# ENERGY WORLD

The magazine of The Institute of Energy

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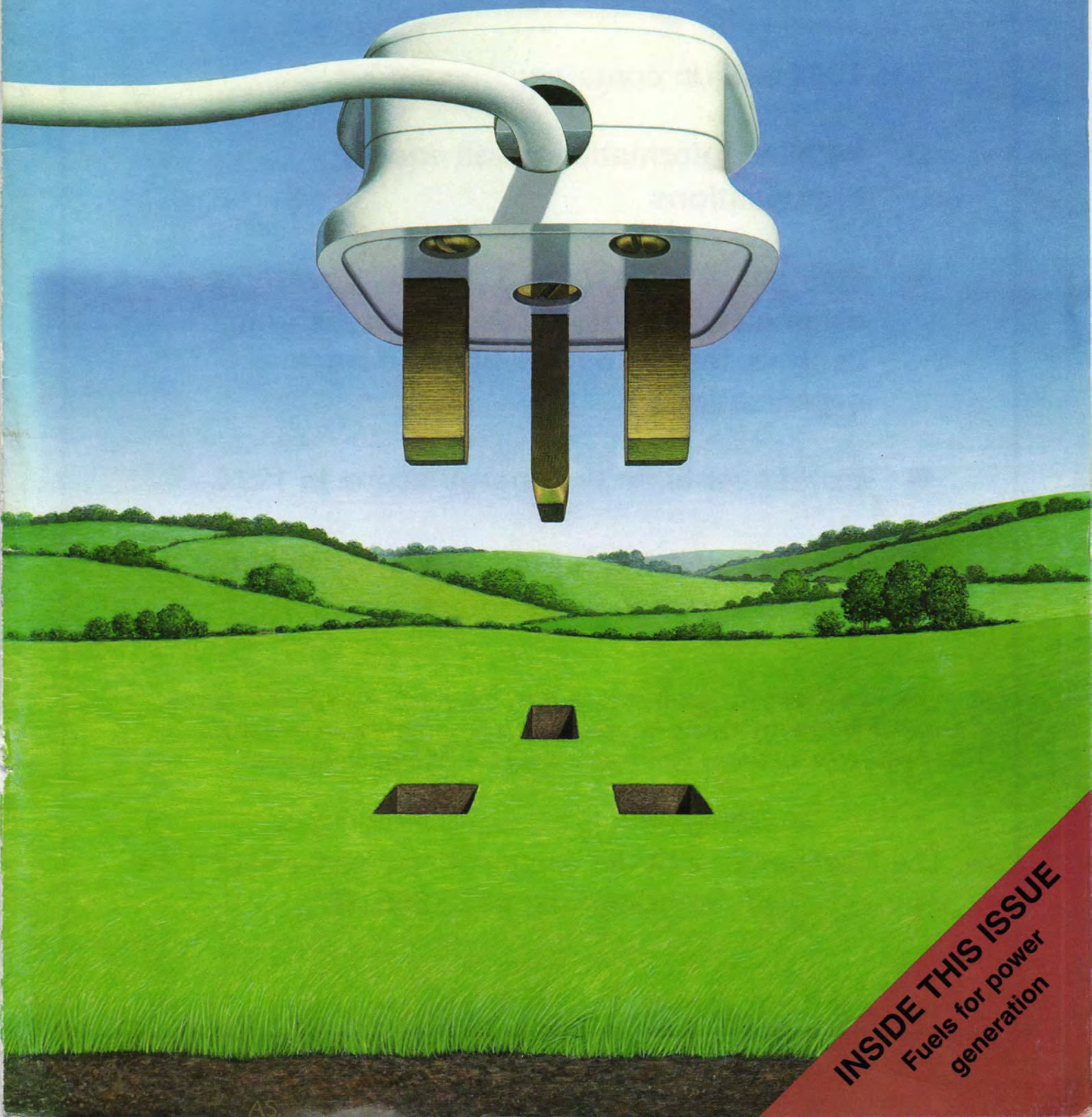

INSIDE THIS ISSUE
Fuels for power generation

# ENERGY WORLD

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## CONTENTS



## COVER

Cover illustration by kind permission of British Coal Corporation.

# Making friends and influencing people

HOW best do we make our presence felt, how do we improve our status. how do we convince the public at large of the worth of our profession?

Both the Engineering Council and our own Institute have been concerning ourselves with these problems.

The Engineering Council has spent much effort in collaboration with its constituent engineering institutions, in considering its present and future organisation. The aim is to improve the status of the engineer in British society by presenting a united front instead of the fragmented appraisal of the current 42 separate bodies. The Institute of Energy has played its part in this general debate, supporting the overall objective but opposing the over-bureaucratic approach of the ambitious plans originally put forward to create a single Institution in which all existing institutions would continue to be the prime registration and accreditation bodies for individual engineers and would continue to operate as learned societies. The individual Institutions would build on their traditional strengths in serving the specialist needs of those concerned with the different branches of engineering.

This is not to imply that the individual societies should not change and evolve, and that there is no scope for collaboration of like-minded societies in order to improve the services which we provide to members.

As in the Engineering Council, we in the Institute of Energy have also devoted much effort to examining our structure in order ultimately to improve our status. We have done this in consultation with our branches and our members with the widest possible consultation to identify more closely the shape we would like the Institute to have in future and the specific objectives we would like to achieve. More recently we have re-examined the relationship and responsibilities of the committees, including branch committees, by which the Institute carries out its various functions. We have drawn up a comprehensive set of guidelines for the future governance of the Institute which goes a long way to clarify individual and collective responsibilities and the management structures of the Institute.

So far, however, neither the Engineering Council nor the Institute has changed the fundamental ways in which they present themselves to the outside world. These improvements to internal structures and the encouragement given to more coordinated action have not yet had much effect on perceptions of the status or importance of our institutions by the outside world.

Energy is once again being recognised as central to the national and international objectives of sustainable development with long-term improvement of the environment. The Institute will have more success in improving its status by taking a more vigorous stance in demonstrating that the activities we organise and the capabilities of our members have major contributions to make to the achievement of the generally accepted aims of increasing energy conversion efficiency, end-use efficiency, energy management, least cost planning, reducing the emission of pollutants, and similar measures directed towards industrial development in a direction compatible with environmental protection.

The Institute of Energy has much to contribute to the way in which energy policy in the UK needs to develop. Is the 'light touch' explained by Mr Eggar at one of our recent conferences adequate to deal with the developing European and indeed global situation? How should British industry be given more incentives to develop the clean technology which will undoubtedly be needed in this country in future, and also in countries now rapidly industrialising and urgently needing improved technology which countries with well developed environmental industries will be eager to supply. What are the likely future contributions from the traditional energy sources, how much from renewables, and at what cost? How should the external costs of environmental disturbance be reflected in the price of energy and how will this affect the relative attractiveness of different sources?

These are some of the issues which we have discussed at recent conferences. The Institute has made major contributions in education and training. A distance learning project for energy managers has been carried out with support from the European Commission, the government and other sponsors. A range of education packages has been produced for the Energy Efficiency Office in collaboration with ETSU.

We have collaborated in establishing the Energy Efficiency Accreditation Scheme, which acknowledges achievement in energy savings and we have contributed to many of the Government's rounds of consultations.

What we have not done is to inform our members and friends about these activities. If we are to improve our shape and our status, we must improve our internal and external communications. This is the best way to gain friends and influence people. If this is a lesson we have learned within the Institute, might it not also be a lesson worth learning by the Engineering Council: regroup, reorganise, federalise by all means, but the best way to improve the status of the engineer is to engage in the public debate and inform people about the activities and achievements of the engineering profession — that is the best and most direct way to improve status and influence people.

**Professor James S Harrison**
*President of The Institute of Energy*

## Developing advanced batteries

A JOINT research project was signed in the USA recently to develop advanced lithium-polymer batteries.

Partners in the project are 3M Corporation, Hydro-Quebec and the US Department of Energy's Argonne National Laboratory. The advanced batteries would be used to power electric vehicles. 3M is already under contract to develop the advanced battery technology for the US Advanced Battery Consortium (USABC) in the next decade.

Hydro-Quebec is a leader in lithium-polymer battery technology, while Argonne will provide engineering and testing support.

The lithium-polymer battery is made from flexible thin-film cells and solid materials. It combines durability and low weight in a small volume. Argonne believes it has the potential to approach USABC's goals for electric vehicle batteries for the early 21st century. Those goals include a power-to-weight ratio of about 400 watts per kg, an energy-to-weight ratio of about 200 watt-hours per kg, as well as a 10-year battery life and a cost of less than $100 per kWh.

The joint project is a cooperative research and development agreement, or CRADA. CRADAs are designed to foster cooperative research between industry and government laboratories by offering private firms advantageous rights to patents and other intellectual property from the joint research, trade-secret-like protection of joint data, and streamlined government approval of the agreement.

Half the funding for the project comes from USABC, with the other half provided by the US Department of Energy's Office of Energy Efficiency.

USABC was formed in January 1991 as a partnership of Chrysler, Ford and General Motors, with participation from the electricity utility industry through the EPRI and the US DoE.

## New technology for non-proliferation and improved safety

A NEW concept in nuclear power generation was announced in the US earlier this year.

The light water thorium reactor concept uses thorium as fuel in addition to uranium. The use of thorium essentially eliminates plutonium as a by-product of reaction; the presence of uranium ensures that residual mixes of uranium isotopes are not suitable for weapons production, making the reactor non-proliferative.

The light water thorium reactor has been designed by Prof Alvin Radowsky, Professor of Nuclear Engineering at Tel-Aviv University, Israel. The system has the capacity to 'burn' weapons-grade plutonium, including discharged plutonium from current reactors, in an energy efficient manner. In addition thorium is more plentiful than uranium, ensuring an adequate supply of nuclear fuel for years to come.

Raytheon Engineers & Constructors has an exclusive licence with RTPC to provide architectural design, and to design, engineer and construct nuclear power plants using the Radowsky concept.

Prof Michael Higatsberger of Austria's University of Vienna has commented: "The thorium reactor design provides a number of salient features, including non-proliferation, greater safety, substantial cost savings, less nuclear waste, as well as providing a practical method for disposing of existing stocks of plutonium.

"The non-proliferative reactor is especially important for the less developed countries, where the chief obstacle to generating nuclear power is the fear of proliferation."

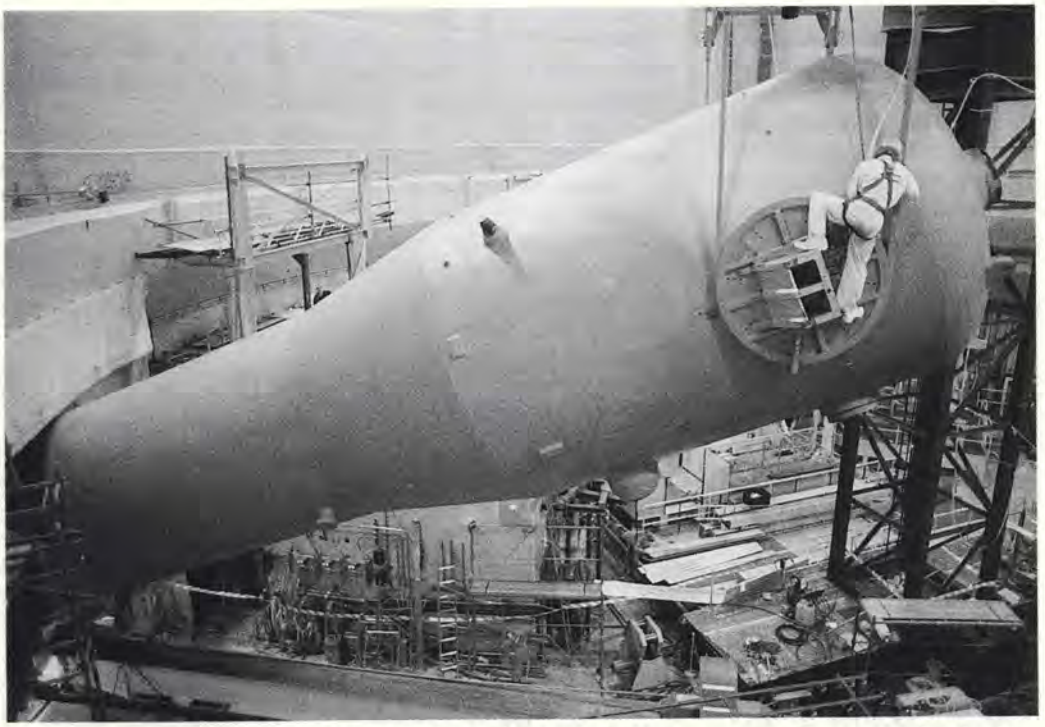
## Ten-mile lagoon wind farm

AUSTRALIA'S largest wind farm Ten Mile Lagoon, on the southern coast of Western Australia, was officially opened in March.

The A$5.8 million State Energy Commission of WA (SECWA) wind farm is expected to provide 30% of the local region's power needs, and has a projected payback period of about 12 years.

The Ten Mile Lagoon Wind Farm was established for the remote town of Esperance after five years of successful operation of a smaller demonstration project at nearby Salmon Beach.

The wind farm will generate 2 MW in conjunction with the local diesel power station, saving 1.9 million litres of fuel each year — the equivalent of 5000 tonnes of carbon dioxide. Unit costs will be eight cents per kWh, compared to 10 cents per kWh fuel costs for the diesel power station.



**At Beznau 1 nuclear power plant, near Zurich, Switzerland, the two steam generators were replaced with the precision of a watchmaker. The main activities in the reactor building were completed in just 44 days, during which time it was also possible to replace sections of the reactor coolant line. The contract was awarded to the power generation group of Siemens AG in consortium with Sulzer Thermtec AG. The picture shows one of the new steam generators, weighing around 205 tonnes, being rigged into position.**

## Green Party accuses 'wreckers'

GREEN Party spokesperson, John Cornford, has accused three Conservative Party Ministers of attempting to 'wreck' the Energy Conservation Bill, due to receive its Report and Third Reading in Parliament on 22 April.

The Bill will give all local authorities a duty to draw up energy conservation plans for their areas, to achieve savings of up to 30%. But the Government is seeking to reduce this duty to a discretionary power, which already exists.

The Government planned to submit five amendments to the Bill at the Committee stage in February, but failed to do so in time. Another amendment redefined the term 'energy conservation authority' to exclude councils in Scotland and Northern Ireland, thus limiting the Bill to England and Wales. A further amendment attempted to change the definition of 'energy conservation' from 'the saving or using of less energy in order to achieve the same level of comfort, warmth or service' to 'the saving or more efficient use of energy'. The Green Party claim this could be interpreted as merely advising people to switch off their heating, if 'energy conservation' is interpreted merely as 'the saving ... of energy'.

## Gas and VAT: price guides

OFGAS has published two new booklets on maximum recommended prices for the resale of gas, taking account of VAT on fuel.

One is aimed at domestic landlords and tenants, the other at suppliers and customers in the industrial gas market.

Both guides are available from OFGAS, Stockley House, 130 Wilton Road, London SW1V 1LQ, tel: 071 828 0898, fax: 071 630 8164.

**A noise reduction of four decibels has been achieved with wind turbines at Blyth, Northumberland (pictured above). Blyth harbour is the first harbour site to house a wind farm, and the noise reduction has been achieved with the installation of a specially-designed elastomeric suspension system, from Metalastik Vibration Control Systems of Leicester.**

**The installation consists of nine computer-controlled 300 kW turbines located on the 100-year old harbour pier. It is quite remote from the main town's population, doesn't intrude on the landscape, and is well placed for the sea winds.**

## Pitlochry dam re-opens

PITLOCHRY Dam, belonging to Hydro-Electric, is listed among the top five tourist attractions in Scotland, but has been closed since October 1993.

The Dam was reopened on 30 March, along with its associated fishladder and visitor centre. The dam had been closed for improvement work to strengthen the structure in accordance with the latest guidelines, under which the standard increases its ability to withstand a 1 in 10 000 year conceivable flood. The project cost half a million pounds, and involved the installation of 31 steel tendons, varying in length up to 38 metres.

Loch Faskally, the last reservoir on the Tummel-Garry scheme, owes its existence entirely to the construction of Pitlochry Dam. The power station built into the dam has an installed capacity of 15 MW, and lying at the end of the scheme it has a catchment area of 1839 sq km. By the time the water reaches Pitlochry, it may have already generated electricity at three or four other power stations down the Tummel Valley.

## Coalfield campaign lobbies MPs

LOCAL authorities in areas where coalfields will be affected by the forthcoming Coal Industry Bill have demanded that MPs listen to their concerns.

At a press conference held just before the Report stage of the Bill, Martin O'Neil MP, Cllr Carole Turner and Stephen Fothergill, director of the Coalfields Communities Campaign, called for the Government to amend the Bill to take into account the effect on local communities.

Changes to the Bill lobbied for by councillors from local authorities in the coalfields include: a continued role for British Coal Enterprise, the industry's job creation arm; effective local control over opencast mining; secure and adequate funding for the Coal Industry Social Welfare Organisation, which provides welfare services to former miners and their dependents; and arrangements to ensure subsidence compensation is swift and fair, and the environmental liabilities arising from mining are dealt with properly.

## Alternative fuel trials for vans and buses

ROADS Minister, Robert Key, has announced a £1.2 million project set up to trial alternative fuels. These will involve conventional vans and buses converted to run on fuels such as compressed natural gas (CNG), liquid petroleum gas (LPG) as well as electricity and biodiesel.

Both the public and private sectors will participate in a two-year programme to compare conventional and alternative fuels. The aim is to identify the part that alternative fuels will play in reducing road transport emissions.

## Pipeline link for N Ireland

NORTHERN Ireland is to be connected to the UK mainland's natural gas transmission system, via a pipeline between Dumfries in Scotland and Islandmagee in Northern Ireland.

The 135km gas pipeline is to be laid by Premier Energy Holdings Ltd, a wholly owned subsidiary of British Gas. The company will simultaneously begin work on converting the 1080 MW Ballylumford power station to a gas-fired facility.

On-site work is expected to begin in June 1995, with completion due in the summer of 1996. Work on Ballylumford power station will involve the conversion of two boilers a year, between 1994 and 1996. Once converted, the boilers will return to service firing heavy fuel oil until natural gas becomes available in late 1996.

The announcement of further investment by British Gas, which will attract EC Regional Development support, follows BG's acquisition of the Northern Ireland power station in 1992, when the electricity industry in the province was privatised. BG's investment in Northern Ireland now amounts to around £300 million.

## Calor enters natural gas market

CALOR Gas Ltd has led the LPG market for over 50 years, and has now entered the natural gas market. The company can offer supplies to all eligible customers — those using more than 2500 therms (73 250 kWh) per year. The company plans to focus its marketing on the smaller commercial user, who may not yet benefit from a competitive gas supply.

Calor Gas Ltd, part of the publicly-quoted Calor Gas plc, has been involved in the gas business since 1935. The name 'Calor' initially became synonymous with 'butane' or 'bottled gas', and later with bulk propane, which the company now supplies to thousands of domestic and commercial customers in the UK and the Republic of Ireland. Calor Group currently employs over 2000 people and turnover exceeds £300 million. Prospective customers should call freephone 0800 906050.

## PEP award for Ford Radiators

ESSEX based Ford Motor Company radiator plant has won the Electricity Association's Award for Technical Innovation at the latest Power Efficiency and Productivity (PEP) national event.

Ford, who represented Eastern Electricity, received its award for its recent investment in an energy efficient controlled atmosphere brazing process.

In addition to energy and production cost savings of over £490 000 a year, the company has been able to increase the production of parts and improve quality.

Producing over a million radiators a year, the Basildon plant manufactures heat exchangers and air conditioning equipment for cars and vans for both the European and American markets.

Ford's Climate Control Division looked at a number of options before deciding to replace the original vacuum system with a new controlled atmosphere brazing process, in conjunction with Eastern Electricity.

The new process has proved highly efficient, and the production of parts has increased from 60 to 300 an hour. In addition, high quality standards are easier to maintain due to better control of the production process, made possible by the all-electric system.

The working environment has been improved, as the handling of epoxy, chromates and other hazardous elements has been eliminated by the new process.

Eastern Electricity's PEP Awards are held annually, and are open to all companies within the region, which through adopting or improving an electrical process or service, have helped create a better business by improving performance, reducing production costs, improving working conditions or reducing energy consumption per unit produced.

More information from Paul Humphrey, Eastern Electricity, tel: 0473 544241.

## Environmental initiative

A NEW joint initiative, pioneered by Midlands Electricity and G & E Consultants Ltd, will help industry to comply with environmental legislation, streamline processes and develop systems, products and processes to safeguard the environment.

Access to G & E services will be through MEB's 30 industrial development engineers, based throughout the Midlands, who collectively support over 20 000 industrial customers.

Services available include site testing, covering COSHH, EPA and public health requirements, asbestos control, odour assessment and noise and vibration studies. Site testing is supplemented by a full range of functions including NAMAS accredited laboratories, BS 7750 support and project management.

For more information contact John Elliott of Midlands Electricity plc, tel: 021 423 2345.

## On top of the world

E H SMITH (Roofing) Ltd is on top of the world after completing a £1.3 million contract to clad a concrete dome bigger than St Paul's Cathedral — the secondary containment of Sizewell B PWR.

The Birmingham-based company undertook cladding of the 72m high secondary containment encompassing the nuclear power station, being built on behalf of Nuclear Electric by John Laing Civil Engineering on the Suffolk coast. It is the first dome of its kind in the UK.

The project was part of £5 m worth of contracts carried out on the site by E H Smith, and involved cladding the dome with 3500 sq m of aluminium panels.

Further information from David Parnell, E H Smith (Roofing) Ltd, 1 Sherbourne Road, Acocks Green, Birmingham B27 6AB.

**Fixing the cladding to the secondary containment dome at Sizewell B involved the use of one of the tallest tower cranes in the UK. Roofers had to work in specially-designed cradles. "The project called for some highly original thinking" said David Parnell of E H Smith (Roofing) Ltd.**

## CHP take over

THE small-scale CHP company, Petbow Cogeneration Ltd, has been acquired by British Gas plc from PGI Ltd, as from the beginning of this year.

Petbow's CHP packages will continue to be manufactured under licence by the original owners from the company's factory in Sandwich, Kent.

Typical applications for the company's product include hospitals, leisure centres, hotels, and similar establishments with a requirement for both heat and power.

The full management team has yet to be announced, although Nevile Henderson and Ted Lanigan, both of British Gas have joined the board of the new wholly-owned subsidiary.

Further information from Jeff Pearson, National Product Manager, CHP, British Gas plc, 326 High Holborn, LOndon WC1V 7PT. Tel: 071 611 3282.

# Electricity from nuclear energy

## an economic or environmental problem?

*by Prof Donald T Swift-Hook**

**Professor Swift-Hook gives a thorough evaluation of the pros and cons of both nuclear power and renewable sources. This article is based on a paper given by the author at the Jakarta Energy conference in October 1993.**

THE ENERGY scene is changing rapidly for technical, political and economic reasons. In the UK, for example, little or no electricity was generated from natural gas one year ago and the highest efficiency of any sizeable power plant was less than 40%. In two years' time, nearly one third of all UK electricity will come from combined cycle gas turbine (CCGT) power plant, with efficiencies of 50% or more.

The massive scale of this 'dash for gas' has eclipsed the developments in wind power, which are on a much smaller scale at present, but which could be equally significant for the future.

Coal is seeing even greater changes in Britain, although unfortunately they are in the opposite direction. 70% of British electricity comes from coal and to help the UK coal industry, five-year contracts were agreed with the electricity supply industry. These contracts kept up the production of British coal when demand for it was actually falling, and surplus supplies were stock piled at the power stations. 19-months supply of coal are already in stock and no coal at all would really need to be bought for a year or so. What should have been a carefully planned run-down of the coal mines over a reasonable period has turned into a shut-down crisis of major proportions. The 100 million tonnes of coal mined annually in Britain a few years ago will drop to 30 million tonnes at most, and possibly much less. Every exciting new development in oil, gas, the renewables or nuclear power, every improvement in energy efficiency in the UK now has to be looked at in terms of the number of mines that will be closed as a result.

These dramatic changes in the UK show what can happen in the energy sector of any country, where technical and/or political and/or economic changes are occurring — and it is difficult to think of a country where they are not.

When changes are happening this rapidly, any figures must be presented and viewed with caution. By the time they are published, they may well be overtaken by events. Carefully laid plans and projections may not materialise and those events that do burst upon the energy scene often appear unannounced. It is against this turbulent background that nuclear power is fighting to survive and to expand.

Amidst all the drama and the politics, false impressions about nuclear power abound. They can flourish anywhere, but the nuclear field seems burdened with more false impressions than most others. Let us therefore look at a few facts.

More than 430 reactors in 26 different countries produce 17% of the world's electricity. That proportion of nuclear generation is nearly doubled in Europe (33%) and Japan (27%) and it is even higher in individual countries such as France (73%) and Belgium (over 60%). Several other countries including Hungary, Sweden and Scotland have more than half nuclear power (10%). It is the less developed countries that tend to have little or no nuclear generation.

So nuclear power represents a significant proportion of total power generation and it is relied upon around the world.

This means, incidentally, that any nuclear problems that are perceived today are not going to disappear. Fears about present levels of radioactivity, about nuclear effects on future generations or of terrorists hi-jacking plutonium (Pu) would not vanish if every nuclear reactor was shut down tomorrow. Nuclear technology will have to be maintained in any case to carry out decommissioning, waste disposal and a range of other activities which flow from the existing generations of nuclear power plant. That is one of the difficulties in declaring a nuclear moratorium. It does not mean stopping all nuclear activities, only the ones that make a good deal of money by generating electricity.

It is worth emphasising the fact that the operation of nuclear power plant is carried out routinely and efficiently in all of the countries with nuclear capacity.

There is a widespread belief that the world stopped building nuclear reactors some time ago. In reality, nuclear generating capacity has increased substantially around the world by nearly 50% in the last decade. One exception is the US, where no nuclear plant is operating that was ordered after 1974, and there has certainly been some slowing down elsewhere in the last two or three years, but Pacific Rim countries are still expanding their nuclear installations quite extensively.

Public attitudes to nuclear power are often misunderstood. When people are asked, they usually tend to be rather negative towards nuclear power but the same is true of people's attitude to income tax. In fact, those same people who say they do not want nuclear power will often grudgingly accept that it is actually necessary, just as they agree to pay their income taxes. So the real strength of public opposition can be quite difficult to gauge.

Furthermore, people still object when relatively benign alternatives are offered which produce no widespread pollution of any sort. Wind farms, for example, are meeting considerable opposition. Wind turbines make a very localised noise, which sounds like the swishing of the wind, and can only be heard when the wind is blowing quite hard, and making a windy noise in any case. That is seized upon as grounds for objecting to them. It is difficult not to suspect that the real objection is to technology and to large-scale engineering (the wind turbines are 50m high), perhaps even to electricity and to the advance of civilisation itself, rather than to any particular method of generation, be it nuclear or wind power.

Whatever the true strength and effectiveness of public concern about nuclear power, there is little doubt about the main area upon which objections focus: health and safety. By normal standards of public safety and risk assessment, nuclear power is relatively safe, but again false impressions are widespread. Concerns can broadly be divided into three categories: major accidents, low-level radiation and long-term effects.

At Chernobyl, 31 people were killed as they tried to control a reactor accident. No additional deaths were found by the World

*King's College London

Health Organisation when they investigated several years after the event. Other major accidents like Three Mile Island and Windscale produced no known deaths. Indeed, at Three Mile Island, contrary to general impressions, there were no radioactive releases beyond permitted limits: the secondary containment did its job.

By contrast, the international oil industry averages two or three major accidents per year, with tank or tanker explosions and oil rig disasters like Piper-Alpha. International trade in coal and hydroelectricity is more limited and disasters in those industries tend to receive less worldwide publicity beyond national boundaries. Names like Incehamani (the Turkish mine disaster in 1992 that killed 434 miners) and Uffa (gas pipe line explosion in the Urals that killed 452 in 1989) are not so widely remembered although the numbers of deaths were very high in both cases. But that is more than enough 'shroud-waving'. The point is clear enough: nuclear is safe.

**Table 1: Deaths from major accidents due to various energy sources**

| Source | Place | Events 1969-86 | Deaths min no | per event max no | deaths av no p/a |
|---|---|---|---|---|---|
| Coal | Mine | 62 | 10 | 434 | 200 |
| Oil | rigs | 6 | 6 | 123 | 25 |
| | tanks/tankers | 57 | 5 | 500 | 90 |
| Gas | various | 24 | 6 | 452 | 80 |
| Water | dam | 8 | 11 | 2500 | 200 |
| Nuclear | Chernobyl | 1 | 31 | 31 | 2 |
| **Totals** | | **158** | **5** | **2500** | **595** |

## Background radiation

The amounts of background radiation due to nuclear power are very small, despite public concerns and widespread impressions to the contrary. The levels of radiation we are subjected to vary according to where we live and where we work, what our houses are built of and how well they are ventilated. If we travel in the mountains or in high flying aircraft there is less air to shield us from cosmic radiation. Radon (and thoron) seep out of the ground and can accumulate in buildings that are not well ventilated.

Radiation also depends on geology. Cornwall has a lot of granite and people living there receive on average three times as much radiation from the rock (and from radon from it) as most other UK citizens, although they do not have a noticeably higher incidence of cancer. Some foods contain more radioactivity than others. Brazil nuts, tea and coffee, for example, would all be listed under the UK Radioactive Substances Act, with more than 370 becquerels per kilogram, if they were not natural substances. Even if fall out from Chernobyl is included, along with all that from weapons tests and the remains from the Hiroshima and Nagasaki bombs, the radiation dose due to nuclear power is minute by comparison with background levels.

Radiation is feared because high levels of it can cause cancer, although it is not known for certain whether low background levels of radiation actually do so. (The number of extra cases would be too small to notice and it is quite possible that body cells may have self-healing mechanisms for minor amounts of damage). Apart from radiation, there are many other causes of cancer such as smoking or other manmade pollution. Without entering the debate about cigarettes, it can be noted that the lifespan of those unfortunate enough to live in centres of population such as London and Manchester in the UK is significantly reduced compared with those living in the surrounding countryside.

The background risks from radiation due to nuclear power are tiny by comparison.

According to the World Health Organisation, evidence does not support fears that low levels of radiation and genetic damage have long-term cumulative effects. The long-term worries that do arise are therefore concerned with the safe storage and disposal of radioactive materials themselves.

In this connection, it is interesting to reflect that nature leaves huge piles of radioactive materials around totally unprotected without any obvious damage to the human race. These are of course just the places we go to in order to mine uranium. The suggestion that water might leach out radioactivity into the water courses and rivers is a fair one. That is indeed one way in which prospecting for uranium is carried out! So it is important not to overstate the dangers of storing radioactive materials, even those with long lifetimes.

Multi-barrier containment systems designed for the long-term disposal of radioactivity typically include layers of rock hundreds of metres thick, and layers impervious to water as well as manmade containers of stainless steel and other non-corroding or alkaline materials. Engineering studies of all aspects of the structures and designs (including studies of two thousand-year old concrete as built by the Romans) give confidence in the long-term performance of the repositories that are being devised for nuclear waste disposal. The problems seem to be no more serious than those of the chemical industry with dangerous chemicals to dispose of which will never lose their toxicity. In engineering terms, proposals for nuclear waste disposal can properly be assessed as safe.

The prices of nuclear power plant have tended to remain fairly stable over recent years at around $2500 per kW, despite the dramatic developments in other energy fields.

Many factors are driving the prices of nuclear reactors downwards: technical developments to improve efficiency and availability, design improvements to simplify maintenance and to reduce construction costs (eg by minimising on-site activities and using prefabrication techniques), streamlining of project management to reduce construction times and interest during construction. One major factor has been the use of standardised designs to spread the costs of research, design, development and tooling over many units and to allow almost assembly-line production. The UK has dropped its own lines of development in gas-cooled reactors, and has built the latest (and safest) design of pressurised water reactor (PWR) at Sizewell in Suffolk. It is now bidding to build the same reactor in Taiwan and other Far East countries.

There are several factors pushing the prices of nuclear reactors upwards. Improvements in safety standards are continually demanded and these tend to be costly. As some of the more elderly plant reaches the end of its life, the long-term problems of

**Table 2: typical radiation doses in the UK from various sources**

| | | |
|---|---|---|
| **Natural** | cosmic rays | 10 |
| | food & drink | 12 |
| | ground & buildings | 14 |
| | radon/thoron from ground | 51 |
| Total from natural sources | | 87% |
| **Manmade** | medical | 12 |
| | miscellaneous | 0.4 |
| | work | 0.2 |
| | fall-out (inc. Chernobyl) | 0.4 |
| | nuclear discharges | 0.1 |
| Total manmade | | 13% |
| **Total dose** | | **100%** |

waste disposal and decommissioning are now being addressed in detail and unforeseen costs have emerged. The result of these conflicting pressures upwards and downwards has been that the prices of nuclear reactors have not changed greatly overall in recent years.

These figures for the cost of nuclear plant do not include any special provision for uncertainties in the cost of decommissioning the power stations or their fuel making facilities and disposing of the radioactive waste produced. Nor do they include insurance against nuclear accidents and the cost of consequential damage. Both these items have undoubtedly been underestimated in the past.

Present plans for decommissioning and radioactive waste disposal involve the storage of very 'hot' radioactive material for perhaps 100 years to allow it to 'cool' and to lose most of its radioactivity. Storage costs are minimal and so the majority of decommissioning costs would arise 100 years after the end of the useful life of the plant.

If a sinking fund were set up with a levy on the nuclear electricity generated and if the savings in the fund produced only a modest 2% real return above inflation, then an 8% levy on nuclear electricity prices would be sufficient to pay for the full costs of decommissioning, even if it cost as much to knock the reactor down and take it away as it had cost to put up and set to work in the first place. That hardly seems likely in the light of experience with the fully decommissioned Shippingport reactor (the prototype PWR) in the US and of progress with decommissioning the Windscale prototype advanced gas-cooled reactor (AGR) in the UK. Decommissioning and waste disposal will therefore add only a few per cent to the costs of nuclear electricity.

On this basis, even though decommissioning and waste disposal costs may have been underestimated in the past, they will still not have any significant effect on the costs of nuclear energy. So another general impression about nuclear power proves false.

Insuring against a serious nuclear accident is difficult and it is usually felt that the commercial costs of insurance would be astronomical. To insure the reactor itself would probably present no great problem if only the loss could be limited to a total write-off of the cost of the reactor. Unfortunately, the possible consequential damage is seen as unlimited in amount and in worldwide extent.

Whether this view is realistic in the light of the relatively modest figures presented on the Chernobyl disaster is immaterial. The judgement of the insurance markets seems set against coping with nuclear catastrophes. So far, losses seem to have been met by national governments with no cross-border compensation. If this continues then, paradoxically, the supposedly astronomical cost of insurance would not effect nuclear energy costs at all.

**Four 1300 MWe PWRs at Palvel in France.**

Nuclear fuel is cheap and plentiful.

This was not the case ten or twenty years ago, when the known reserves of uranium were not enough to fuel the nuclear plant under construction or being planned. Then, the price of uranium was high and the fast breeder reactor was seen as the only nuclear fission route forward since it can use the abundant U238 isotope to breed more fuel and not just the U235 used by present-day thermal fission reactors. If their technical problems can be overcome, fast reactors can produce 50 times as much energy from uranium as present thermal reactors and then nuclear fuel reserves are greater than all the reserves of all the fossil fuels put together: an attractive prospect.

In the last few years most fast reactor programmes have been stopped because enormous new reserves of uranium have been discovered and the price of uranium has fallen by a factor of 20. Nuclear fuel must be fabricated into fuel elements for reactors (in the same way that crude oil must be refined) so nuclear fuel costs have not fallen quite so dramatically (just as pump prices for motorists do not swing as drastically as the prices posted by OPEC) but anyone in the oil industry who thinks that they have experienced big price changes in recent years should spare some sympathy for the nuclear industry! In all events, nuclear fuel is now cheap and plentiful.

In this situation, with nuclear reactor prices stable and nuclear fuel prices falling, the future for nuclear power should be assured, and it is likely that worldwide nuclear capacity will have increased by as much as 50% shortly after the turn of the century. This trend will be led by countries such as Japan and Korea, with few or no indigenous sources of energy. In many other countries the future of nuclear is not at all assured. In fact it is quite uncertain.

## Market reforms

There are several reasons for nuclear power's problems, and most of them are associated in one way or another with the market reforms that are sweeping the world. In the former Soviet Union this has been associated with the break up of a whole empire. In the UK, and other countries in both western and eastern Europe it has involved widespread privatisation of state monopolies, and other moves to expose utility industries more fully to competitive market forces. The World Bank is using its persuasive financial strength to encourage utility reform in developing countries.

So market reform, accompanied by a substantial amount of privatisation of state-owned companies, is already a major feature affecting energy economics around the world. It seems predictable that this trend will continue and must influence energy developments until well into the next century.

A declared intention of market reforms is to introduce competition, and that is happening to nuclear energy with a vengeance.

Natural gas used to be regarded — and priced — as a scarce premium fuel that should be reserved for cooking, heating and industrial processes, but was far too clean and valuable to be used to generate electricity. Institutional and legal barriers were erect-

# We don't contribute to global warming, we don't contribute to ozone depletion and we don't cause acid rain.

## Are we friends of the earth?


Currently, 40% of the gases that contribute to the greenhouse effect are caused by the burning of fossil fuels. What's more, if the same amount of power produced by us was produced by fossil fuels it would mean an extra fifty five million tonnes of $CO_2$ every year. Breathtaking isn't it.

The fact is the nuclear power stations we operate in England and Wales are safe, environmentally responsible and reliable. Spend an afternoon at a nuclear power station and we'll be able to tell you so much more. It certainly won't affect your body but it might just change your mind.

NUCLEAR ELECTRIC'S VISITOR CENTRES IN ENGLAND AND WALES

**1.** Trawsfynydd **2.** Wylfa **3.** Heysham **4.** Hartlepool **5.** Sizewell

**6.** Bradwell **7.** Dungeness **8.** Hinkley Point **9.** Oldbury-on-Severn

Nuclear Electric

To visit a nuclear power station, or for more information, write to this address: Peter Haslam, Nuclear Electric plc, 123 Pall Mall, London SW1Y 5EA.

ed between gas and electricity, by making them separate government departments or utilities, and/or forbidding the use of gas in major power plants. The was the case in the EC up to the late 1980s.

Recent discoveries of natural gas in substantial quantities around the world have made claims of scarcity obsolete, and other developments, such as the removal of regulations in Europe, have encouraged a 'dash for gas' in power generation.

Gas turbines, which were direct developments of aircraft jet engines, have long been used to provide small peak power plants, as a cheap way of meeting peak demand. Now, much larger industrial gas turbines discharging their hot gases into steam-raising plant are being installed in substantial quantities around the world. These combined cycle gas turbines (CCGTs) use clean fuel, far less polluting than other fossil fuels, and which produces no sulphur dioxide, limited oxides of nitrogen and only half as much carbon dioxide. (Care must be taken to avoid leakages of natural gas along pipelines — not only because of the danger of explosion — but because methane is itself a damaging greenhouse gas). CCGTs have generating efficiencies of more than 50%, and installations which are planned are nearer 60% efficient. Increases in efficiency bring corresponding reductions in pollution.

Gas can therefore claim many of the advantages of nuclear power in terms of cleanliness, but its greatest impact is on costs. CCGT plant, costing as little as $600 per kW of generating capacity, are not as capital intensive as nuclear reactors, at more than $2500 per kW. Gas is a cheap fuel, and has been discovered in large quantities in many countries throughout the world. Many more countries have access to gas because of major pipelines being installed, eg, from Siberia to Europe.

In many places where gas is now available in large quantities, CCGTs are sufficiently cheap to replace existing coal and oil-fired plant. In the UK, for example, one third of all electricity generation will have been replaced by gas in two years' time. This will leave substantial surpluses of spare coal-fired power plant lying idle, and it will then be difficult to justify building additional spare capacity of any sort, certainly not capital intensive nuclear plant costing over $2500 per kW.

Nuclear will also suffer competition from the renewables in many places. Only two or three years ago the Southern California Edison utility showed that wind farms had displaced CCGTs as the cheapest generating option in that part of the US. Such a conclusion, of course, depends upon the wind resources available in the region in question.

Winds at ground level tend to be driven by stratospheric winds, so wind speeds are greater over the sea, which is smooth, than over land with rough terrain. Coastal regions and islands are windier than continental or inland areas, being nearer the sea, and upland regions are also windier, being closer to the stratosphere. So mountainous islands, such as Greece or Indonesia, often have particularly good wind resources, which are competitive with nuclear.

**Some of 103 wind turbines at the Penrhyddlan and Llidiartywaun wind farm in Powys.**

Centres of population produce large amounts of waste that can represent low, or even negative-cost fuel. Direct combustion of such waste locally in suitable steam raising plant or the production of gas from nearby landfill sites can be competitive with other methods of generation. Other forms of biomass produced directly or as waste from agricultural or industrial processes are also commercially viable in many places. Since the carbon content is recycled, biomass is included among the renewable sources of energy. It does not add to the long-term carbon dioxide content of the atmosphere because it only puts back carbon that was taken from the atmosphere a relatively short time before. So biomass does not contribute to the greenhouse effect overall.

The nuclear industry often claims credit too for not contributing to the greenhouse effect. That argument can certainly be used to influence public opinion in favour of nuclear power (and renewables). Unfortunately, it has little effect at present as far as economics are concerned. Moral credit does not translate into financial credit. Until fossil fuel polluters are made to pay, through carbon taxes or equivalent legislation, nuclear energy will gain no financial advantage from its cleanliness.

Some countries are making limited financial provisions in this direction, for instance the UK has imposed a Non-Fossil Fuel Obligation (NFFO), but the prospect of taxing fossil fuels until they become as expensive as nuclear is not very attractive to a world deep in recession. Even if carbon taxes are widely introduced, they will bear less heavily on nuclear's main competitors which, in many places, are now natural gas and renewable energies. Natural gas has only half the greenhouse emissions of coal or oil, and none of the acid rain ones, while the renewables produce no (nett) emissions at all. So carbon taxes will not remove the competition from nuclear.

## Short termism

Even if there are other, cheaper alternatives available, governments may still prefer to have a component of nuclear power for a variety of reasons. These include avoiding dependence on imported fuel; diversity of supplies; the desire to introduce advanced technologies to help raise technical standards; preference for a few large central units, that can be closely controlled and protected; as part of a nuclear defence policy; or in the belief that the World Bank will approve a large single project more easily than several small ones.

Unfortunately the views of governments and of the financial markets are not easily reconciled, as recent experience in the UK demonstrated when attempts were made to privatise the whole of the electricity supply industry. Even in areas of strategic policy, such as the desire for a nuclear power industry, governments who wish to tap financial markets find they are not omnipotent. When proposals have to satisfy stringent market tests, recent nuclear projects have been found to fail.

**Table 3: Effects of financial short termism**

| Terms of $1000 loan | Annual charge | Relative cost of capital |
|---|---|---|
| 20 years at 5% | $80.24 | 100% |
| 20 years at 10% | $117.46 | 146% |
| 10 years at 10% | $162.75 | 203% |

In the 1980s, most governments used to require real rates of return on investments of only 5% above inflation when there was no commercial risk, for instance when a project was backed by the government itself. In the general move towards market financing, required real rates of return have increased substantially. In the UK the rate rose from 5% to 8% in April 1989, and capital suddenly became 60% more expensive in all project proposals. (An attempt was made to retain a 5% test discount rate for nuclear projects, but that ran counter to the wish for market influences to operate).

Worldwide moves to encourage private investment in public projects and to tap the free financial markets mean that governments are now less willing to provide finance with open-ended guarantees. Individual projects must cover their own commercial risks, and that means paying even higher rates of return to investors. In the UK, power station projects must now produce at least 10% or 12% rate of return above inflation, compared with 5% only a few years ago. The cost of capital has effectively doubled.

One consequence of this has been to reduce time horizons. 5% real interest (above inflation) allows a time horizon of 20 years, but 10% real interest reduces the time horizon to 10 years. (For present purposes, an appropriate time horizon is the time span beyond which mortgage repayments or levelised annual charges become insensitive to repayment period, and this occurs for the time over which equal capital repayments would fall below initial interest payments). So 'short termism' is an inevitable effect of higher real interest rates. Inflation itself can work in the other direction, to encourage borrowings for long-term capital investment, since debt is eroded in real terms by inflation.

When financial time horizons are reduced to 10 years, investors do not like to see their money tied up for longer periods than that and capital repayments or amortisation cannot be extended over the useful life of the plant, which is likely to be 20 years or more. Energy prices must then be higher over the payback or amortisation period, than the levelised cost would be because enough cash flow must be produced to service the loan. So shorter terms for loans increase energy prices even further with new plant.

For capital intensive systems, such as nuclear or the renewables, these increases in the cost of capital must be reflected strongly in generating costs. Where fuel costs dominate, as with most fossil fuels, capital cost increases are less important. That is why nuclear energy has become more expensive than electricity from gas.

The facts and figures set out here contradict many of the general impressions about nuclear power that seem to be current. When environmental problems arise and risks are assessed in the same way as they normally are for other technologies, nuclear energy does not raise great concerns, and it is in many ways benign. It is likely that worldwide nuclear capacity will have increased by as much as 50% soon after 2000, with countries such as Japan and Korea in the lead, because they have no energy sources of their own.

On the other hand, market forces and competing technologies, particularly gas and renewable energies, such as wind, have set nuclear energy at a serious economic disadvantage, and that is why further nuclear developments in countries such as the UK and USA are uncertain. ❑

# Prospects for coal

*by John Baker**

**The following article is based on a recent speech to the Coal Industry Society. National Power's Chief Executive gives his views on the future energy mix for power generation.**

THERE are few industries more in the glare of the public spotlight than the British mining industry at the present time. That is not surprising when you look at its historical importance to the nation, and the fundamental changes it is undergoing.

There are those who have all but written off the British coal industry. National Power is not among them. That is not to underestimate the scale of British Coal's continuing restructuring. Nor do I underestimate the challenges confronting the industry as it responds to the inexorable market pressures.

But in spite of the uncertainties, there are realistic opportunities for coal — at the right price — to remain a major source of fuel for power stations into the next century. Here I would like to consider the opportunities and obstacles facing coal in the future.

A look at the current mix of fuels for electricity generation in the UK tell their own tale of coal's reducing role.

Just five years ago, three quarters of electricity supplies in England and Wales came from coal-fired power stations. In the current financial year, they are likely to supply a little over half. Coal's loss of market share so far is due to three main factors:

- first, and most important, a substantial increase in nuclear power, which has a 'must run' status, and does not need to compete in the market. This year it will account for more than 20% of electricity output. Next year, when Sizewell B is fully operational, the percentage will rise to 25%;
- second, the emergence of gas-fired plants, which will produce about 10% of electricity supplies, where none was produced from gas five years ago;
- and third, a doubling of electricity 'imports' through interconnectors with France and Scotland to around 10% of the market in 1993/4.

Since oil burn has been negligible for years, all these increases have to come out of coal. There isn't anything else — and total electricity demand has been flat.

These developments underline the growing competitive forces in power generation in England and Wales. Despite that flat demand, competition has increased far more quickly than anyone forecast at the time the industry was privatised.

One outcome of all this rapid change is that too much coal has been mined for the market — leading to a significant rise in coal stocks at pithead and power station. At their height last year, National Power's coal stocks alone totalled over 19 million tonnes, tying up some £700 million capital. And national coal stocks were around 50 million tonnes.

While our coal stocks have at last started to fall during the winter, they are still considerably above the level anybody could remotely seek to justify on commercial or operational grounds. We have, therefore, little short-term requirement for additional supplies beyond those we are contracted for; although we did recently buy an extra 350 000 tonnes from British Coal.

So much for the present — where does this leave the role for coal in the production of electricity over the next few years; say by the turn of the century? Crystal-ball gazing into the energy scene is fraught with difficulty, and most forecasts invariably end up in the waste paper basket. The increasingly competitive generation market makes the task of estimating more difficult, but the trend is clear.

The major influence on fossil-fuelled generation for the next ten years will continue to be the cost of cleaning up electricity to meet ever-tightening environmental regulation, particularly emission limits. We estimate the electricity industry has already committed around £5 billion to environmental investments that will produce 130 billion units a year of cleaner electricity — that's nearly 50% of current consumption. The total bill could rise to over £8 billion by the end of the century.

Cleaner electricity is being achieved in three main ways. First, from new nuclear stations like Sizewell B. Then there are the new combined cycle gas turbines (CCGTs), which are environmentally more attractive on all counts than coal-fired plant. And there is the retrofitting of existing coal stations with emission control equipment, both for sulphur and oxides of nitrogen. Finally, there is a minor contribution from renewables, particularly from wind power.

At National Power we have experience both in building CCGTs and fitting sulphur removal plant (FGD) to our most modern and efficient coal-fired power station at Drax. In either case, based on our experience, the incremental cost of cleaning fossil-fuelled electricity is about the same — 0.6 p/kWh, or around 25% of the current Pool price of electricity. This 0.6 p/kWh figure is not a comparison between the cost of producing electricity from gas and from coal. It is a comparison between the cost of cleaner generation and conventional coal-fired generation, whose environmental days are

* *Chief Executive*
*National Power plc*

## The author

**John Baker has had a career in both public and private sectors. An arts graduate from Oxford University, he spent ten years each dealing with transport policy and finance, and then with urban regeneration and social housing.**

**He moved into the energy sector in 1979 as company secretary to the CEGB. Appointed to the Board in 1980, he became Corporate Managing Director, responsible for commercial matters, and led management of the privatisation programme.**

**He has been Chief Executive of National Power since the company was established in 1990.**

now numbered. So there is nothing irrational in the construction of gas plant, as has been suggested.

However, if the costs of CCGTs and cleaned up coal plant are broadly the same, the investment risks are quite different. FGD retrofitted coal plants are clearly more vulnerable to new environmental regulation than gas-fired plants. This is particularly true of the possible imposition of carbon taxes, remembering that CCGTs burning gas are significantly more efficient, and produce only 45% of the carbon dioxide of an equivalent coal-fired plant. And after Drax and Ratcliffe, all the other large coal stations belonging to National Power and PowerGen would be well over 30 years old by the time they could be retrofitted with FGD. It would, therefore, make no economic sense to do so — these coal plants are now withering assets.

So Drax is one form of cleaner coal generation. But it is yesterday's technology. However, we are also involved with our European partners in the development of new clean-coal technology. This is the 300 MW Elcogas project in Spain, which will use a coal gasification process. Although it will take a number of years to develop, it holds out the prospect in the next decade of commercial coal burning in a new breed of environmentally acceptable plant — provided of course coal is a competitive fuel. Whether this technology benefits British-mined coal in particular depends on whether its production costs can match imported coal prices.

Meanwhile, environmental regulation is tightening year by year. Even now, international negotiations are being concluded to increase the severity of the emission reduction targets the UK must achieve. Power station emissions will continue to be reduced in line with ongoing EC directives. On top of this, we are discussing with HMIP how 'new plant standards' or their equivalent will be met by each of our plants by the year 2001. The importance of HMIPs requirement here is that these standards are plant specific, so that when individual plant limits are aggregated, it may mean the total is even less than the umbrella targets agreed within the European Union.

These new standards will mean that by 2001, all plants which run virtually continuously — that is at or near base load — will have to produce cleaned-up electricity irrespective of their design technology. Other coal or oil-fired generating plants in service at that time, no matter how efficient, will be constrained to operate significantly below base load, probably at below 50% load factor, in order to ensure that their overall contribution to sulphur emissions is limited.

Against this background, you can see why National Power believe that the main driver behind the progressive reduction in coal-fired generation is current and prospective environmental legislation. There are naturally a number of other factors that will influence the fuel mix for generation by the turn of the century. Amongst these are: the pace at which new players continue to enter the generation game on the tide of natural gas; the level of demand for electricity; and the price of competing primary fuels.

**National Power's Killingholme combined cycle gas turbine power station.**

Bearing all this in mind, and my earlier caveat about forecasting, we estimate that gas will increase its share of the generation market to more than 35% by the turn of the century — a threefold rise on its current share. Nuclear output and imports through the interconnectors seem likely to remain broadly constant over the period though French imports might decline with a bit of luck. Other fuels, such as oil and Orimulsion, and renewable energy resources, are in total likely to retain a similar, small share of the market.

That leaves coal. Its share of the market will reduce to no more than 30%, no matter who owns the coal-fired power stations. But that still represents a core tonnage of around 30 million tonnes of coal for electricity generation — by no means an insignificant business. And British producers' continuing efforts to reduce costs will leave them well placed to compete successfully for much of that business. However, its a market that we all now know has to be won on price and quality. It won't be gifted to the British mining industry by subsidies from taxpayers and electricity consumers.

The close supplier-customer relationship between the coal and electricity industries is not the only thing we have in common. Like mining, electricity supply also receives its fair share of publicity. A good deal of the comment about electricity privatisation tends to centre on criticism, no matter how biased or ill-informed some of it might be. Yet I believe that electricity privatisation is a success story — and I would like to give you a few facts to support that view.

There is now more competition in generation in England and Wales than any other integrated system in the world — and competition continues to increase. Large users can and do shop around for supplies from different generators and suppliers. This opportunity is open to middle-size customers with a demand down to 100 kW from this April, and by 1998 domestic and small consumers will be free to choose their supplier.

Electricity Pool prices are still below the level predicted at the time of privatisation. Moreover, virtually all consumers are paying lower wholesale prices in real terms than before privatisation. For example, National Power's wholesale charge in the tariff for domestic and small users is about 8% lower in real terms. Our wholesale charge to the great majority of large industrial users is on average 16% lower, and the very largest users would have enjoyed price reductions had they not lost government subsidies. In 1991, these subsidies were worth 0.27 p/kWh for most large intensive users. For the largest customer, it was 0.67 p/kWh. Even without these subsidies, they are paying on average no more in real terms than before privatisation.

I think its true to say that this is a 'good news' story on wholesale prices. But it doesn't make the headlines. Lower prices of course have not been achieved without tremendous effort. They result from the fall in primary fuel prices, particularly British-mined coal, all of which have been passed on to consumers, and from the huge costs we have driven out of the business. And, of course, Pool prices are now being pegged for the next two years.

Let me give you a few figures that illustrate our efficiency gains. In the past three years, National Power's productivity has risen over 50% per employee. Manpower is down from 17 000 when we were set up in

1990 to only 6000. We are starting to achieve world's best practice in the operation of our power stations. And we have closed around 6000 MW of redundant plant, nearly a quarter of the capacity we inherited, reflecting our loss of market share from 47% when we were privatised to less than 35% today.

At the same time, we have committed £2 billion to measures to produce cleaner power, by building new state of the art gas-fired plants and fitting clean-up equipment to our existing stations. And in fact our capital investment exceeds our aggregated pre-tax profits over the period.

It perhaps goes without saying that as an obvious enthusiast and believer in the benefits of privatisation, I am a strong supporter of coal privatisation. It surely can't make sense for two industries as closely linked as electricity and coal for one to be in the private sector, and the other remain in public hands. I am in no doubt that coal's privatisation will be to the ultimate benefit of the consumer.

Indeed, we signed the current five-year back-to-back coal and electricity sales contracts at the lower end of what we considered to be a credible price range because we wished to encourage coal privatisation. We always saw the contracts as a pre-requisite of that, even though the first instinct of anyone in the energy business is not in favour of long-term contracts. History is littered with long-term energy contracts that go wrong, because no one can predict prices. Long-term contracts are unnecessary. They are uncompetitive, as in the case of the 10 and 15 year contracts between the independent power producers and the regional electricity companies, in that they foreclose the market, and they are unwise. So were it not for coal privatisation, we would have gone for much shorter contracts than five year ones.

As regards what form coal privatisation takes, we look to see the introduction of a competitive structure — a structure that enables the industry to build on the great productivity strides it has already made.

On a world scale our concerns about the precise structure of our electricity and gas industries are simply trivial. Half the world's present population doesn't have access to commercial energy supplies at all, and that is likely to be true for many of the three billion extra people in the world by 2020; 80% of whom will be born in just four countries — China, India, Pakistan and Indonesia. As the congress of the World Energy Council agreed, this requires us to focus on the needs of developing countries.

That is easier said than done. To do so in a sustainable way poses a major new challenge to governments and the energy industries alike. It requires, too, a radical reappraisal of many aspects of energy policy.

In particular, the developed countries will have to take the leading role in facilitating local and global finance, and the transfer of technology to the developing nations. Failure to achieve this will severely retard the supply of energy on economic and affordable terms to meet their basic needs and economic growth.

There is therefore an urgent need for the developing nations to adopt market structures and stable institutional arrangements to attract debt and equity finance from the OECD countries and their enterprises. This is already starting to happen. National Power is one of a number of major energy companies involved in joint ventures to develop power projects in developing countries.

It is axiomatic that under the pressure of population growth, there will be a major increase in energy demand, Over the next 30 years world demand is forecast to rise from 10 Gtoe to somewhere in the range of 11 to 20 Gtoe. Ten of anything, of course, doesn't sound very much, but the range is between 17 000 and over 30 000 million tonnes of coal equivalent. Even with the most radical energy conservation programme imaginable, the bottom of the range is unattainable, and its a fair bet that the demand will be some 50% above current levels.

There is no single source of energy in prospect that will take the place of fossil fuels, or even make a significant contribution over this period. They will therefore remain the main source of primary energy over the next few decades. We don't have the luxury of a policy that is based on coal or gas or nuclear or renewables or energy conservation. The world will need all these in combination — putting as much emphasis on energy efficiency as we can.

We should, however, continue to pursue technological development of new, less polluting energy sources with great determination, despite the lack of any short-term imperatives, such as shortage of resources or high prices. For it takes several decades to develop and implement new technologies on a global scale.

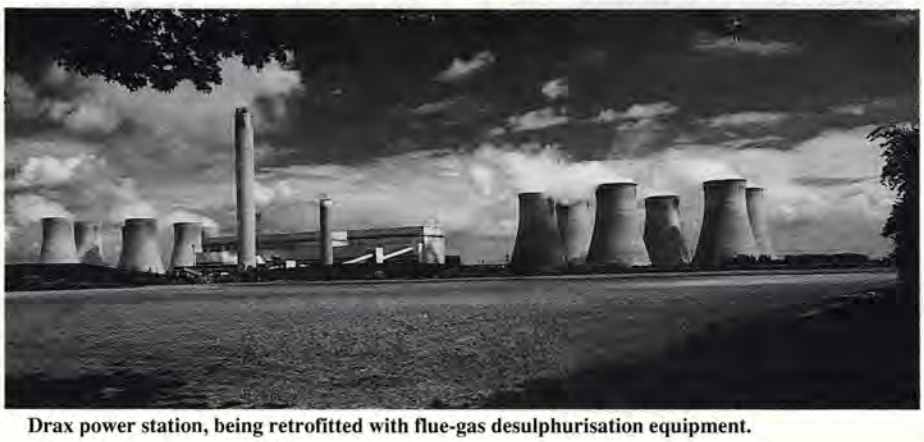
In the meantime, the major responsibility we all share is to ensure that there are, worldwide, the proper incentives in place to bring about energy efficiency in production and use, and disincentives to the misuse of energy. This is fundamental to all future energy paths, both on environmental grounds and to help get the available energy supplies where they are needed.

That brings me back to the fundamental issue of the distribution of energy supplies throughout the globe. How do the energy industries hope to satisfy the growing demand for energy with the least demand on resources?

Well, the World Energy Council concluded that the answer lies in four main directions, which I might crudely summarise as 'market economics'. These themes are as relevant to the developed economies such as that of the UK's as they are to the developing countries. The directions are: full cost energy pricing — including the cost of environmental impact; liberalised energy markets — including phasing out subsidies; removal of global trade barriers in energy, and new mechanisms for facilitating investment worldwide.

These changes will not be achieved overnight. But I believe that this country — and the companies in the electricity supply industry including National Power — are leading the way in the implementation of the principles of these market economics. This is ultimately where security of energy supplies is to be found. The ring-fencing and protection of domestic sources, or bending prices to protect them, in the end does no one any favours. Diversity is the name of the game.

The world and its burgeoning population face major issues trying to reconcile the need for economic welfare, for a cleaner environment, and for sustainable development. It is a grave mistake if all we discuss in this country is how many pits should be open, or whether the Pool price should be 2.5 rather than 2.6 p/kWh. Let us lift our eyes and turn our minds to solving the problems of the developing countries efficiency, and with care for the environment. ❑



**Drax power station, being retrofitted with flue-gas desulphurisation equipment.**

# The recycling of plutonium and uranium

*by Kenneth Jackson**

A LARGE-SCALE reprocessing facility was built at Sellafield in the UK in the early 1950s. A second reprocessing plant was built at Sellafield and commissioned in 1964 to serve the UK's Magnox nuclear power programme, as well as Magnox stations built in Japan and Italy. To date over 35 000 tonnes of Magnox fuel have been reprocessed at Sellafield, and over 50 000 tonnes will have been reprocessed to the end of the Magnox programme, sometime in the first decade of the next century.

The Thermal Oxide Reprocessing Plant (THORP) has been constructed at Sellafield, and recently received authorisation to commence operation. THORP will reprocess some 700 t of oxide fuel over its first 10 years of operation, about two-thirds of which will be from overseas reactors.

The UK is a world leader in recycling uranium recovered from the reprocessing of irradiated fuel. From the 35 000 t of Magnox fuel reprocessed to date, over 15 000 tU have been converted to gaseous uranium hexafluoride and enriched to levels up to 3.42% U-235 to provide over 1650 t of advanced gas-cooled reactor (AGR) fuel for the UK utilities.

Recycled uranium from oxide fuels has been re-enriched and re-fabricated into fuel for reactors in Germany, France, Belgium and the UK. As yet quantities are small, but sufficient to demonstrate the viability of the use of recovered uranium. British Nuclear Fuels (BNFL) is currently preparing to undertake small scale reprocessed uranium conversion ($UF_6$ to $UO_2$) trials in existing plants.

Plutonium is already in use in every uranium fuelled nuclear reactor throughout the world. For example, for fuel that has achieved a 40 GWd/tU burnup, nearly 40% of the electricity generated has been derived from the fusion of plutonium that has built up in the fuel.

**BNFL's Thermal Oxide Reprocessing Plant (THORP) received the go ahead earlier this year. Mr Jackson's article is based on his paper to The Uranium Institute's 18th annual symposium.**

The first mixed oxide (MOX) fuel fabricated using plutonium separated by reprocessing was loaded in the BR3, a small PWR in Belgium, in 1963, and also in that year MOX was used for the first time in the UK in a prototype AGR, the forerunner of the current generation of UK nuclear power stations. To date over 358 t of MOX fuel has been fabricated for commercial use in light water reactors (LWRs) with no operational difficulties being encountered.

The current world LWR MOX fabrication capacity is all in Europe, and the fact that there are currently about 30 European reactors licensed to use MOX fuel, then all the MOX fuel fabricated until the end of the decade could be used in Europe. However, there are plans in a number of countries, including France, Germany, Belgium, Switzerland and Japan to licence further reactors for MOX use and a figure of 50 reactors loading MOX fuel by the end of the century seems to be a reasonable prediction.

If MOX is utilised at the 400 to 500 t per year level, the requirement of 30 t plutonium per year will be greater than the output of separated plutonium from the European reprocessing plants; the shortfall in availability would have to be met from existing stocks. Thus, existing stocks of separated plutonium could be exhausted from about the middle of the first decade of the next century if the requirement for MOX fuel reaches the expected 400 to 500 t/year level.

The recycle of plutonium as MOX fuel not only utilises a valuable resource but it also reduces the call on the world's uranium stocks. One tonne of plutonium, if it is recycled in a PWR which achieves a normal 40 GWd/t burnup, will substitute for approximately 107 t of $U_3O_8$ and 74 t of separative work units (SWU). Hence MOX utilisation at the 400-500 t/year level would result in a saving in uranium requirements of over 3200 t $U_3O_8$ and separative work requirements would represent approximately 6% and 8% respectively of the annual requirements of OECD countries.

The current fabrication capacity for uranium reprocessed from oxide fuel is some 200 t/year. It is anticipated that this capacity will increase to over 300 t/year by 1997, when BNFL's current AGR fuel fabrication plant has the capability to produce up to 250 t/year of fuel derived from ex-Magnox reprocessed uranium.

The recycling of repossessing uranium is a proven route. Its immediate attractiveness depends upon the prevailing economic climate (uranium prices, etc) and the isotopic composition of the reprocessed uranium (U-235 / U-236 levels). For every tonne of reprocessed uranium that is recycled, assuming an average isotopic content of 0.85% U-235 and 0.3% U-236, there is a saving in natural uranium requirements of 1.1 t $U_3O_8$ and in separative work requirements of 0.8 t of SWU in the production of fuel capable of a nominal 40 GWd/t burnup.

The economics of recycling recovered plutonium as MOX fuel are dependent upon the prices for MOX fabrication and for $UO_2$ fuel, the quality and age of the plutonium, and the fuel cycle of the reactor into which the MOX fuel is to be loaded.

Different uranium fuel costs apply in each country and can vary even from utility to utility. Current indications of the likely prices that will apply for MOX fuel manufacture towards the end of this decade suggest that it can be produced at prices which will give front end fuel cycle costs that are economic in comparison to natural uranium-based fuel.

LWR operators are striving for ever higher fuel burnups, and have expectations of achieving burnups as high as 60 GWd/tU. Increased burnup will generally favour the economics of MOX fuel, all other things being equal. The cost of uranium fuel will increase with the increased uranium and separative work requirements of the higher enrichment required to achieve the increased burnup, while the cost of MOX fuel will be

* *Group Director, International British Nuclear Fuels plc*

little changed.

The present generation of LWRs is geared to optimising operation with uranium core loadings. It is possible to load only some 30% MOX in the current LWR designs, although work is underway on the feasibility of increasing the MOX/$UO_2$ ratio. The next generation of LWRs could be designed with the optimisation of MOX fuel use in mind.

The transport of separated plutonium has been demonstrated to be safe and feasible; however, it will probably be easier to convince the general public about the acceptability of transporting MOX fuel rather than separated plutonium. The co-siting of reprocessing plants and MOX fabrication plants will help improve public acceptance, as the need for transport of separated plutonium to a distant MOX fabrication site is avoided. Given the wealth of experience in transporting spent fuel around the world, the transport of MOX fuel need not pose any problems.

The economics of recycling uranium recovered by reprocessing depends not only upon the residual levels of U-235 and the poisoning isotope U-236, but also upon the cost penalties for handling reprocessed material because of its increased level of activity. However, with the expected isotopic composition of reprocessed uranium, less separative work will be required to achieve equivalent reactivity in the fuel to that of fuel based on fresh uranium.

Even when the savings in enrichment and natural uranium purchase are off set by the increased unit charges for conversion, enrichment and fabrication of reprocessed material, savings in fuel procurement costs are possible by using recycled uranium fuel. Assuming that reprocessed uranium is available at a typical LWR composition of 0.85% U-235 and 0.3% U-236, and that it is to be converted into reactor fuel equivalent to 40 GWd/t fresh uranium fuel, then there is an economic advantage in the use of fuel based on recycled uranium when natural uranium prices are above about US$11 per pound of $U_3O_8$.

Both plutonium and uranium storage are included as part of the overall reprocessing package. BNFL has stored both plutonium and uranium at Sellafield for more than 30 years safely and cost effectively.

Environmental considerations will play an equally important role as economic considerations in determining the future of recycling reprocessed products.

The toxic potential of a particular waste stream is a measure of the potential to cause harm. It takes account of the treatment and radionuclide content of each waste stream, and is thus useful in comparing different options. Multiple recycle of plutonium, or irradiation of MOX fuel followed by direct disposal, reduces the toxicity of the waste to be disposed of; this is because the plutonium isotopes and associated actinide products which dominate toxicity in the longer term have been reduced by recycling.

**Table 1: LWR MOX plants in operation, under construction, and planned**

| Country | Organisation: Plant | Capacity (t/y) | 1st year of operation |
|---|---|---|---|
| Belgium | Belgonucleaire:P0 | 35 | operating |
| | Belgonucleaire:P1 | 40 | late 1990s |
| Germany | Siemens: Hanau | 120 | mid 1990s |
| France | MELOX: Marcoule | 120 | 1995 |
| | CFCa | 15 | operating |
| UK | BNFL/AEA: MDF | 8 | 1993 |
| | BNFL:SMP | 120 | 1997 |
| Japan | Unannounced | 1001post 2000 | |

**Table 2: Indicative waste volumes for reprocessing/recycling and direct disposal**

| Waste type | Waste arisings ($m^3$/GWe.year) | | |
|---|---|---|---|
| | Waste category | Recycling | Direct disposal |
| Mill tails | Low | 15 000 | 20 000 |
| Conditioned wastes | High | 3 | n/a |
| | Intermediate | 36 | n/a |
| | Low | 170 | n/a |
| Conditioned fuel | High | n/a | 35* |
| | Intermediate | n/a | small |
| | Low | n/a | small |

*A packing factor of 1.26 $m^3$/tU is assumed for this comparison, consistent with Swedish data and within the range of German estimates.

The ratio of the integrated toxicities of recycled MOX fuel and once-through uranium fuel is between 1000 and 100 000 years after irradiation. These timescales are of interest when considering disposal of materials in a repository.

The major element of waste arising from the operation of the fuel cycle in terms of volume is mill tailings; recycling can reduce this volume by about 25%. The volumes of high level waste (HLW) requiring disposal in the reprocessing/recycle option are reduced by a factor of up to 9 or 10 compared to the direct disposal option, dependent upon the technology used to encapsulate the spent fuel. The combined volume of HLW and intermediate level waste (ILW) derived from reprocessing, containing 99.9% of all the radioactivity in wastes, is similar to the volume of the fuel conditioned for direct disposal. Table 2 gives indicative waste volumes for the recycling and direct disposal fuel cycle options.

Ex-weapons material could be incorporated into the civil fuel cycle as MOX fuel, although this would require considerable investment to convert the plutonium metal to oxide and blend it with other material to make it safe to handle in large-scale MOX fabrication plants. The use of ex-weapons material in the civil fuel cycle may provide economic benefits to its country of origin and would ensure that the material is fully safeguarded in the future.

Plutonium separated from civil reprocessing is under full safeguards control and is transported subject to stringent security procedures. Separated civil plutonium when combined with uranium to form MOX fuel is an unattractive proliferation target in comparison with ex-weapons material, or indeed with weapons themselves.

The best place for separated plutonium is in MOX fuel which is then irradiated in a reactor. Recycling plutonium in MOX fuel also serves to reduce the total plutonium inventory; after irradiation the plutonium content in the MOX will have reduced by about one third. If multiple recycling was adopted as a long-term strategy rather than using the plutonium in MOX fuel just once, then the plutonium inventory could be reduced by almost one half.

It is clear that there are significant benefits to be obtained from recycling the products of reprocessing. Recycling of uranium and plutonium recovered by reprocessing reduces the call on the world's natural uranium reserves, while maximising the energy extracted from the reprocessed uranium and plutonium. The use of MOX fuel will reduce the overall plutonium inventory. Recycling uranium and plutonium results in a lower toxic potential in the long-term, and can provide a real saving in fuel cycle costs. ❑

# Energy in Central and Eastern Europe: Political Initiatives and Opportunities for Business

*by Johanna Fender*

JOINT seminars between the Institute of Energy and the Parliamentary Group for Energy Studies (PGES) have become an annual occurrence over recent years. The theme of this year's conference was the energy scene in Central and Eastern Europe: a subject of great importance in both national and global terms, but one which tends to be overlooked only too often, and is perceived as 'unglamorous'.

The conference was divided into two halves. The morning session was ably chaired by Dr Michael Clark MP, who is also chairman of PGES. Energy usage, he pointed out in his introduction, is one of the most accurate measures of a country's prosperity. And he emphasised the UK perspective bias, more apparent in the afternoon's programme of speakers.

Dr Clark kept his introduction brief and to the point before introducing the first speaker of the morning: DTI Energy Minister, Tim Eggar MP. In his opening address Mr Eggar attempted to define the geographical scope of the conference. Russia, he believed, is an indispensable part of the equation, with energy playing a vital role as catalyst in reviving the Russian economy. This revival was essential to the West for a number of reasons, the most obvious being political stability, and of course, good environmental management. Oil and gas account for between 53 and 70% of Russia's hard currency exports.

In the rest of Central and Eastern Europe, the need to import energy represents a major drain on the economies of those countries, and here Mr Eggar felt energy efficiency was the key. Energy consumption in the countries of the old Eastern Bloc is between three and four times higher than in Western Europe. The solutions are cheap and easy: metering, insulation — the high rate of return for a small investment makes energy efficiency an attractive option for countries with an urgent need to reduce their consumption of imported energy.

In a reference to nuclear safety Mr Eggar acknowledged that East European standards needed urgent attention, but the reliance on civil nuclear power is such that existing stations will have to continue operation for some time to come.

At this point Mr Eggar identified the market opportunities for UK businesses. He spoke of this country's unrivalled expertise in the mining industry (the Ukraine was identified as a significant market for mining equipment), as well as in oil and gas exploration. The latter was in direct reference to Russia, whose technical knowledge is sound, but whose production techniques are flawed, by inadequate materials for example. This sector is ripe for technology transfer, said Mr Eggar, and warned against creating a dependency culture through the provision of aid. He concluded his presentation by declaring the obvious need for stable and consistent energy policy among the countries of Central and Eastern Europe.

Deputy Executive Director of the International Energy Agency (IEA), John Ferriter gave a presentation on IEA initiatives in the region.

He began with a brief history of the IEA, created in 1974 in response to the first oil shock, and spoke of the events over recent years which have caused the IEA to change with times. Energy restructuring in the Eastern Bloc, the deregulation and liberalisation of energy markets, and environmental consequences of energy use have led the IEA to expand its original goal of energy security to the 'three Es', also encompassing environmental protection and economic sustainability.

Ambassador Ferriter shared some key points from the IEA's latest *World Energy Outlook*: that energy intensity in Central and Eastern Europe will remain above that of OECD countries, and that the region is not capable of financing efficiency and environmental protection measures necessary. It is also expected that energy supply in area will remain primarily based on coal, although a shift towards oil and gas (mainly from Russia) will also occur.

He went on to look more closely at the work of the IEA — dissemination of information, shared goals providing a policy framework, country surveys, and statistical exchange. In the latter area the IEA Secretariat has been successful in establishing close working relations with statisticians in Central and Eastern Europe. Recent studies include a project to identify power system options in the event of the closure of Soviet-designed nuclear reactors in the area. They also support the negotiations, which were mentioned by all speakers, to establish the European Energy Charter, which will build a framework for integration of the energy sectors throughout Europe.

Randal Fischer, Group Head of Natural Resources at the European Bank for Reconstruction and Development (EBRD), gave a progress update for private sector oil, gas, mining and chemical projects.

Mr Fischer began by emphasising the Bank's focus on the private sector, and recognised the need for foreign investment in the areas of Central and Eastern Europe, as well as the need for risk sharing among those investors. There has been, he remarked, a dearth of foreign investment in the area to date. In response the Bank has concentrated on establishing a portfolio of sound investments in the area of natural resources. Some general guidelines for projects likely to attract ERBD support were outlined: private sector, joint venture projects are preferred which are also sound economic investments. ERBD looks to provide around 25% of the capital required, and prefers to participate in the projects involved, part of its 'showing by doing' approach.

Over the past two years the Bank has screened around 400 private sector opportunities, of which 16 projects have current

PHOTO: JOHN BAKER

**Chairman, Dr Michael Clark MP introduces Tim Eggar MP, who gave the opening address of the conference.**

mandates with the Bank. Mr Fischer summarised nine board-approved private sector projects, most of which are in Russia, although this weighting will shift.

By the end of 1996 the Bank hopes to have a investment portfolio worth US$2—2.5 billion in a total of 14 countries, of which 80% will be in the oil and gas sector, 20% in mining and chemicals.

The closing speaker of the morning session was the Deputy Minister in the Czech Republic's Ministry of Industry and Trade, Milan Cerny. From a power engineering background, Mr Cerny joined the Ministry as Chief Director of the Energy Policy Department, and was soon appointed Deputy Minister. His presentation to the conference drew entirely on the experiences of the Czech Republic, but gave a comprehensive impression of a country in economical and political transition.

The attitude of the Czech Republic to privatisation differs from recent UK experience, in that it allows its citizens to take a greater part in the ownership of its enterprises. Coupons are exchanged for shares in companies of the citizen's choice: all can participate, although to do so is not obligatory.

Mr Cerny outlined the current energy mix in the Czech Republic. Most of the country's electricity is produced in lignite-fired power stations, with one nuclear plant in operation, and another under construction. The state-owned power utility, CEZ, has been converted into a joint-stock company. The urgent need for investment in desulphurisation equipment to meet environmental standards has led the company to issue Eurobonds on the London financial market.

At the beginning of this year a further eight regional power companies were founded. 15% will be subject to the coupon privatisation, with up to 34% transferred to municipalities, 20% sold to foreign investors and the remainder remaining in state hands for a limited period. It is hoped that foreign investment will bring in much-needed know how in the fields of management and technological processes.

Gas will be the next privatisation target in the Czech Republic, although price subsidies, due to continue until 1998, mean that for the moment at least, the gas industry will remain largely under state ownership.

An area Mr Cerny thought of particular interest to foreign investors was that of district heating. Existing schemes will be obliged to conform to new environmental standards, which will probably mean switching from lignite to natural gas, and converting to combined heat and power technology — areas which the Czechs themselves know very little about.

Mr Cerny ran through the advantages of investing in the Czech Republic rather than other Eastern and Central European: political stability, low inflation, a well-qualified, skilled labour force. Energy prices were the only disadvantage envisaged by the Minister, and he estimated these would be equalised by 1996.

**Deputy Minister Milan Cerny**

Following lunch, the afternoon session was chaired by Professor James Harrison, President of the Institute of Energy.

Dr John Rhys, Director of NERA Economic Consultants began the second half of the proceedings with a paper on economic reform and developments in the energy sector. Much of NERA's work in Eastern Europe has been in the context of the PHARE programme. Dr Rhys identified a major problem in the reform process in Eastern Europe: not so much adapting to the new markets, as lacking a framework, in the form of legal and regulatory institutions, to enable the new markets to operate effectively. It is in this area that NERA have been most active.

Dr Rhys also identified specific opportunities for UK businesses: in energy metering and associated hardware and software; in gas distribution; in energy efficiency; in conversion/upgrading of district heating networks; and in power generation. He concluded by reminding the audience that commercialisation skills and disciplines would also be required if projected East European enterprises were to succeed.

The subsequent speaker, Chris Le Fevre, Director of Operations at Global Gas, British Gas plc, picked up on Dr Rhys' point about the potential in gas distribution in the region. British Gas had entered the arena because of their need to diversify away from their dependence on internal markets, which were increasingly subject to competition, coupled with the recognition of a major growth opportunity. In addition, several of the countries involved are strategically located on key transit routes. Globas Gas is involved in the 'downstream' gas business: transmission, distribution and power generation.

But British Gas insist that their involvement in the area is of mutual benefit, to both local consumers and the local economy, as well as to British Gas. As an example, Mr Le Fevre described his company's 'datagas' system, which is effectively gas-fired district heating. The boilers, water tanks and pipes for the system are all manufactured locally, and installed by licensed local contractors.

PowerGen's Director of Business Development in Europe, Andrew Fawcett, spoke next, emphasising the two prerequisites of stability and market attractiveness. He went on to describe recent deals secured by PowerGen in East Germany: a joint venture acquisition of an open cast brown coal mining and power generation operation from MIBRAG.

Mr Fawcett made the point that countries in the region vary considerably: the overall trend in the Czech Republic, Hungary and Poland is a positive one, and it is in these countries that PowerGen will be concentrating their operations. Heavy energy subsidies, resulting in low prices act as a deterrent in many of the countries of Central and Eastern Europe. Within its chosen areas, PowerGen hopes to offer expertise in the areas of coal and oil-fired plant, CCGT technology and as a leader in Orimulsion technology.

Dr John Topper, Commercial Director of the Coal Research Establishment (CRE) rounded off the afternoon's proceedings with a presentation on the subject of improving coal use in the area, through technology transfer and technology assistance.

As had been pointed out in the recent WEC report *Energy For Tomorrow's World*, by 2020 coal would still be the dominant supplier of primary energy, particularly in Central and Eastern Europe. This made the requirement for the transfer of appropriate technology for the clean burning of coal imperative.

For the past two years CRE has made a conscious effort to promote technology transfer in China, India, Poland, Czech Republic, Bulgaria, Rumania, Russia, the Ukraine and Kazakstan, where it has worked with other companies under the aegis of various funding programmes, such as the EC TACIS programme and the UK Know-How Fund.

Dr Topper concluded his paper with the confident assertion that the effective transfer of clean coal technologies will contribute to reducing the predicted rise in energy demand, as well as minimising environmental damage.

A lively and informative discussion followed the final session of the day, with concluding remarks by Professor Harrison. ❑

# SELCHP — a story of successful collaboration

IN THE mid 1980s London was faced with a scarcity of landfill sites to take the capital's refuse. In 1986 the London boroughs of Greenwich, Lewisham and Southwark joined forces to search for a realistic alternative.

In 1988 the South East London Combined Heat and Power Consortium — SELCHP — was formed. The consortium brought together a cross-section of public and private interests, including the regional electricity company, in the form of The London Power Co Ltd, and energy-from-waste specialists, AEP, ISS Mainmet and Laing Technology Group.

The consortium's first step was an in-depth feasibility study into the viability of an energy-from-waste facility, to include an assessment of such a scheme's environmental impact on the local community in North Deptford. The assessment addressed concerns over emissions, noise, increased traffic and finally, the visual impact. Conditional planning permission was granted in 1990, although further studies on environmental impact were required.

The impact on the local environment is often the biggest hurdle such projects have to face, and recognising this, SELCHP committed itself to understanding the needs of the community. An Incinerator Monitor Group was set up among local residents, who had access to operational details, and whose members could attend SELCHP board meetings.

Commissioned at the end of last year, SELCHP is the first UK plant to comply with the 1989 EC Directive on Air Pollution, as well as HMIP's stringent 1PR 5/3, in accordance with the 1990 Environmental Protection Act. A flue-gas treatment system removes pollutants, ejecting clean, dust-free gases to atmosphere via the plant's 100 m chimney. Sound emissions are also regulated so that there is no increase in background noise levels, and traffic movement is carefully planned to minimise disruption.

## Heat and power

And the founding principles of the scheme: that it should be a combined heat and power plant, fired by municipal solid wastes, are both environmentally-friendly concepts. It is a well-established fact that waste sent to landfill produces a higher concentration of greenhouse gas (methane) than if the same waste is combusted. In addition, the combustion process used results in minimal residues: around 10% of the original volume of waste. This residue is mainly ash and flyash, which is biologically inactive and free of odour.

The 'heat' element of the plant's production will be used in the future to provide district heating for a network of local houses, but is currently still at the planning stage. When complete the scheme can serve six housing estates in the London Borough of Southwark, and there are three additional estates and four schools also under consideration for inclusion.

The 32 MW plant will burn 420 000 tonnes of msw per year, through two waste streams, handling 29 tonnes of waste per hour. Steam leaves the boilers at a temperature of 395°C and 46 bar, and is fed directly to a single 32 MW(e) steam turbine generator. Steam from the turbine can be used to produce maximum electricity output, or alternatively, some or all can be diverted to heat exchangers to provide heat for the future district heating network. Steam is also used to preheat the combustion air for the refuse burning process in the air preheater.

The five-and-a-half acre site does not provide a source of cooling water, making it necessary to provide a bank of air-cooled condensers. These are forced draught units with variable low speed drives to prevent noise emissions. The plant has a storage capacity of 5 000 tonnes — four days of full plant capacity — and a total of 11 tipping bays.

Approximately 60% of SELCHP's income comes from the sale of energy, and these revenues are used to keep the cost of refuse disposal low. SELCHP has the additional advantage of predictable revenues, making it possible to offer low-cost, long-term contracts —up to 30 years, without break clauses.

**The SELCHP plant in North Deptford, South East London during construction (left) and after commissioning (right).**

*Obituary*

## Alun Hughes

IT WAS with great sadness that Members and Past Members of the Institute of Energy, and former colleagues at NIFES, several of whom had been co-students, heard of Alun Hughes' death, by accident only a few days before Christmas 1993.

Alun's industrial career started with the Ocean Coal Company in Treorchy, and continued with employment at Parke Davis, NIFES, and Lenier's Chemicals Cardiff, before he started his own company: Energy and Environment Consultancy Services, Pontypridd. His investigations into energy utilisation in the steel and chemical industries resulted in major energy savings for the companies concerned, especially at a time when fuel was in short supply. He spent all his time in the energy business, and supervised energy efficiency projects in Eire and Pakistan, among many other countries.

Of particular interest was his participation in the study of temperature distribution within partially loaded and fully loaded soaking pits. On two occasions he was invited to undertake a lecture tour in Australia, and gave the opening lecture of a national conference of the Australian Institute of Energy in Sydney in 1981, and the keynote lecture at the Australian Institute of Energy Conference in 1985.

As a committee member and Past Chairman of the South Wales and West of England branch of the Institute, his guidance in branch affairs resulted in its ongoing continuation as a respected local entity, and as a virile force in the Principality.

Alun was a staunch and loyal supporter of the branch for 40 years. He was Chairman in 1977/8, and initiated a series of summer lunchtime lectures now held annually at British Coal's Coal Research Establishment at Stoke Orchard. He served for many years as a committee member and was most supportive of every Chairman he worked with since 1957. The branch owes the success of many its programmes over the years to Alun's suggestions and constructive criticism.

He was an all rounder: a good wicket keeper, and was a past Chairman and member of the world famous Treorchy Male Voice Choir. The lasting memory for many Members of the Institute was his evident sincerity at saying Grace at the Annual Dinner, both in Welsh and in English. This sums up his character: he was a gifted engineer and a man of integrity who conveyed his sincerity to all who worked with him. A good friend who will be greatly missed.

*Arthur Aston, Edgar Brown, Trefor David and Doug Mustoe*

## Joint symposium

*Energy Management and Water Services* is the title of a joint symposium, organised by the Yorkshire branch of the Institute of Energy, and the Institution of Water and Environmental Management.

To be held on 23 June at the Penine Hilton National Hotel in Huddersfield, the symposium will begin with a keynote paper from Prof Ian Fells, of University of Newcastle, and Past President of the Institute. Other scheduled speakers include: Andrew Dyer of Montgomery Watson; Vilnis Vesma of Vilnis Vesma Associates; Jim Watt of the March Consulting Group will speak on 'Energy benefit from waste minimisation.

Following a break for lunch Peter Jennison of Yorkshire Water will address the symposium on 'Energy savings through process control at Knopstrop Sewage Works', and other contributors include Paul Venn of North West Water, Tom Kirk of Merz and McLellan Ltd and Colin McNaught of ETSU.

This joint symposium was organised to reflect the common interests of both institutes in efficient energy production and utilisation, with minimum impact on the environment.

**South Wales and West of England branch**

PHOTOGRAPH: JOHN BAKER

**The 60th Melchett Lecture of The Institute of Energy was given at the RSA on 22 February 1994 by Dr S William Gouse Jnr, who is pictured above left with Institute President Professor James Harrison. Dr Gouse, senior vice President of The Mitre Corporation spoke on the subject *Energy, Where Have We Been and Where Are We Going?'***

## Branch meetings and events

### *Midland*

12 May 1994
Works visit to Birmingham International Airport, followed by branch AGM.
Visit commencing 2.15 pm, AGM at 4.30 pm
Contact: Hon Secretary, David Evans on 0384 374329

### *South Wales & West of England*

17 June 1994
Annual lunchtime lecture: 'The Renewables — will there be a significant impact on the UK energy mix?'
Dr Kevin Brown, Director of ETSU.
At the British Coal Research Establishment, Stoke Orchard, commencing 11 am to be followed by lunch.
This event is sponsored by BCRE and is free of charge for both the lecture and lunch.
Contact: Mr Steve Mills on 0242 673361

### *Yorkshire*

23 June 1994
Joint symposium with the Institution of Water and Environmental Management: 'Energy Management and Water Services' at the Penine Hilton National Hotel, Huddersfield. Price (inc meals and light refreshments) £120 for members of either Institute, £140 for non-members.

## New members

### *Graduate*

**Stephen Alan Auld,** Napier University, Edinburgh
**Austin Baggett,** ECD, London
**Michael Crisp**
**Nicholas David Reid Gardner,** MJ Carter Associates, Warwickshire
**Michael Garwood,** PowerGen plc, Ratcliffe-on-Soar
**Alison Hunt**
**Bridget Helen Shore,** British Gas North Eastern, Leeds
**Jonathan Henry BayfieldCraig**
**John Thorpe**
**Peter James Wooders**

### *Major Group Affiliate*

**Royal Mail,** London

### *Group Affiliate*

**Alliance Gas Ltd,** London
**Datum Solutions,** London
**Johnstone Terotech Ltd**

## Objective analysis

**"Energy Watchers IV: Energy, Economics and Environment: Imperatives, Realities and Balance"**
**"Pacific Basin Demand and Downstream Activities: Is Middle East Supply the Answer?"**
**Edited by Dorothea H El Mallakh**
**Published by The International Research Center for Energy and Economic Development (ICEED), Boulder, Colerado, USA, 1993.**

THIS is the edited proceedings of the 1993 ICEED International Energy Conference. There are two main themes, and the goal of the first was to look at the complex linkage between energy and environment which cannot be decoupled in the near to medium term. The second theme examined the relationship which could develop between two regions which represent major areas of growth in energy demand and petroleum supply. A total of twenty papers were presented and some of the key elements are discussed below.

The first point to emerge was that one man's idea of balance is not necessarily the same as another's. The 'reality' perceived by an environmentalist living in the beautiful mountains of Colerado is far different to the reality seen by a poor peasant living in Bangladesh. On over population, this is regarded as an environmental problem by those living in the top fifth of humanity, leading to gross depletion of resources, massive local pollution and degrading poverty. The subsistence farmer will not take this view, regarding an extra child as literally extra energy. Several authors drew attention to the inevitable increase in energy intensity, which will be seen in all the new industrialising countries, while Eric Price (formerly chief economic advisor to the DTI) showed that the former centrally-planned economies of Eastern Europe were as mush as four times less energy efficient than most OECD economies. A thoughtful analysis of the politics of confrontation by Peter Fusaro deserves consideration, as he notes that the three groups involved in the environmental debate — government, industrialists and environmentalists — rarely talk to each other except in an oppositional manner. Robert Beck's view of energy forecasts and forecasters is both shrewd and amusing, reminding the reader that the moment you forecast you know you will be wrong. Several authors called for more efficient use of energy which, in turn, would cut emissions and thus reduce pollution.

Among the broader conclusions from the papers on the second main theme, there was agreement that Japan and the other Asia-Pacific countries will continue to rely on Middle Eastern oil and gas resources for at least another decade, if not longer. The area has the world's largest population and the highest potential for economic growth among other global regional trading blocs. Problems with the exploration and production efforts in Sakhalin (East Russia) could be solved by joint venture participation.

Perhaps the most interesting feature in many of the papers was the way in which objective analysis was almost always placed before narrow sectional interests. There was emphasis on how the problems of the necessary growth in economic activity in the world could be put to work to raise the quality of life in developing countries, while preserving and enhancing environmental quality. This is a first class set of papers, reasonably priced, and particularly useful for post-graduate studies in a variety of energy and environmentally related topics.

*Dr Cleland McVeigh*

## Comprehensive review

**"Metallurgical Failures in Fossil-Fired Boilers" by David N French**
**Published by John Wiley & Sons Inc, New York, USA, 1993, 514 pp.**

FIRST published in 1982, this book has been extensively updated with Electric Power Research Institute (EPRI) and other material to justify a second edition.

The author, David French, was the Director, Corporate Quality Assurance at the Riley Stoker Corporation, before retiring in 1984 and setting up an independent metallurgical consulting company. This new edition therefore draws on experience from other North American boiler makers as well as Riley's. However the book is aimed at an American readership and, although degrees centigrade are given in parentheses, the units are British ones, the materials specifications the ASME's and the coals, North American.

Although new conventional fossil-fired plant is not being built widely in USA or elsewhere, there are many boilers which are still operating which were originally built up to 40 years ago. Outages due to tube failures are generally more likely for old plant.

The technology of the materials used in the tubing of boilers and their ability to withstand overheating, attack from the gas side and deposits is a subject of great complexity. The experience of operators in America is relevant worldwide because the materials and fuels there, as well as the designs, are basically those used elsewhere. But there are limitations too. The special problems from the high chlorine levels in British coals are not covered here, nor are the 9 and 12%Cr stub sometimes used in Germany. There is also little material on the effect of low NOx burners, and none on fluidised beds or flue gas desulphurisation.

The engineer and the metallurgist often find difficulty in communicating, and books such as this one provide enough basic materials information — with definitions of the specialised language, to help an engineer understand the materials on which his equipment depends. In addition to the general information about the materials the book describes a large number of failures and how their causes were determined. There are many photographs (not all of them good) of the thinned or failed tubes and deposits. There are also photographs of the microstructures associated with failures. Interpretation of metallurgical structures is often a key to discourage the cause of failures and clues to ways of awarding further trouble.

This book, therefore, is a comprehensive review of tube failures in North American boiler plant. It brings together a lifetime's experience of a materials expert from one of the major boiler companies. It is therefore a good reference document. It also has a valuable section outlining the technical options which can reduce failures — such as avoidance of pendants and replacement by drainable components — but these nearly always involve extra expense, which may, or may not, be justified.

*N G Worley*

## Recently published

**"The Environment and the Planning System — business implications"**
by Peter Bulleid. Business and the Environment Practitioner Series. Series editor: Ruth Hillary. Published by The British Library, in association with Technical Communications, 1993, 100 pp (P/B), £25.75

**"Point and Diffuse loads of selected pollutants in the River Rhine and its main tributaries"**
RR-93-1, February 1993, International Institute for Applied Systems Analysis.

**"Paving the way to Natural Gas Vehicles"**
by James S Cannon. Published by Inform, 1993.

**"European Service Stations: Strategies for Retailers and Suppliers"**
by Anthony Barnett & Dean Bubley. Published by FT Management Reports, 1994, £280.00 (UK).

## Apres moi le Deluge

There is a very dangerous tendency to use the word 'sustainable' to mean a solution to a problem which will patch it up for two or at most, three decades. This is precisely what Louis XIV meant by his statement, and history tells us of the deluge that came to France after his death. It will be more than 70 years by the time my youngest grandchildren are my age, and I do not want them drowned in the deluge which will be inevitable, if we continue to take this short-term view.

There were previous civilisations that lived in equilibrium with 'Mother Nature' for more than 10 000 years. The North American Indians were one example, and they lived in equilibrium with the buffalo. Other examples were the Australian Aborigines, and the Kalahari Bushmen. However, there are now far too many people in the world for their type of nomadic existence. Moreover the development of technology has given us certain advantages which are surely necessary for a life of self-fulfilment, such as universal literacy, warm comfortable homes, hygiene, clean water, sanitation and reliable food supply.

The problems looming up are:

- the ever-increasing gap between rich and poor in all countries, which is a major cause of violence, destruction, and the wars being fought in so many parts of the world;
- the fact that only a small proportion of people have jobs which give self-fulfilment, such as a skilled craftsman. This is a consequence of the assembly line, which replaced craftsmen, while automation throws people out of work. For many years it was thought these people would be absorbed by retraining in service activities, but now computers do the job more cheaply. Thus unemployment is inexorably rising everywhere, but especially in countries like Britain, where manufacturers save money by going abroad to take advantage of the lower labour costs. Such factors are among the principle causes of crime and drug taking. When someone looks long and hard for work without success, it makes them feel unwanted, and can even cause serious illness;
- we are using up oil and natural gas at a rate which will make them very scarce by the time my grandchildren reach my age. World oil production is expected to peak around 2010 at about $3.8 \times 10^9$T/a (3.8 billion tons per year) and fall thereafter at a rate of $45 \times 10^6$T/a (45 million tons per year). The present world consumption is $3.2 \times 10^9$T/a;
- we are destroying the ecosphere by polluting the air with $CO_2$, $CH_4$, CFCs or substitutes, NOx, SOx, partially burnt hydrocarbons (some carcinogenic); polluting the land with artificially radioactive elements, cyanides and other chemicals, concrete roads, giant dams — many of which will be full of silt in a few decades, derelict buildings, and by destroying forests; the water with nitrates, chemical effluents etc. As a result we destroy enormous numbers of species every year, so that 'Gaia' or 'Mother Nature' will cease to be viable within my grandchildren's lives.

*Where there is no vision the people perish* (Proverbs 29:18).

The only hope that my grandchildren will live in a habitable world is that we produce a vision of genuine sustainability, a world in which all humanity can live in permanent stable equilibrium with the earth, and begin quite soon to move towards it instead of going in the opposite direction.

It is certainly not possible to have a stable system in which the rich keep getting richer and more extravagant, while the poor get poorer and look, with growing envy, at the rich, so the vision must apply to the greater part of humanity.

I suggest that such a vision can be defined as follows: **a world in which more than six billion people have the opportunity to earn by their own efforts decent and self-fulfilling lives for hundreds, if not thousands, of years in stable equilibrium with the ecosphere.**

As I wrote in *The Engineer's Conscience* the essential condition for this is that a sufficient number of people listen to their conscience which tells them to care for future generations, and to judge their success in life by life quality, rather than by quantity of possessions.

We are now in a position to study the question of sustainable energy supply. Ultimately it must all come from renewable resources: sun, wind, wave, micro-hydro, coppiced trees, specially grown crops or agricultural refuse. All electricity will be generated locally in power plants up to 500 kW, since the cost and land-consumption of almost indestructible GW power plants (whether fossil fuel, nuclear fission, fusion or giant dams) with grid distribution systems rule out the introduction of these systems for all peoples.

This leads us to the definite conclusion that we must regard a large fraction of the fossil fuels as capital to be invested in equipment for renewable energy for future use, rather than as income to be spent as we wish.

The second unavoidable conclusion is that the rich countries will have to come down to a small fraction of their present consumption of fossil fuel per capita: perhaps to 1/20 in USA and 1/6 in Japan, with Europe coming in between.

It follows that the vital task of the fuel engineer is to find how to give us all we really need for self-fulfilling lives with no more than 1/3 to 1/2 toe/ca (tons of oils equivalent/capita-annum) of fossil fuel and some 30 W/c of electricity, plus as much renewable energy as can be produced. Many steps which would give worthwhile employment as well could be undertaken immediately. They would have negligible cost if saving of unemployment benefit is taken into account. Some of these are: investment in domestic and industrial energy efficiency; installation of CHP systems in every urban area, and from diesel generators; fuel-efficient, convenient and comfortable public transport; village windmills; extensive coppicing plantation — eg, on set-aside land; growing crops for production of diesel substitutes: methanol and ethanol.

Once again, as in wartime, the fuel engineer has a vital role to play in our survival.

**Prof M W Thring ScD FEng**
Brundish, Suffolk



**The editor welcomes readers' letters for publication on any energy or energy-related subject, or in response to past contributions to *Energy World*. Send your correspondence to: The Editor, Energy World, The Martins, East Street, Harrietsham, Kent ME17 1HH.**

# Migration report published

THE Science and Engineering Polisy Studies Unit (SEPSU) published a report at the end of 1993, entitled *The Migration of Scientists and Engineers 1984-92*, giving factual evidence of the state of 'the brain drain' in UK academe. It builds on the previous SEPSU report, published in 1987, which gave directly comparable data for the period 1975-85.

The Government White Paper *Realising our potential* emphasised that a vigorous research base is a key ingredient in our national wellbeing. Yet the brain drain shows many examples of scientists and engineers leaving the UK to take up overseas employment.

However, the latest report shows that the brain drain has slowed, in some subjects at least, while migration into the UK has increased slightly. Emigration of recently qualified British PhDs was 13.5% per year, of members of academic research groups, around 2.1%, and for permanent members of academic staff, only 0.3%. Immigration rates for UK staff are slightly higher at 4% for members of research groups and 0.5% for permanent members of academic staff.

However, as found previously, there is still a tendency for emigrants to take up longer-term posts, while immigrants tend to take short-term posts. Moreover, British emigrants tend to leave for professional reasons but return overwhelmingly for personal ones. Care therefore should be taken not to draw too much comfort from a simple numerical headcount, however, a conclusion reinforced by the continuing increase in the proportion of Fellows of the Royal Society who lives overseas.

*The migration of scientists and engineers 1984-92* SEPSU Policy Study No 8, ISBN 0 85403 4765 is obtainable from Publications Sales Department, 6 Carlton House Terrace, London SW1Y 5AG. Tel: 071 839 5561. Price (inc P&P) £25.00 (UK) £27.00 (overseas).

# Update on unification of the engineering profession

IT IS NOW eleven months since the report of the steering group for the first stage of the investigation into the unification of the engineering profession, *Engineering into the Millennium* was published. The second stage of the project is currently well under way. To keep engineers informed of the deliberations, a series of newsletters will report on the progress towards the development of a unified profession.

The Millennium Report received a great deal of comment from a broad constituency of engineers — from Institutions, industry and individuals. There is almost universal support for the concept of a 'new relationship' between a reformed Engineering Council and the Institutions. But there is less agreement as to how this relationship might be achieved. The majority of respondents accepted the need for some form of grouping of the Institutions for various purposes. But the college concept set out in the Millennium report did not find favour and will not be pursued in stage II of the investigation.

There is support for a study of next steps for the profession beyond the new relationship. This would embrace the concept of a federal arrangement that would mould the Institutions and a reformed Engineering Council into a powerful single voice for issues best dealt with at the centre, but would also allow the Institutions to retain their individual identities and roles.

In order to carry the work forward, a policy group has been set up under the chairmanship of Sir John Fairclough to undertake stage II. The group is made up of senior representatives of a number of the engineering institutions and four members of the Engineering Council.

The group has agreed its term of reference and approved a budget for stage II. These were sent to the presidents of the forty-two institutions in October last year.

The group's main priority is to establish a proposal for the new relationship, which will be put to the Council of Presidents of the Institutions, the Engineering Council and the profession as a whole by the autumn of 1994. To this end, a New Relationship Working Group, consisting of a chairman and vice chairman drawn from the Policy Group, an Engineering Council director and the secretary of an engineering institution, has been appointed by the Policy Group to take the work forward. The Working Group, which reports to the Policy Group at monthly intervals, has agreed its terms of reference and is now getting to grips with a range of issues that need to be addressed in the preparation of a detailed plan.

A second Working Group has been set up to study the need or otherwise for new legislation to regulate the profession, and a third Working Group will be appointed early in 1994 to consider possible next steps for the profession beyond the new relationship.

It is the Policy Group's intention to maintain a tight timescale on the stage II study, with the aim of publishing proposals for the new relationship by the autumn of 1994, and electing a reformed Engineering Council in June 1995.

***The Institute of Energy responds:***

*The Institute welcomes this note on the latest thinking on the way forward, particularly:*

- *a concept of Federation*
- *the reforming of the Engineering Council, and*
- *the recognition that colleges were not the favoured approach.*

*We look forward for further opportunities to influence the developments, and would welcome comments from our members.*

# Wind energy competition for London schoolchildren

MORE than 1100 schoolchildren from 26 London schools are building windmills to generate electricity in a wind energy competition organised by Neighbourhood Engineers, the Engineering Council's scheme to link professional engineers with their local schools.

Each school team has received a standard kit of parts from their Neighbourhood Engineer as the base for development of the windmill. The windmills will be judged on efficiency, elegance and cost of construction. The competition was devised by City University, London, in conjunction with Neighbourhood Engineers.

The aim of the competition, sponsored by BT and Sir John Cass's Foundation, is to introduce pupils to the concepts of engineering design and problem solving in the context of the economic, environmental and efficiency aspects of power generation by wind energy. The project will give pupils an insight into the problem solving methods used by engineers and encourage team building. Pupils will learn that engineering can be applied to environmental issues and that many factors are involved in finding a satisfactory design solution. The project links into the alternative energy topic in the National Curriculum.

Preliminary judging is currently underway, with three wind tunnels touring the schools in 11 London boroughs to test the windmills. A total of 32 teams will be invited to the grand final on 8 July 1994 at City University, London.

The top prize will be a visit to the Alternative Energy Centre in Machynlleth in Wales. The trophies will be made from wind turbine blades. Special prizes will be awarded for the two best entries from inner London schools.

## April 1994

**Institution of Plant Engineers' combined Scottish branches annual conference & exhibition**
20 April, Falkirk, Scotland. Details from the Conference Organiser, 20 Gillett Lane, Rothwell, Leeds LS26 0EG. Tel: 0532 824986.

**Wind-powered generators**
Lecture by G Holland, N Ireland Electricity, Belfast. Details from IEEIE, Savoy Hill HOuse, Savoy Hill, London WC2R 0BS. Tel: 071 836 3357.

**Sustainable Technologies for Efficient Energy Production**
Brokerage event, 21-22 April, Budapest, Hungary. Details from Mr Philip Sharman, ETSU, Building 156, Harwell, Didcot, Oxfordshire OX11 0RA. Tel: 0235 432669; fax: 0235 432753.

**Clean fuel technology**
Conference, 25-26 April, London. Details from Sarah Ashmore, IBC Technical Services, tel: 071 637 4383; fax: 071 631 3214.

**38th annual IEEE Rural Electric Power Conference**
25-26 April, Colorado Springs, USA. Details from OPPD, 444 South 16th Street Mall, Omaha, Nebraska 68102-2247. Tel: (402) 636 2585.

**Asian Electricity**
Conference, 26-27 April, Hong Kong. Details from FT Conference Organisation, 102-108 Clerkenwell Road, London EC1M 5SA. Tel: 071 814 9770; fax: 071 873 3975/3969.

**Electrochemistry for a Cleaner Environment**
Seminar, 27 April, Capenhurst, Chester. Details from Joanna Billing, EA Technology, Capenhurst, Chester CH1 6ES. Tel: 051 347 2557; fax: 051 347 2178.

**The future of the UK gas industry in the new competitive market**
Conference, 27-29 April, London. Details from Louise Pasha, IEA Conference Office, 56-60 St John Street, London EC1M 4DT. Tel: 071 490 3774; fax: 071 490 2296.

**Petroleum retailing — regulation and competition**
Conference, 28 April, London. Details from Caroline Little, Conference Officer, The Institute of Petroleum, 61 Cavendish Street, London W1M 8AR.

**Demystifying energy options**
Conference, 28-29 April, London. Details from Monique Quant or Nicola Coslett, IBC Financial Focus Ltd, 57/61 Mortimer Street, London W1N 7TD.

**Competition in gas and electricity — options for major energy users**
Workshop, 29 April, London. Details from Rebecca McInally, Business Seminars Ltd, tel: 071 490 3774; fax: 071 490 2296.

## May 1994

**Small hydro power stations in the Baltics**
Seminar, May, Riga, Latvia. Details from Mrs Gunta Primane, Assistant Director, EC Energy Centre, 1st Ganibu, Dambis, 12
LV-1230 Riga, Latvoa. Tel: +371 2 328857/3228856; fax: +45 30 24 99 03.

**The North Sea Conference 1994**
Conference, 4-5 May, London. Details from Sandra Aldred on 071 379 7400; fax: 071 497 3646.

**Uninterruptible & standby power systems**
Seminar, 5 May, Manchester. Details from Dr Alan Sherratt, Programme Director, tel: 081 788 5337.

**Heavy Oil Technologies in a Wider Europe**
EC symposium, 7-8 June, Berlin, Germany. Details from GOPA-Consultants, Energy Division: Heavy Oil Symposium, Hindenburgring 18, 61348 Bad Homburg vdH, Germany. Tel: +49 6172 9300; fax: +49 6172 35046.

**13th international conference on Fluidised Bed Combustion**
Conference, 7-10 May, Orlando, Florida, USA. Details from EPRI, 3412 Hillview Avenue, Palo Alto, CA 94303, USA. Tel: (415) 855 2823; fax: (415) 855 29954.

**Control & Instrumentation Exhibition '94**
10-12 May, Birmingham, UK. Details from MGB Exhibitions Ltd, Marlowe House, 109 Station Road, Sidcup, Kent DA15 7ET. Tel: 081 302 8585; fax: 081 302 7205.

**Exporail '94**
International exhibition, 10-12 May,, Los Angeles, USA. Details from Anne Crompton, Mack-Brooks Exhibitions, tel: 0707 275544.

**Mining Latin America**
Conference, 10-14 May, Santiago, Chile. Details from The Conference Office, IMM, 44 Portland Place, London W1N 4BR.

**Technological advances towards low loss power distribution transformers**
Workshop, 16 May, Athens, Greece. Details from Cathy Durston, OPET, tel: 0235 433062; fax: 0235 432050.

**Energy demand and supply-economics and policies in a changing world**
Short course, 16-20 May, Oxford. Details from The Registrar, The College of Petroleum and Energy Studies, Sun Alliance House, New Inn Hall Street, Oxford OX1 2QD. Tel: 0865 250521; fax: 0865 791474.

**Buildings and the Environment**
International conference, 16-20 May, Watford, UK. Details from the Buildings and Environment Event Group, BRE, Garston, Watford WD2 7JR. Fax: 0923 664787.

**Advances in Environmental Auditing**
Conference, 17-18 May, London. Details from Amanda Wright, IBC Technical Services, tel: 071 637 4383; fax: 071 631 3214.

**Safe use of programmable electronic systems**
Technical seminars, 17 & 19 May, London and Loughborough respectively. Details from Mr K R Young, Seminar Secretary, IGasE, 21 Portland Place, London W1A 3AF.

**Power-Gen Europe '94**
Conference & exhibition, 17-19 May, Cologne, Germany. Details from Ms Annette van der Gun or Mr Jan van Aken, PennWell Conferences & Exhibitions, Kaap Hoorndreef 54, 3506 GK, Utrecht. Tel: *31 30 650 963; fax: *31 30 650 915.

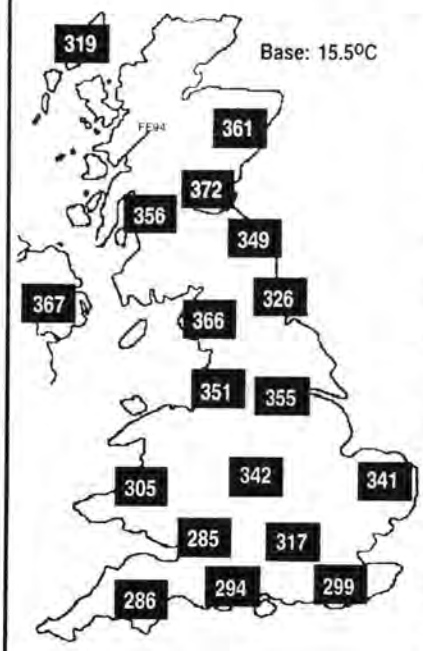
**Understanding Heat Treatment**
Course, 17-19 May, Birmingham. Details from Course Administrator, Wolfson Heat Treatment Centre, Aston University, Aston Triangle, Birmingham B4 7ET. Tel: 021 359 3611, ext 5212; fax: 021 359 8910.

**The Energy Agenda**
Conference & exhibition, 18 & 25 May, Daventry and West Bromwich respectively. Details from IMC Ltd, Allen House, Boltro Road, Haywards Heath, W Sussex RH16 1BP. Tel: 0444 458080; fax: 0444 441215.

**Clean Fuel Technology**
Conference, 19-20 May, London. Details from Miss Sarah Ashmore, IBC Technical Services Ltd, Gilmoora House, 57-61 Mortimer Street, London W1N 7TD. Fax: 071 631 3214.

## DEGREE DAYS: FEBRUARY 1994

Source: **Degree days direct**




These regional figures, calculated from daily outside air temperatures, provide an index of demand for space heating over the month and thus enable excessive consumption to be detected.

A well-controlled heating system should manifest a straight line relationship between monthly fuel used and the local degree-day value; any significant deviation from this 'target characteristic' is likely to signal the onset of avoidable waste (such as a stopped timeswitch or an open isolating valve).

Readers can get more information on the use of degree days from Vilnis Vesma, 17 Church Street, Newent, Glos GL18 1PU (0531-821350)

*INSTITUTE OF ENERGY*

# CONFERENCES

Please note that the conference programmes are subject to modification. For the latest information please telephone or write to Judith Mackenzie on 071 580 0008. The Institute of Energy, 18 Devonshire Street, London W1N 2AU.

**Autumn 1994**
New Business Opportunities in the Energy Industries

**Winter 1994**
Energy From Waste

## Topics for 1995

**September 1995**

2nd International conference on
COMBUSTION &
EMISSIONS CONTROL

- Performance of Large Gas Turbines — *technical conference*
- Demand Side Management

## Events Co-Sponsored by The Institute of Energy

**4 & 5 July, 1994**
**Robinson College, Cambridge**
**European Standards for Combustion & Control Equipment**

***Enquiries should be directed to:***
The Combustion Engineering Association on
Telephone/Fax: 0685 879119

## CALL FOR PAPERS

*THE INSTITUTE OF ENERGY'S*
*2ND INTERNATIONAL CONFERENCE ON*

**COMBUSTION & EMISSIONS CONTROL**

**September 1995, Cambridge, UK**

Following the success of the *Institute of Energy's first International Conference on Combustion & Emissions Control* held at the University of Wales, College of Cardiff in September 1993. We are pleased to announce that the next conference on this subject will be held in September 1995 in Cambridge *(the venue details and date will be announced shortly).*

**CALL FOR PAPERS**
We are pleased to invite the submission of abstracts (in English) of a maximum of 250 words on the following subject areas:

- High temperature processes
- Advanced power generation
- Energy from waste
- Emissions reduction
- Plant performance
- The role of consultants/technology transfer