.org.uk/template.cfm?name=Solutions>.

## **Meeting Report**

Lecture by Lord Wakeham on the House of Lords Report on the economics of climate change.

Lord Wakeham is the chairman of the House of Lords economic Affairs Committee.

This important meeting was organised by the Energy Management Group of the Institute of Physics and held at the Institute on Monday evening 28 November. It was chaired by the Institute chief executive Dr Kirby-Harris and a capacity audience heard Lord Wakeham start by saying how important it is in climate change analysis to give the economics due prominence. The economics are important for two reasons, first because it has a bearing on economic growth and second because the economics are crucial when weighing up the options for alternative action. Lord Wakeham took a very balanced view of the subject stressing it was important to get a balance between reducing emissions and responding to change with new technologies coming into play. The report was a very positive one which encouraged the government to step up work on the economics. He stressed it is important to try and bring along the US, India and China to try and get a consensus. He mentioned that the committee in the House of Lords was encouraged that two weeks after the publication of their report the government asked Sir Nicolas Stern to look at the economics of climate change. He also noted that so far the Kyoto climate change protocol has had little effect on global warming. He noticed a change of emphasis seemed to be on its way with a willingness to bring along other countries and a willingness to get agreement on the technologies needed to help control climate change as very important. A longer term view on this subject was important and he noted that the government had stressed that economic growth would be maintained.

(The House of Lords Report will be available on line via the Energy Management group web site <http://groups.iop.org/EG/>)

### **Power to the People: Numbers Count, Professor Maxwell Irvine**

#### **Lecture to IOP South Central Branch, Guildford, October 2005.**

Report by Peter Gill ([gill.pf@virgin.net](mailto:gill.pf@virgin.net))

Professor Irvine chairs the RSE Committee of Inquiry into Energy Issues that is due to report in June 2006.

This was no bland lecture. Professor Irvine pointed to risks of a serious future energy gap, destabilisation of world economies, political instability and conflict. He argued for an early decision on nuclear new build for the UK and a non-departmental Energy Agency to implement a new energy strategy.

Prof. Irvine started by stating that energy is simply the most important commodity for our existence and the survival of our society and civilisation. In contrast to those that believe in other drivers Professor Irvine said that our highest national priority should be ensuring adequate, safe, sustainable and

secure supply of energy. It is clear that he believes that urgent political action is required to satisfy these requirements.

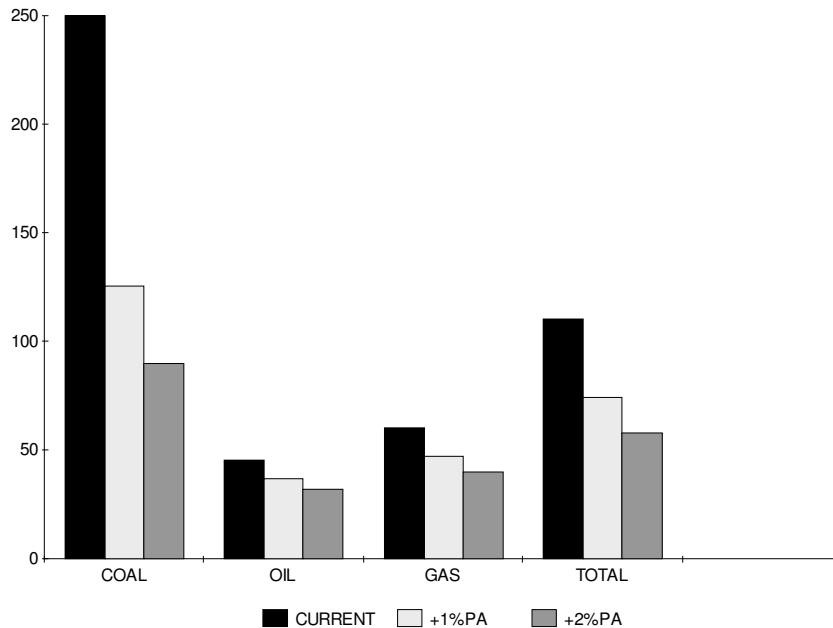
He contrasted his approach with that of the Government White Paper of 2003. The latter seeks to create a low carbon economy with no nuclear stations in the foreseeable future, heavy dependence on 'renewables' and the replacement of domestic fossil fuels by imported gas. Professor Irvine pointed out that "This is not a White Paper; it is a Green Paper with a broad yellow stripe" (House of Commons Select Committee). "We have met no one outside Government that believes these figures" (House of Lords Select Committee) "... that is why it is a political aspiration and not a policy target" (Energy adviser, DTI).

With the theme that economic development feeds on energy and so the more people do the more energy they require Professor Irvine reviewed the actual and likely population growths by world regions, the past, present and possible future demand for energy by primary energy type and by region and final global energy types by region.

World population increased from 2.4 billion in 1950 to 6 billion today. The UN predicts 7.5 billion by 2020 and 9 billion by 2050. Energy demand quadrupled in the period 1950 to 2000 and is expected to double in the period to 2050. The total primary energy supply in 2002 was about 81% fossil fuels (35% oil, 25% coal, 21% natural gas), 11% biomass, 9% nuclear, hydro and others (wind, waves, tides, solar, geothermal etc account for less than 0.5%). This primary supply was largely consumed by OECD (52%) and by Asia (24%). Of OECD's primary energy consumption 40.4% was oil and fossil fuels in total amounted to 83%.

In 2002 two thirds of world electricity was generated by fossil fuel combustion (coal 39%, NG 19%, oil 7%). The other third was shared almost equally by nuclear and hydro with other generating sources accounting for less than 2%. Direct fossil fuel burning accounted for two thirds of world final energy consumption (oil 43%, gas 16% coal 7%), the other third being largely electricity (16%) and biomass (14%). In OECD countries three quarters of final energy consumption was from fossil fuels, mainly oil.

Having established this background Professor Irvine moved on to the dramatic part of his talk on energy sustainability, availability and impact of use. He showed (slide below) the number of years to exhaustion of proven oil, gas and coal at current consumption rates and with modest 1% and 2% growth rates. As various conversion processes can be operated on fossil fuels he also showed the situation if this were done. So whilst coal could last at least for 250 years at current rates and for around 100 years at a 2% growth consumption rate if coal is converted to oil and gas proven fossil fuels could be exhausted in the next 60 years at 2% consumption growth and in the next 110 years even if consumption remains at current levels!



Ordinate in years

Professor Irvine pointed out that new reserves will be found and new technologies will lead to greater depletion efficiency and as costs rise currently non economic fields will become viable. However oil and gas finds have lagged behind field exhaustion for nearly twenty years.

With respect to the environment concerns on burning coal go back to the Industrial Revolution. In the UK smoke was banned in the 1960s and sulphur emissions controlled from the 1970s. Such clean up costs money and coal consumption peaked in the 1980s. Now the concern is of carbon gases emitted by fossil fuel burning. Per capita CO<sub>2</sub> emissions range from 0.9 tpa in Africa to 11tpa in OECD countries. The Kyoto agreement requires all signatories to reduce carbon emissions in stages until 2050 (UK by 60%). So whilst 81% of all energy comes from fossil fuels and global demand is set to double by 2050 environmental and availability issues suggest that fossil fuel consumption should half by 2050. If the latter is accepted then fossil fuels should only contribute 20% of energy by 2050.

In 2050 if fossil fuels account for only 20% where will the rest of the requirement come from? Professor Irvine offered the following maximum figures: savings and efficiency gains 20%, hydro 5%, biomass 10%, nuclear (under current global policies) 10%, all others 10% (excluding fusion which is not expected to be commercial until after 2050). Thus at the most optimistic Professor Irvine predicts an energy gap of 25% going that route. (Professor Irvine did not discuss the option of making up the gap with fossil fuels and CO<sub>2</sub> sequestration but clearly felt that nuclear is the only hope).

Other perhaps even more serious problems arise from Professor Irvine's opening statement about the importance of energy. These include destabilisation of world economies with rising fuel prices and a world recession, the world economy driven by China, political instability and

terrorism through the international competition for depleted fossil fuels especially where these are present in politically unstable territories.

At home in the UK with North Sea gas and oil declining and virtually exhausted in 20 years time, under current policies domestic coal uneconomic, nuclear (currently 25% of electricity generated) phased out by 2030 and reliance on wind and marine power (less than 50% of electricity generation by 2050) with concerns over the grid we will have serious problems.

All things considered Professor Irvine felt that new nuclear build is essential with hydrogen production from part of the electricity generated. However even this option is problematic in view of a desperate shortage of technical capacity, expected international competition for energy plants (160 nuclear plants currently on order).

Professor Irvine concluded by indicating the urgent need for a decision on new nuclear build. He said that the biggest obstacle to efficient energy use is conflicting Government bureaucracies. He also believes that a non-departmental Energy Agency should be set-up to implement a new energy strategy.

A lively question and comments session followed the lecture but I was left wondering whether the audience had really grasped the seriousness of what Professor Irvine had said.

## **Climate change Jake Hacker & Simon Roberts**

In the Spring edition of this newsletter we placed a short note regarding the issue of climate change and the role of the Intergovernmental Panel on Climate Change (IPCC) in facilitating the formation of an international consensus on this issue. Our note was prompted by and intended to provide balance to a write-up by Peter Gill of a lecture given by Peirs Corbyn. Corbyn conjectures that Earth climate, and in particular contemporary 'global warming', is governed not by the internal thermo-hydrodynamics of the atmosphere and oceans, as generally believed, but by solar activity (ie. the thermo-magnetohydrodynamics of the Sun). We hoped our note would simply point out that such a 'monotheistic' view of Earth climate is controversial and out of kilter with modern scientific understanding of Earth climate, which takes a holistic view in which all important processes are taken into account.

In the September issue of this newsletter, Dr Sonja Boehmer-Christiansen responded to our note. Her piece took particular issue with the IPCC and its objectives. Some of her comments were directed us, we felt it only appropriate that we should respond.

For the sake of brevity, here we will only respond to the first two of the points made:

### *1. Why differentiate between global warming and climate change?*

We do, but didn't in our note. In fact, we didn't use the term 'global warming' at all. 'Climate change' is a term that now has a generally accepted formal

scientific meaning. It refers to any shift in the Earth's climate, whether due to human or other causes, both now and in the past. 'Global warming' is a term now used only in an informal sense to describe contemporary climate change. Since its manifestation is a move towards warmer climate conditions across most of the globe, it is not a good descriptive term to use in this context. It is not used in scientific circles for the important reason that contemporary climate is not just about temperatures increasing, but also changes in other important aspects of climate, such as rainfall patterns and storm intensities, as well as related issues, such as sea level rise. That said, with these limitations in mind, the term 'global warming' is useful and descriptive of what is going on with the Earth's climate at the moment and is therefore often used interchangeably with 'climate change'.

In this first point Boehmer-Christiansen goes on to state that the world has been warmer or at least as warm during historical times and much warmer and colder during geological time. The second part of this statement is undoubtedly true, but regarding the first part, relating to 'historical times' (which we take to mean recent history not pre-history) all credible scientific studies point to contemporary climate change being unprecedented, in both its magnitude and rate for at least the last 2000 years. While that observation alone does not mean we can conclude that human beings are the cause of that climate change, it does suggest we should be asking why that change is occurring.

Boehmer-Christiansen also says in this first point that the biogeochemical cycles are not considered to be important and are not modelled in the bodies of work summarised by the IPCC. We simply don't know where she gets the idea and is the first indication perhaps that she is actually not that familiar with the work of the IPCC, despite criticising it vehemently. In fact the biogeochemical cycles are central to modern understanding of climate. The IPCC 2001 summary report (TAR-I) on the science of climate change contains two chapters (Chapters 3 and 4, see [http://www.grida.no/climate/ipcc\\_tar/wg1/index.htm](http://www.grida.no/climate/ipcc_tar/wg1/index.htm)) devoted to a discussion of the carbon cycle and the other biogeochemical cycles controlling concentrations of greenhouse gases in the atmosphere. In fact, the extent of modern climatology's holistic outlook is not limited to biogeochemical cycles. As stated above, modern climatology takes an "Earth systems" view, seeking to take account of all important processes, including changes in solar activity.

## *2. In what sense is the IPCC objective and authoritative?*

We didn't use these words in our piece, but would broadly agree with their sentiment. Boehmer-Christiansen seems to believe that the IPCC *is the* climatological establishment. In fact, the IPCC commissions very little research itself. It was set up jointly by the UN and the World Meteorological Organisation in the later 1980s, because of the growing concerns about climate change at that time. Its purpose is to bring together, summarise and disseminate the 'state of the art' with respect to the understanding of climate change and its implications, to the scientific community and to policy makers. It does this by a comprehensive peer review process in which many hundreds of scientists and other researchers internationally give up their time voluntarily

to synthesise and provide a second level of peer review to the published literature. More information about the IPCC process can be read at <http://www.ipcc.ch/about/about.htm> . The IPCC should not be seen as the mouthpiece of the climate change research community, therefore, rather its self-appointed watch-dog and commentator. That is why the IPCC reports are held in such high regard internationally and the primary resource for anyone interested in climate, climate change and implications for policy. Few other fields of human study are subject to the same level of scrutiny during the process of synthesis of IPCC reports. The IPCC is perhaps unique in attempting such a task.

In this second, point Boehmer-Christiansen goes on to say that the assessment of the climate change issues ‘do not come from observation and a genuine interdisciplinary effort, but from simplistic models and statistical analyses that do [not] represent the complexity of climate and economic growth’. [We are assuming the *not* was intended]. Again, we find it hard to believe that Boehmer-Christiansen has any familiarity at all. The bulk of TAR-I is concerned with observations of present and past climate and interdisciplinary analyses involving all the physical sciences.

Not wishing to burden the reader anymore than is necessary, we will not to address Boehmer-Christiansen’s other points (although would be happy to do so in future issues of this newsletter if there is interest).

We are not climate scientists (although one of us – JH – spent a short period in his career working in this field); neither are we ‘greens’. We would prefer to see ourselves as physicists seeking to make an objective assessment of the state of climate science, based on physical understanding, obtained through the scientific method: the iterative process of observation, theory, numerical modelling, and peer-review publication that is used not only in physics but all the physical and biological sciences. We are not suspicious of the climate science community perhaps because we are familiar with this process and, for all its flaws, is the only objective rational process we have available to ask the big questions about the natural world and our role within it.

### ***Nuclear power and climate change – but is there enough uranium to make a difference?***

Simon Roberts

Nuclear power is certainly hitting the headlines in the context of climate change and reducing carbon dioxide emissions. It is pertinent to examine its credentials in this light. Furthermore, check the availability of uranium needed to fuel the sort of expansion plans that would make an impact on global carbon dioxide emissions.

One particular study to note is by Jan Willem Storm van Leeuwen and Philip Smith “Nuclear power , the energy balance” (<http://www.oprit.rug.nl/deenen/>). Their analysis, first published in 2002, was critiqued by the World Nuclear Association (WNA) prompting the authors to add more detail of their sources of data, all from the nuclear industry itself. (The WNA appears not to have responded since.)

They observe that the production of electricity by nuclear reactors, as long as rich uranium ores are still available, leads to considerably less CO<sub>2</sub>-emission than does the use of fossil fuels for the purpose. However in the course of time, as the rich ores become exhausted and poorer and poorer ores are perforce used, continuing use of nuclear reactors for electricity generation will finally result in the production of more CO<sub>2</sub> than if fossil fuels were to be burned directly. Their work includes a complete, up-to-date overview of all of the known or presumed uranium ore bodies, and the amount of net energy that burning them would deliver. They estimate that using these resources to exhaustion would provide only four years of electrical energy at the present world rate of electricity use, or 25 years at the current contribution (16%) by nuclear to power generation. This is estimate agrees with a nuclear industry document on "A Technology Roadmap for Generation IV Nuclear Energy Systems" ([http://gif.inel.gov/roadmap/pdfs/gen\\_iv\\_roadmap.pdf](http://gif.inel.gov/roadmap/pdfs/gen_iv_roadmap.pdf), graph on page 13 "Findings of the roadmap").

The remarkable conclusion of this research might prompt one to ask how it was possible that an entire energy industry was built up when in fact, using all available resources, it could only provide such a small amount of electrical power. There are two reasons that may explain this remarkable fact, one arising from unrealistic, and easy to refute, assumptions concerning the (energetic) yield of nuclear power and the other on an (up to the present) unjustified technological optimism.

The first is that the full energy content of the 0.7% <sup>235</sup>U in natural uranium could be converted into electricity (with essentially no losses, except for the unavoidable loss when heat energy is converted into electrical energy). The magnitude of the costs of this conversion become clear when the *energy costs of energy production* are taken into account. The largest unavoidable energy cost is that of mining and milling the uranium ores. To make this calculation, the authors use only the data on these processes provided by the industry itself. When the rich ores are exhausted, the energy needed for the exploitation of leaner ores will require more input energy from fossil fuels than the nuclear power-plant will provide, so that a nuclear power-plant would become a complicated, expensive and inefficient gas burner.

The amount of <sup>235</sup>U in ores that can be mined and milled profitably (in energy terms) is simply too small to make nuclear energy a long-term solution. Although most political leaders and the public were not aware of this, one must realize that in the 1950's the belief in the great promise of nuclear energy was based on the assumption that fast-neutron breeders would provide a practically infinite amount of fissionable fuel by breeding plutonium from <sup>238</sup>U. The use of <sup>235</sup>U was seen as a temporary stopgap to be used until breeders took over the energy supply but only one fast reactor is still in operation: at Beloyarsk in the Urals. However a report on the operating history presented at an IAEA meeting by the plant manager (Saraev 1998) does not even mention breeding. It has never bred any fuel, although it has experienced quite a number of accidents.

After a half a century of failed attempts at building a breeder system, the assumption of fissionable fuel by breeding plutonium has quite disappeared from public utterances of the nuclear-power industry. If breeding is impossible it will mean that nuclear energy can never be a viable energy source. That after twenty years of operation the Beloyarsk reactor has bred no new usable

fuel apparently (one can never be sure, of course) tolls the bell for long-term energy production by nuclear fission.

## **Contacts**

This newsletter is produced by the Energy Management Group of the Institute of Physics, a professional group comprising members with interests in all aspects of energy use, energy policy, power generation and energy technologies. Further information can be obtained from the following:

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Contributions to the newsletter from group members are always welcome. In particular if you would like your company or research institute to feature in the snapshot section, please draft a short description and send it by e-mail for inclusion. The deadline for contributions to the Spring newsletter will be in February 2006 and all contributions should be sent to the Group Honorary Secretary at the e-mail address above.

For further information on the Energy Management Group see our website at [www.iop.org/groups/emg](http://www.iop.org/groups/emg)

## **Events**

Events currently being considered by your Committee include a visit to a Renewable Energy Site, a Joint Meeting with another Institution on Options for New Build Nuclear Fission Stations and a meeting on the future of Fossil Fuels. Anyone wishing to suggest other events should contact our Hon. Sec. (see Contacts).