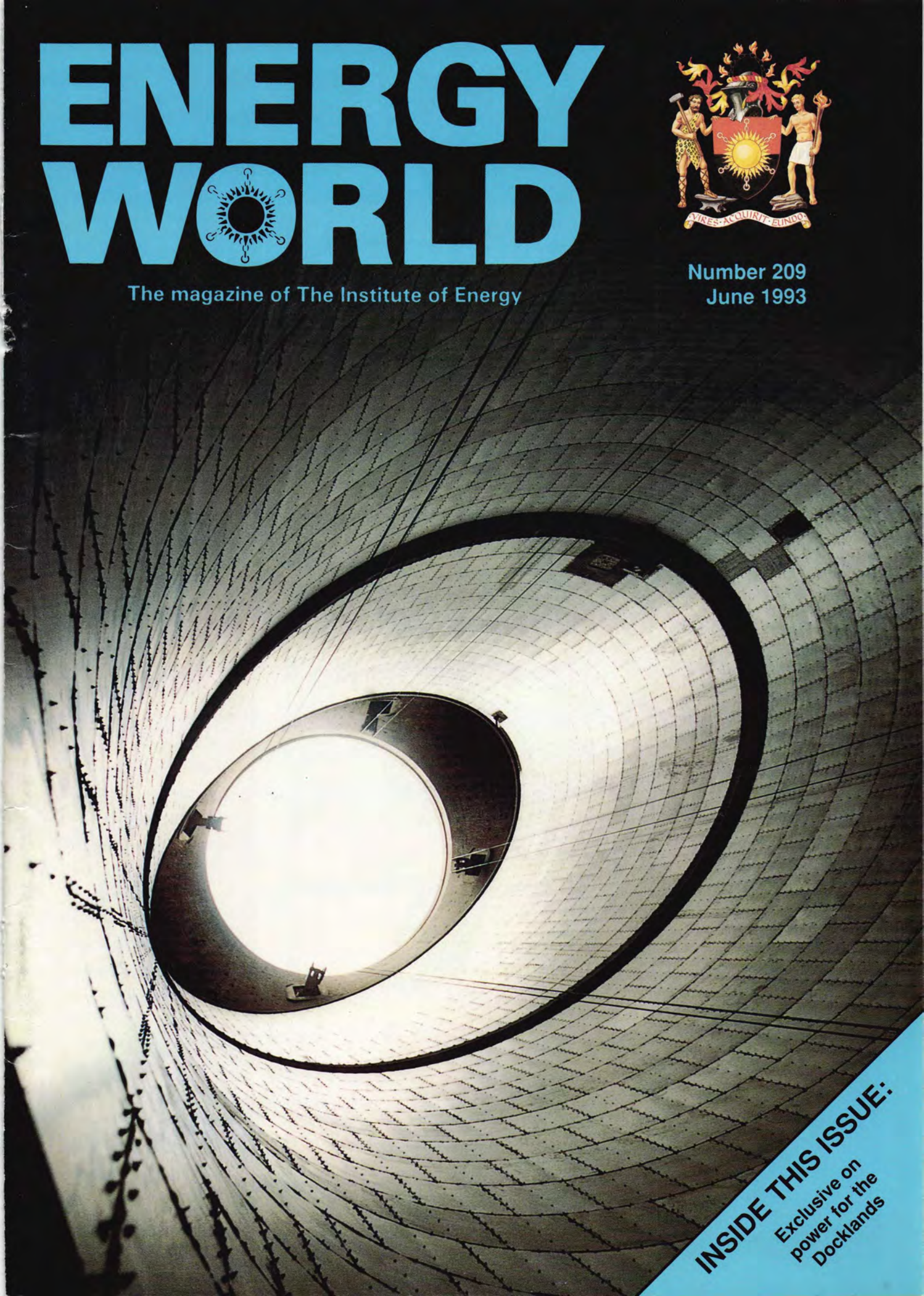
ENERGY WORLD

The magazine of The Institute of Energy

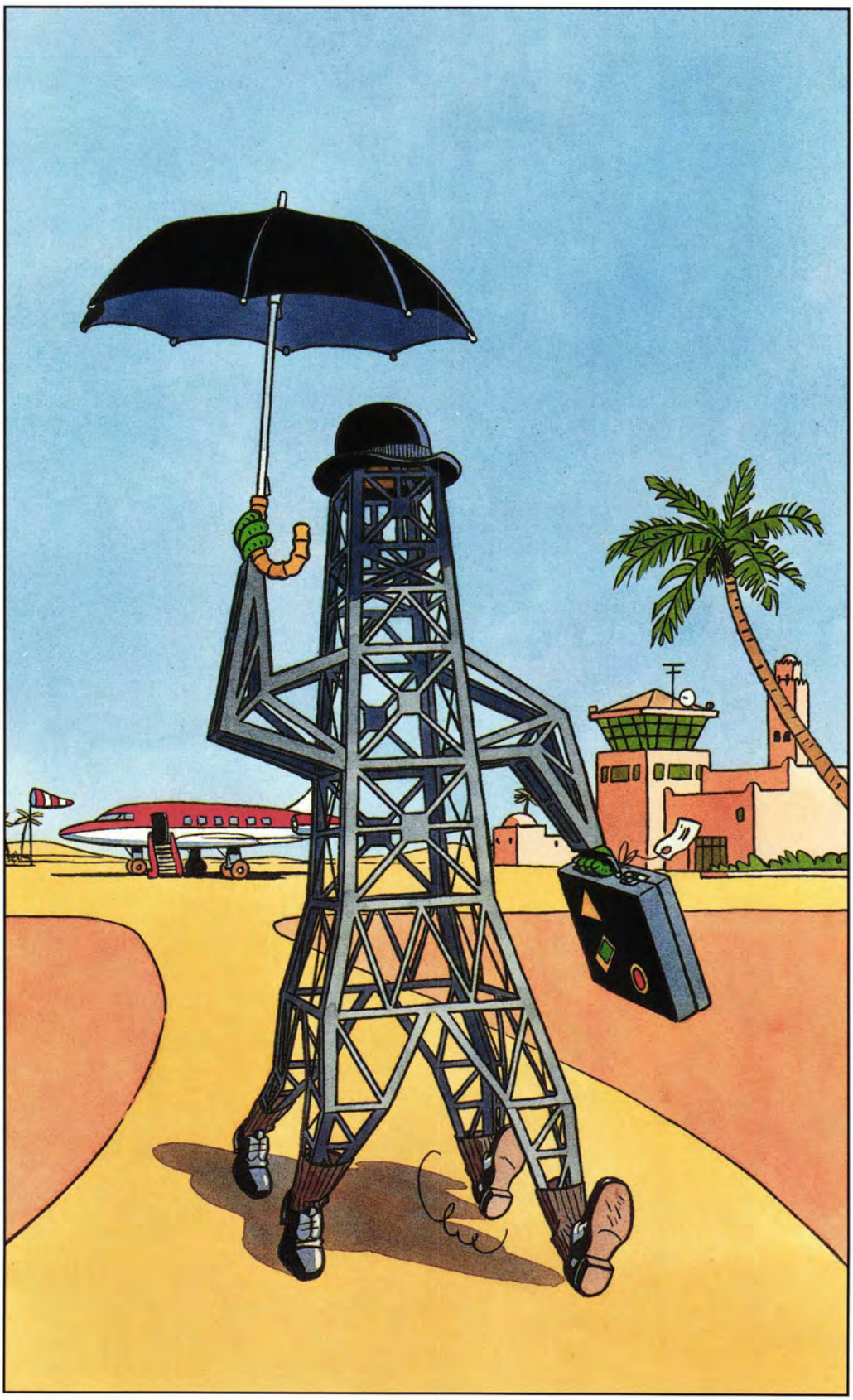
Number 209
June 1993



INSIDE THIS ISSUE:

Exclusive on power for the Docklands

The next small step for National Power: International Power.



Where do you go when you're already the leading power generating company in the U.K.? Why, overseas of course. Which is why we have launched a new division, "National Power International," to operate and expand that side of our activities. Amongst other projects, a National Power-led consortium has recently won one of the biggest independent power contracts in Europe, to buy and operate the Pego coal-fired station in Portugal. By the year 2000, (is it only seven years away?) National Power expects to invest more than £1 billion in overseas projects. But all this is hardly anything new to us. As it is, we're already involved in the development of major power projects in Pakistan, Malaysia and India as well as Portugal. In fact, to date, our experience abroad stretches across 75 countries worldwide. "National Power International" is part of our long-term growth strategy. Today Britain, tomorrow... well let's not get too carried away.

National Power.
Ahead of
current thinking.

ENERGY WORLD

JUNE 1993 Number 209

CONTENTS

COVER

A view inside the stack at National Power's 4000 MW Drax power station is on this month's cover. Being National Power's largest, most modern coal-fired plant, Drax was the only National Power power station chosen for the installation of flue gas desulphurisation (FGD) equipment. Construction began in 1989, and it is expected to become progressively operational between now and 1996. When in full operation the FGD equipment is expected to remove around 90% of Drax's SO_2 emissions, equivalent approximately to 16% of the total SO_2 emitted by the company's power stations in 1990.

The magazine of The Institute of Energy

Published by H Howland Associates, The Martins, East Street, Harrietsham, Kent ME17 1HH, on behalf of The Institute of Energy, 18 Devonshire Street, London W1N 2AU.
Editorial tel/fax: 0622 850100
Conferences: 071-580 0008
Administration: 071-580 7124
Membership, Education and Journal subscriptions: 071-580 0077 Fax: 071-580 4420

Editor
Johanna Fender

Advertisement sales
Harris Howland, tel: 0622 850100

Printed by Headley Brothers Ltd The Invicta Press, Ashford, Kent

THE INSTITUTE OF ENERGY

Patron
Her Majesty The Queen

TERMS OF CONTROL

Energy World is circulated free of charge to all paid up members of The Institute of Energy. To libraries, organisations and persons not in membership it is available on a single subscription of £60 (UK), £70 (overseas) for 10 issues.

ISSN 0307-7942

Energy for a sustainable world

THE FACT that the UK is well endowed with energy has been an excuse to avoid the formulation of an explicit energy policy. Energy policy such as exists arises from the Government's view of the merits of competition and market forces, and of the principle that having established the ground rules, the Government should not be directly involved in final decisions.

However, it is evident that these principles do not adequately explain the forces that operate in energy. Certainly they do not explain the behaviour of governments of other countries with which we are in competition. However desirable it may be in theory to treat energy just like any other commodity, not subject to undue restriction, not subsidised or taxed either directly at production, or at point of consumption, the world we live in is just not like that. In practice, all governments in all countries regard energy supply as too important to be detached from overall strategic planning.

In this country too, energy is subject to Government intervention. But policy is not explicit, it is not codified: it is based on a mixture of history, dogma and pragmatism (or expediency). We have regulators and we have financial intervention. We have subsidised nuclear power, supposedly for decommissioning and waste management costs, but used in the current account to finance Sizewell B. We have subsidised coal, diminishing as the coal industry became more competitive, but historically arising from the confused and contradictory remits given to the coal industry to cover social costs, redundancy payments, as well as to assist capital reconstruction and reinvestment. On the other hand we have taxes on oil and gas, and particularly on vehicle fuels; and we have taxes on the consumption of energy, now extended to the domestic consumer.

These taxes and subsidies are not, however, coherent or consistent. For example, the recent changes in taxation were introduced by the Exchequer, apparently without any kind of appraisal of their effects on individuals, or their impact on investment and exploitation policy in the North Sea. We have the Department of the Environment apparently favouring the introduction of a carbon tax, while Mr Major says he opposes it.

We have pressures from the Rio agreement to level out and then reduce CO_2 and other greenhouse gas emissions, with potentially profound effects on standards of living in this country and abroad. We have pressures to conform to the principles of sustainable development with major impact on the use of energy and the form of supply of energy in the future. The efficient use of energy is once again a key factor, and security of supply continues to be of fundamental importance, but the extra factor of sustainability means that we have also to respond to questions of continued economics and global environmental acceptability.

All this must be seen in the context of concerns of increasing populations, the elimination of poverty and of improving standards of living and the environment everywhere. From this perspective it is obvious that we in this country, just like the rest of the world, need to ensure that the role of energy in solving these common problems is properly appreciated.

Energy is the way to solve these problems, *not their cause*. Unless we are to stand in the path of progress, we must ensure that all forms of energy: fossil, nuclear and renewables have their place. We cannot afford to neglect any of them. Their role in various countries will be different, depending on resources, needs and the availability of expertise to use and adapt them properly. As perhaps never before we need an energy policy, and that policy has to be politically and socially acceptable, and at the same time demonstrating sustainability in this wider global context.

The Institute of Energy must have an important role in all these matters: the efficient use of fuel has been our traditional strength, and I suggest will remain so. But we must accordingly be concerned with broadening the concept of 'fuel' to include nuclear and renewables 'fuels', and to include end-use efficiency — more efficient appliances of all kinds, conservation, insulation, energy management and efficient transport systems. We must increasingly be involved in the dissemination of information on the contribution that newer energy concepts can make to resolving the competing objectives of human development and the natural environment, and responding to the needs of other countries as well as our own.

We have been putting some of these ideas into practice. For example, by taking a major role in the debate on the future coal and electricity industries with two major conferences recently. We have taken a leading role in Mr Major's Technology Partnership Conference, providing a highly successful workshop on sustainable energy generation, and we intend to contribute to the Government's conference in Manchester in September.

The Strategy Working Group has produced many fruitful concepts for the future involvement of the Institute in these areas, and Peter Johnson has led the discussions with local branches as to how our members can make a positive contribution to the future evolution of the Institute's role in these matters.

We need to continue to pursue these ideas; we need to update the Institute's activities. We have strength in our Members and recently-appointed Companions. We intend to build on these strengths. In particular to broaden our interests in energy policy matters, in economics, in legal affairs, and above all in environmental matters. One promising initiative is that these particular topics should become the focus of special Chapters in the Institute, and I am glad to see progress in getting them established. In this way the Institute can make its contribution to the establishment of an energy policy for the UK, responding to the immediate problems we face and to the broader imperatives of the world we live in.

Professor James Harrison, BSc DLC FInstE FIChemE CChem CEng, President

Refinery up-grade for Russia

PROJECT financing is now in place for one of Russia's largest refineries, Novokuybyshev. The total project, when complete will be in excess of US$1.1 billion, financed in tranches of US$250 million, arranged by Barclays Bank of Canada.

The deal, which has taken a year to structure, is the first time a Canadian chartered bank has acted as project and financial adviser to a Russian refinery upgrade. It is also the first project where revenues from the refined oil exports will be used to finance the project.

Barclays will manage the revenues as part of the financing structure, working in close cooperation with Canada's Export Development Corporation. Approval for the release of oil quotas and export tax exemption was required from the Russian Prime Minister.

Baltic energy project begun

WORK started in May on a major project for the European Bank for Reconstruction and Development (EBRD) which should improve energy efficiency in the Baltic States.

The project is to be undertaken by WS Atkins International in partnership with Danish consultancy, RH&H, in the major cities of Lithuania, Latvia and Estonia.

The EBRD has provided loans totalling ECU120 million, repayable over a ten-year period, for equipment which will achieve substantial energy savings and improve conditions in schools, hospitals and 30 000 flats. Industrial energy projects include the conversion of five large boilers in Estonia from oil and coal to wood chips and peat, which are less expensive and less polluting.

The equipment required for all these projects has been identified in outline. The consultants will support local teams in specifying and procuring the equipment and will act as project managers for the EBRD, ensuring the Bank's objectives are met.

"Many items we will be buying are relatively modest and would be taken for granted in the West," according to Gopal Srinivasan of W S Atkins Manufacturing and Process Industries Group. "For example, we will meter energy used for heating and give people the ability to set the temperature they want in their own flat. At present, if you are too cold you can only put on more clothes and if you are too hot, your only option is to open windows."

"I and my colleagues are looking forward to the work, which will bring real benefits to the countries involved. The loan is being provided from the EBRD's emergency fund and is an example of the bank working to good effect," Mr Srinivasan says.

DTI mission to Azerbaijan

REPRESENTATIVES of nearly 30 of the UK's leading oil and gas supply companies set off in May for Azerbaijan, Central Asia, on a mission organised by the offshore supplies office (OSO) of the Department of Trade and Industry (DTI).

The mission was led by DTI's Dr Ken Forrest, director of the OSO, and included delegates from AMEC, Foster Wheeler, John Brown, GEC and Rolls Royce. A three-day seminar in Baku, the capital of Azeri, was included in the visit.

President of the Board of Trade, Michael Heseltine, first suggested the mission when he visited Baku last September. Wishing the delegation well he said: "Azerbaijan appears to have massive oil and gas deposits under the Caspian Sea. Several western oil companies, including BP, are already in the final stages of negotiations with the State Oil Company SOCAR to start operations." Mr Heseltine hopes the visit will lead to new export opportunities for UK firms working in association with Azeri organisations.

Thirteen representatives of Indian industry visited the UK in May as part John Major's Technology Partnership Initiative. The industrialists, all members of the Confederation of Indian Industry (CII) were in the UK to investigate three major sectors of business — automation, power and instrumentation. Their tour took in factories and businesses to explore possibilities for forging strategic alliances between Indian and UK companies. Among the companies visited were National Power International, Sir Alexander Gibb and Partners, GEC Alsthom Turbine Generators and Rolls-Royce.

Four members of the delegation are pictured above with Robert Evans (centre), chairman of British Gas, past President of The Institute of Energy, and UK leader of the newly formed Indo-British Partnership Initiative.

US offers clean coal funds

THE ILLINOIS Clean Coal Institute, USA, has issued a request for proposals of clean coal projects to be funded by Illinois and the federal government.

The focus of these projects is to ensure that high-sulphur Illinois coal doesn't lose out in the marketplace as phase 1 and phase 2 of the Clean Air Act emissions requirement come into force, in 1995 and 2000 respectively.

Illinois authorities are concerned that Clean Air Act limits on SO_2, NO_x and other emissions will put high-sulphur coal on the endangered list, unless new clean-burn technology is forthcoming in the next few years. Funding is expected to total US$3.2 million, of which the US DOE will provide $1m.

Nuclear Electric's yacht, seen here setting off on the first leg of the journey from Southampton last September, won the British Steel Challenge: a 28 000 mile race round the world — the wrong way. The 14 crew members, all amateurs apart from the skipper, were at sea for eight months, and were the overall leaders for most of the race, despite a cracked keel, discovered during a routine check in Hobart, Australia.

New Chairman for UKAEA

SIR ANTHONY CLEAVER has been appointed Chairman of the UK Atomic Energy Authority (AEA) as from 1 July 1993. He will succeed John Maltby, whose term of appointment expires on 30 June.

An Oxford graduate, Sir Anthony joined IBM UK in 1962, and was chief executive from 1986 to 1991. Since 1990 he was part-time Chairman of IBM UK Holdings Ltd. He is a director of General Accident, Business in the Community and the English National Opera.

27 clean coal projects funded

TWENTY SEVEN new clean coal research projects, worth around £33 million were announced at the end of May, by Energy Minister, Tim Eggar.

UK Government contributions amount to £6 million for the projects, which are in collaboration with British Coal, UK industry, SERC, the EC and overseas organisations.

The projects, announced at a conference in Wakefield, are Point of Ayr coal liquefaction plant (operating phase); 18 Coal Research Establishment coal science projects, including environmental studies on emissions from coal; Babcock Energy's low NOx axial swirl burner; a joint programme of fundamental coal research with SERC; and advanced generation research, consisting of six projects aimed at taking forward British Coal's 'topping cycle' concept.

About £2.7 million of the Government's £6 million contribution is earmarked for British Coal's liquefaction plant in North Wales. The total cost of the operating phase will be around £7.5 million. The project is also supported by the EC, Ruhrkohle (Germany) and Amoco (USA).

Pits for sale

FOUR of British Coal's deep mines are on offer to private investors, following the court decision that BCC's decision to close 10 collieries is within the law.

The mines on offer are Easington in the Durham coalfield, Bolsover in Derbyshire, and Cotgrave and Silverhill in Nottinghamshire.

Independent mining operators are invited to bid for a licence to mine coal and to lease the colliery surface. Proposals to develop closed collieries for uses other than mining will also be considered.

Consent for Staythorpe C

CONSENT was given by the President of the Board of Trade, Michael Heseltine, at the end of May, for the construction of Staythorpe C.

National Power will build and operate the 1500 MW combined cycle gas turbine power station. Nottingham County Council had objected to the application, necessitating a public inquiry, held in January of this year.

HMIP green light for Belvedere

THE energy from waste plant proposed by Cory Environmental and sited at Belvedere in Kent has received a clean bill of health from HMIP.

The proposed plant is designed to convert 1.2 million tonnes of refuse per annum into 103 MW of power. The scheme was the subject of a recent public enquiry, from which a decision is expected later this year.

HMIP have confirmed that the plant will conform to strict government regulations set down in the Environmental Protection Act 1990, ensuring operations do not result in any adverse impact on the environment.

£10 million refurbishment

BABCOCK Construction Ltd in a consortium with ABB Stal of Sweden, have been awarded a contract by the Zimbabwe Electricity Authority (ZESA) for the refurbishment of power stations at Harare and Munyati.

The total value of the order is approximately £20 million, to be split evenly between the two companies involved.

Babcock Construction will be responsible for the extensive overhaul, refurbishment and supply of replacement equipment for nine boilers and ancillary equipment, while ABB Stal will undertake a similar package on five steam turbines and associated plant.

As a result of securing this contract, Babcock Construction will be placing subcontract orders with many UK companies for the supply of goods and services.

Babcock Construction has been associated with the supply and overhaul of many boilers in Zimbabwe, and is currently undertaking major repair work at the Hwange power station.

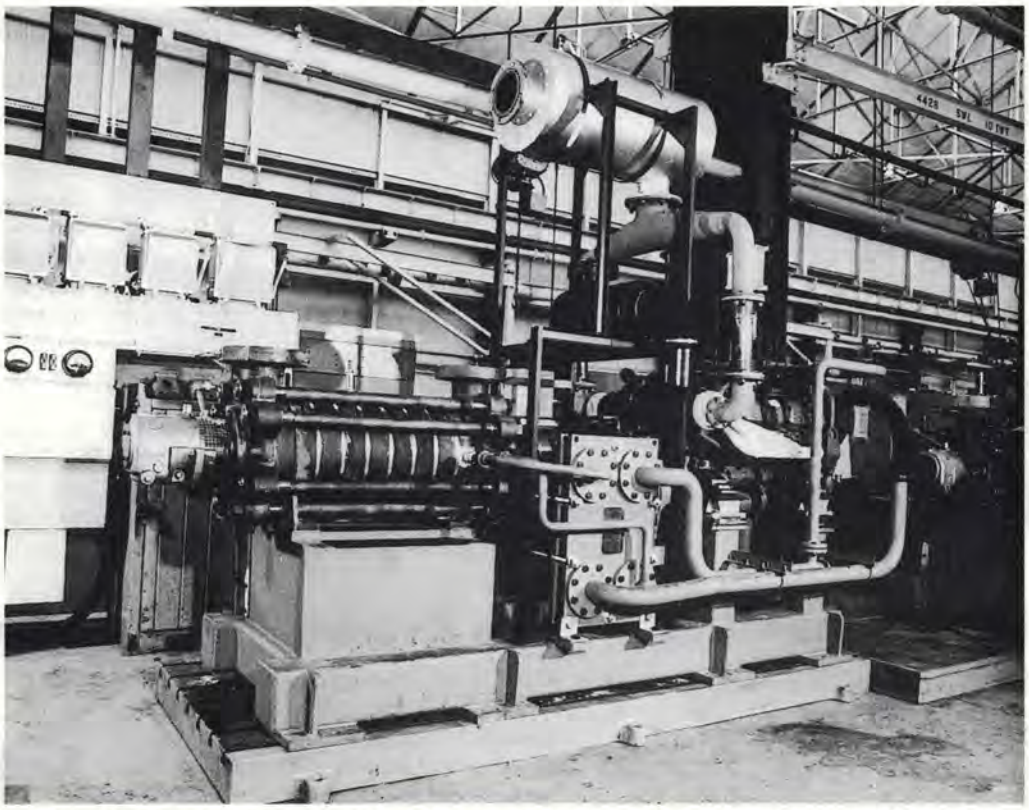
War games

THE DTI's Innovation Unit is producing a technology development exercise with Lancaster University Management School which will give a 'real life' vision of technologies in six key industrial sectors in the year 2000, energy being one of them.

Called 'Innovation War Games' the objective of the exercise is to inspire companies to follow directions now that will make them the innovators and major wealth creators of tomorrow.

The exercise involves the development of a science, technology and product-led answer to simulated disaster scenarios in the energy sector, as well as in aerospace, chemical, transportation, textiles, and automotive industries.

Scenarios devised include dramatic changes in environmental legislation, loss of skills and investment crises, among others.



Birmingham-based specialists in heat transfer technology, Sellworthy, have recently supplied Weir Pumps with three titanium plate gasketed heat exchangers. The heat exchangers are being used on the cooling system of MTU engines, which Weir Pumps are using as prime movers for three cooling pump systems for installation at Sizewell A power station, on the Suffolk coast.

Titanium plates were specified for the exchangers because in the event of failure of the normal water supply, sea water would be used to cool the pumps. Titanium offers the optimum performance, in terms of heat conductivity and corrosion resistance, for heat exchanger plates which are to be used with sea water at elevated temperatures.

The heat exchangers each have a duty rating of 154 kW and are designed to decrease the engine coolant temperature from 90°C to 87.5°C. In the process, water in the secondary circuit of the exchanger increases in temperature from 30°C to 64°C. In addition to the use of titanium plates, Sellworthy had to incorporate several special design features to meet the specific needs of the application. They designed the exchangers with a reduced length, compared to their standard model for the same duty, to suit the restricted installation space available. Also, the primary water pressure drop across the heat exchangers had to be designed to match the cooling circuit of the MTU engines.

The Weir Pump sets are being installed by SLPC Ltd in a new pump house which they are building as part of a £1 million contract for Sizewell A power station.

New Quality Standard awarded to AHS Emstar

AHS EMSTAR (Nottingham) is the first company to be awarded creditation of the BS 5750 Quality Standard under the new heading of Energy Management.

The Nottingham office acted as a pilot for the Quality Standard application, which will now be used as a template for other AHS Emstar regional offices, of which there are 12.

The accreditation was achieved in 18 months by a team led by David Dickman, regional operations manager, and implemented by the quality manager, Alan Yates.

Said Rob Knight, Midlands regional director, "In essence, accreditation to BS5750 means that our clients are the focus of everything we do, and an unfailing quality of service is guaranteed. Besides improved quality for our clients, accreditation has also brought many benefits to our company itself. The quality guidelines now form the 'bible' for every employee and we have achieved a standard set of operating procedures which result in improved reliability and safety. The concept of quality has positive ramifications for both corporate and personal growth."

David Dickman added, "As an energy management company we are very much concerned with the environment. One way of demonstrating our commitment in the future will be adoption of BS 7750. This new Environmental Standard means that a structured system is in place which is integrated with overall management activity and addresses all aspects of desired environmental performance."

BCC Chairman warns of price to pay for transitional coal subsidy

PHOTOGRAPH: JOHN BAKER

THE INSTITUTE of Energy's Annual Luncheon was held at the Grosvenor House Hotel in April.

This year's speaker was Neil Clarke, Chairman of British Coal (BCC)(left). He spoke of the coal 'core' contracts negotiations, saying they demonstrated the problems of winning additional sales. However the transitional subsidy meant that BCC could be more aggressive in its pricing. It was necessary, he added, to define as quickly as possible the structure and extent of the Government price support quickly, as coal stocks traditionally rose in summer months, and continued production without extra contracts would exaggerate that trend.

Institute member's second invention being marketed

MICROCEL (UK) Ltd, the company set up to market 'Bulbsaver', is now marketing a second invention by Institute of Energy member, Allan Wright: the 'ElectroSaver'.

ElectroSaver has been designed primarily for use with fridges and freezers. It saves users a minimum of 15% of power consumption, and has the potential to save up to 40%.

Electric motors are only under full load when first switched on. After the initial start-up period the motor no longer requires the same power. ElectroSaver monitors the back electro motive force (emf) of the motor, which is proportional to the excess power being wasted. The control circuits then establish if the current is less than 50 amps per phase; if so the triac circuits are brought into play to reduce the power without affecting the performance or speed of the motor. At present the maximum ElectroSaver rating is 7kW, but a 30/50kW unit is under development.

Mr Wright has calculated that the payback period for the device is less than a year.

The unit is suitable for applications such as conveyor belts in mines, quarries, compressor motors, large fans, mixers, and process machinery: indeed anywhere large motors are used.

Mr Wright has estimated that if all large motors in the UK were fitted with an ElectroSaver, a couple of power stations could be closed.

His first invention, Bulbsaver, is still selling well. A trial is currently being carried out with Malaysian Railways, and in Ontario the device is being used for traffic signal bulbs.

Ellis Memorial Lecture a great success

THE MOST prestigious event in the Midland branch calendar, The Ellis Memorial Lecture, was delivered by IoE past president Professor Brian Brinkworth (pictured right) on 29 April.

The lecture, whose title was *The Great Energy Crisis — could it have been averted?* was well received by a distinguished audience numbering around 100 at Staff House, University of Birmingham.

Among those attending were (pictured below, from left to right) Midland branch Vice Chairman, David Kirby; branch Chairman, Les Green, and the Institute's newly appointed President, and former Director of British Coal's Coal Research Establishment, Prof James Harrison.

There will be no edition of Energy World in July.
The combined July/August issue will appear in August.

Three Musketeers!

DURING the latter half of 1992 and the first quarter of 1993, all the UK branches have had a visit from any two, sometimes three, of the gentlemen in the picture (right). They are (right) Peter Johnson — Chairman of Executive Committee; John Holroyd (centre) — member of Executive Committee; and on the left, Jim Leach — Institute Secretary.

The object of the visits was to make a presentation on the Institute, entitled 'Survival and Success'. The title was carefully chosen, as following our poor year in 1991 the first objective was the survival of the Institute. Few could doubt after the publication of the Report and Accounts for 1991 that this was the first priority. Members will now know that the Report for 1992 has shown a dramatic improvement, and we have taken great strides to ensure our survival. The fight is not yet over, but I believe we are ahead on points.

The second objective is how to build on to the firmer foundations of our survival to ensure success for the Institute in the coming years. In 1991 we employed a firm of Management Consultants to look at every facet of the Institute, and together with our own Strategy Working Group, the aims and aspirations of the Institute were crystallised. Target audiences were identified and priorities assessed.

One of our immediate priorities was to raise the profile of the Institute, and in this we appear to be succeeding, as demonstrated by the impressive list of speakers at our recent successful conference on *Fuels for Power Generation* and the increasing number of occasions we are asked for comments by Government and others.

Our influence in Europe is also gathering pace with our membership of EFEMA (European Federation of Energy Managers Association) of which Peter Johnson is President. The registered office of this body is our own headquarters at 18 Devonshire Street.

PHOTOGRAPH: JOHN BAKER

'All for one and one for all': the Three Musketeers — from left to right — Jim Leach, John Holroyd and Peter Johnson.

In association with the University of the West of England, the Institute has taken the lead in developing open learning material specifically aimed at those in industry and elsewhere, whose function it is to manage energy (the energy managers). This project, which is funded by DGXVII, Energy Technology Support Unit (ETSU) and Seeboard is on course for completion by March 1994, and when completed will comprise of some 140/150 hours of learning material. One further aim of the project is to link the material into the NVQ framework.

The Institute is also linked with ETSU on the production of learning material on CHP which is being produced by the Manchester Metropolitan University. It is hoped that this will be the forerunner to further collaboration in the future.

As you can see by this, your Institute is alive and well and is building more positively now for our future. The belief is that we have a role to play, and we have the will and determination to succeed.

Jim Leach
Secretary

Flying Scotsman will ride again

THE MIDLAND branch AGM and works visit was held this year at the Oldbury works of FKI Babcock Robey Ltd.

Besides viewing a variety of boilers and pressure vessels at various stages of manufacture, members were also able to inspect the latest low NOx boiler. Branch members were delighted to have the chance to look at the Flying Scotsman locomotive, currently being retubed at the works.

Branch Chairman, Les Green is pictured (right), with Vice Chairman David Kirby (right), with three staff members from FKI Babcock Robey.

Plant life management

by Eur Ing F John L Bindon

Extending the operating life of Magnox power stations is likely to produce some of the cheapest nuclear-generated electricity seen so far in the UK. Technical editor of *The Nuclear Engineer*, John Bindon looks at the whole question of plant life management in the nuclear industry.

EXPERIENCE shows that large electricity generating stations begin to deteriorate with age after about ten years' operational life. The phenomena prevails regardless of the type of power plant. Nuclear power plants are designED with much greater complexity than fossil-fuelled stations, because of the essential need to build in higher standards of safety. More intricate maintenance systems and control devices are employed in nuclear power plants which demand greater attention.

This ageing phenomena must be clearly monitored if the highest safety standards are to be maintained. From a competitive point of view, high performance in terms of reliability and availability commensurate with low operating and maintenance costs must be achieved.

Nuclear power began to supply electricity commercially in the 1950s, and is itself evident that as the numbers of nuclear plants built since that time has increased, then the average age of power reactors world wide has also increased. By the end of this decade more than 50 or so reactors will have been producing electricity for 25 years or more.

Today, the question of nuclear power station lifetime being lengthened as an alternative to decommissioning and the construction of new plants, has taken on a far greater priority and importance for many utilities. Figure 1 (p 10) shows the age distribution of reactor units in operation in IAEA member states at the end of 1991. The accompanying table (table 1) shows the number of reactor units in the age range of 30-40 years in the period 1991-2005. It is clear that the USA has an older plant inventory than most other countries, with the UK also having to come to decisions over a number of nuclear stations before the end of this decade. Other countries have plants that are 20 years old or more, although in general the situation is not so critical.

The IAEA is currently pursuing a number of activities in the field of life management. Some of these are quantified below:

- formulating a systematic approach and methodology for the management of the plant ageing process;
- establishing a methodology to rank plant components according to their impact on the plant's lifetime;
- identifying the requirements for a database on the properties of irradiated materials which can provide information relevant to life management programmes and to the design of new reactors;
- defining the specifications for a suitable database to merge operating experience for component lifetimes;
- achieving a better understanding of the ageing phenomena and their mechanisms;
- completing work on pressure boundary integrity surveillance programmes and their analyses.

UK position

The UK's nuclear power programme began in 1955, following the publication of a Government White Paper (Cmnd 99391) which allowed for the building of a series of natural uranium gas-cooled reactors, the Magnox design, to produce electricity commercially.

The early Magnox reactors were those at Calder Hall, officially opened by H M The Queen in 1956. Calder Hall was owned and operated in those years by the UKAEA. Following the setting up of a new company, British Nuclear Fuels (BNFL) in 1971, the station passed into their control. The station was primarily built to produce weapon-grade plutonium, with electricity as a by-product. A similar station was later opened at Chapelcross in Ayrshire, Scotland.

The basis of the Calder Hall design was adopted for the first of the commercial power-producing nuclear stations proposed in the White Paper. Eight Magnox stations were commissioned in England and Wales over the years from the early 1960s to 1972, when the last Magnox station at Wylfa in Anglesey, Wales, came into operation. These were owned and operated by the CEGB. A similar station was built at Hunterston in Scotland for the South of Scotland Electricity Board (SSEB).

The first two commercial stations came on stream at almost the same time, when the Berkeley nuclear station in Gloucestershire and the Bradwell nuclear station in Essex, commenced operation in 1962. Berkeley was shut down in 1988, the basis for the decision to close being taken on purely economic grounds.

In 1976, the first of a new type of reactor was commissioned, the advanced gas-cooled reactor or AGR. Today, there are five AGRs operating in England and Wales, owned by Nuclear Electric; and two in Scotland: Hunterston B and Torness, owned by Scottish Nuclear Ltd.

In the passing of the Electricity Act in July 1989, in which the whole of the electricity supply industry was privatised, the exception was the nuclear power industry. The Government decided late in 1989 that the nuclear component of the industry should remain under their control. Fears by the City's financial experts that the nuclear industry with a number of stations nearing the end of their operational lives — together with perceived problems over waste management — might prove too great a burden to a successful sale. Nevertheless, the nuclear stations, both Magnox and AGR, which were becoming even more successful in terms of their performance records, would have to operate within the structure of a free market economy for electricity. The result has been for the two new companies set up to operate the nuclear stations, Nuclear Electric plc and Scottish Nuclear Ltd, to examine very closely ways and means of cutting their operating costs.

Again in 1989, the Government declared that a moratorium would be imposed on any further expansion of nuclear power in the UK until a wide searching review had been carried out in 1994. With Sizewell B, the UK's first PWR, being the only new nuclear station under construction at present, the two nuclear utilities are seeking to lengthen the lives of their existing nuclear power plants.

In the UK we have 36 operating reactors, 22 Magnox and 14 AGRs. In addition we

have one PFR at Dounreay and one PWR under construction at Sizewell, the first of its kind in Britain.

The total gross capacity of the Magnox and AGR stations is 12 746 MWe. The ages of the stations range from 31 years (Bradwell) to four years for the last of the AGRs: Heysham and Torness. Calder Hall and Chapelcross owned by BNFL, were commissioned in the 1950s, as mentioned previously.

In order to operate these stations, the licensee has to obtain an operating licence from the Nuclear Installations Inspectorate (NII), a branch of the Health and Safety Executive. The licence lays down a number of statutory requirements in order that regulatory control can be effectively administered.

The Magnox stations at their conception did not have a specific life ascribed to them but they were expected to have safe and economic lives of at least 20 years. Confusion has often occurred as to what exactly is the life span of a nuclear power station. The Magnox stations were originally costed over a 20 year assumed life. However, for well planned and constructed plant and equipment, designers generally provide implicit margins more appropriate to a 40 year life expectation. When the nuclear stations were built in the 1960s and 1970s, it was clearly recognised that technology would not stay still, and that would mean the adoption and modification of the plant as the years advanced. Spares of plant and equipment available for use in the early years has now become obsolescent and thus affected many maintenance aspects where modifications have been needed.

Safety is and has been in the nuclear industry an absolute priority. To achieve the very high standards necessary, it is imperative that continual assessment and monitoring of the plant takes place. This is done not only for safety reasons, but also to ensure the station sustains a high level of availability at all times. By so doing, experience provides a year on year estimation of where the safe operating boundary limit lies.

Ageing

'Ageing' is defined as a continuing time-dependent degradation of material due to normal operation and transient conditions. It is common experience that over long periods of time there is a gradual change in the properties of materials. These changes can affect the capability of engineered components, systems or structures to perform their required function. Although the ageing process normally involves a gradual reduction in performance, not all changes are necessarily deleterious. The phenomena of ageing affects both active and passive components, the malfunction of the active equipment does increase with time.

The main effects of ageing causing concern to the utilities owning and operating nuclear power plants, as well as the Regulators, are changes in physical properties. Such changes can be brought about by irradiation, embrittlement, thermal cycling, creep, fatigue, corrosion, including erosion and cracking and wear combined with fretting characteristics. Thus the term 'ageing' is addressed to all those cumulative movements that may occur within a component over a period of time. The phenomena is a complex business, and therefore considerable monitoring of all plant and equipment is essential.

Each year major items of station plant are shut down for statutory inspection and refurbishment and this programme of work commences almost following on the completion of station commissioning. On the reactor and its associated plant and equipment, the start up after a major outage cannot commence without the approval of the NII, who are independently appointed to issue the licensee with permission to recommence operation.

This programme of work is a year on year continual examination of the nuclear power plant and occurs with conventional power plant as well, except that in the latter case the NII are not, of course, involved. These annual outages give the opportunity for careful examination of equipment and components to take place, and allow maintenance work to be carried out — particularly useful for many items which are not readily accessible during normal operation. This outage work should not be considered necessary for just an exercise for dismantling the whole of the station's plant and repairing any damage detected. The policy must be to use the outage time effectively through renovation of equipment in order to restore it to an almost 'new' condition. The aim is to allow the clock to be restarted from zero, after replacing ageing components and materials.

Good maintenance practice over the station's years of operation is essential, not only to ensure safety, but to establish the plant performance in terms of reliability. Maintenance has a large impact on overall costs of operating a station, because the consequences of poor application may not necessarily be seen in the short term, Good

Table 1: Nuclear power plant units with an age of 30-40 years in 1991-2005

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Argentina														1	1
Belgium														1	3
Bulgaria														1	2
Canada											2	3	4	4	4
France						1	2	2	3	3	4	5	6	6	6
Germany						1	2	3	3	3	4	5	6	8	8
India									2	2	2	3	3	3	3
Japan					1	1	1	1	2	4	4	5	7	10	12
Netherlands								1	1	1	1	1	2	2	2
Pakistan											1	1	1	1	1
Spain								1	1	1	2	3	3	3	3
Sweden											1	1	1	4	5
Switzerland									1	1	3	3	3	3	3
Former USSR							1	1	2	2	3	4	6	9	11
UK	8	10	10	11	17	19	20	20	19	15	16	16	14	14	14
USA	1	2	2	2	2	2	4	4	7	11	13	21	30	42	48
Total	**9**	**12**	**12**	**13**	**20**	**24**	**30**	**33**	**41**	**43**	**56**	**71**	**86**	**112**	**126**

Source: International Atomic Energy Agency

maintenance strategy combined with well thought out programmes executed by a well-trained staff of engineers and craftsmen, will bring rewards by reducing the risk factor or loss of availability. The work will contribute to increased station costs, but performance will register an overall benefit in terms of competitiveness.

Maintenance concepts need to be fully understood and supported by all the station's management. There are two classifications, one relates to preventative maintenance, the other the corrective work which from time to time is necessary. The former is of great value, if properly executed. It will lower the probability of equipment failure and seek to reduce any degradation in performance and allay ageing of certain components by early replacement.

Preventative maintenance falls into two categories, time based, or periodic maintenance. This work is undertaken to a well established schedule, regardless of any equipment condition. The other category which could be termed condition-based maintenance, will be initiated by a set of pre-determined criteria which involves measuring the equipment's deterioration over time.

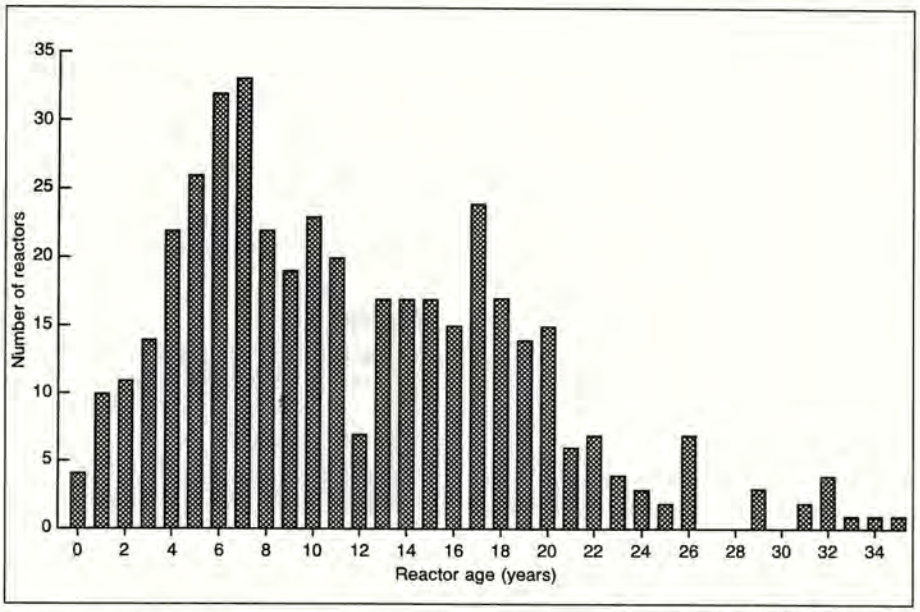
Surveillance is the key to ensuring the station plant is operating at its optimum condition and it remains the only way in which the risk of failure during normal operation can be reduced or eliminated. Obviously inspection of the equipment at statutory outages is vital, along with ensuring the highest standards of workmanship by applying sound quality assurance methods to the system.

LTSR

In order to maintain a proper programme of compliance within the terms of a nuclear site licence, the NII in the UK, discussed the essential aspects on plant ageing in the early 1980s. A Health and Safety Commission summarised its thoughts on the question, in a paper published by the NII in January 1984.

In this regard the advisory committee felt it to be most important that regular safety reviews should be undertaken at all nuclear stations, if the licencee wished to operate the station beyond 20 years. Thus, nuclear stations are now required to present to the NII a comprehensive review commonly referred to as long term safety review (LTSR). These reviews are seen by the NII as establishing the primary basis on which to judge a station's adequacy for continued operation.

The LTSRs have been completed on a number of stations to date, and although the work undertaken to perform this task has been most demanding, it nevertheless has established a key anchor point from which to accept a licensee's request for continued operation of a station. The scope of these reviews has been extensive, and indeed has widened as the work proceeded. However, it has added substantially to the store of knowledge of the plant, its performance and ability to operate within safe limits. Where any divergence has been discovered, then appropriate actions have been undertaken.



Source: International Atomic Energy Agency

Fig 1: Age distribution of power reactors in operation (December 1991)

The three principal aims of the LTSR programme are to confirm that the plant is adequately safe for continued operation; to identify and evaluate any factors which may limit the safe operation of the plant in the foreseeable future; to assess the plant's safety standards and practices and to introduce any improvements which are reasonably practicable and which reflect modern technology.

The last point can be a matter of judgement and contention, in that one has to clearly interpret, as well as demonstrate, the way in which the old plant can embody the new standards required.

Many countries have similar views on justifying the continued operation of their nuclear power stations. Although countries such as USA, France and Japan do not carry out similar reviews as in the UK, their approaches towards lengthening the lives of their power plants are given the utmost priority. The policy has been for these countries to adopt a programme of refurbishment or back-fitting at regular intervals throughout the life of the station.

As with maintenance work at nuclear power stations, difficulties in carrying out comprehensive physical examinations of key structures and components required for these LTSRs exist because of the high radiation levels. However the attractions of undertaking a programme of remedial work to lengthen the lives of these stations, rather than their replacement with new high capital cost plant, has seen a great deal of life management work being undertaken. The ageing of power plants is clearly a very important subject, and is of concern to all member states of the IAEA, who recognise the importance of having a detailed inventory of all stations as the plants get older. To manage effectively physical and non-physical ageing with its resulting degradation, and sometimes equipment obsolescence, requires both pro-active programmes and an international effort in cross fertilisation of all the work undertaken to allow the maximum amount of international cooperation.

It has to be said in conclusion that the continued operation of plants beyond their design life does not necessarily pose an undue risk to public health and safety. Most of the desirable and practicable changes which can be employed to improve plant safety and performance can be ascertained by comparison of the old standards of techniques employed against modern practice. Obviously the methodologies for the effective management of the lives of nuclear power stations need continual appraisal.

About 6000 reactor years of operating experience has led to an ever improved safety record of all those reactors presently in operation. From the two major accidents, Three Mile Island and Chernobyl, much has been gained in relation to making every effort to prevent such events ever being repeated. To that end, the work of the IAEA in the establishment of nuclear safety standards will do much to sustain the relationship between the Regulators, utilities and manufacturers in achieving the highest standards of excellence. ❑

Low NOx combustion

*by William Reynolds BSc CEng MInstE**

The group of companies responsible for much of the retrofitting that is carried out in UK power stations, Credfeld Camtorc, has also carried out much work in North America. Here the company's project engineering manager discusses two such projects carried out in California.

THE Credfeld Camtorc Group of companies offer a complete combustion package, from liquid and gaseous fuel handling plant, through to efficient, low pollution burning equipment located on the boiler. Documented results prove that current legislation on emission levels can be met and improved upon using combustion equipment from the range of designs available, from small package boilers to power station units.

Two such power station NOx reduction projects were carried out for the Southern California Edison Company by a member of the Credfeld group: Todd Combustion of Stamford, Conneticut, USA.

Two large boilers — opposed fired with natural gas and residual fuel oil — were reburnered with Todd venturi registers. The object of the exercise was to improve the flame shape and NOx emission levels, with all burners in service at full load equal to or less than the levels previously achieved by off-stoichiometric firing with FGR. These conversions were carried out at Alamitos Generating Station, unit six and Ormond Beach Generating Station, unit two.

Unit six at Alamitos is a B & W, opposed fired, gas/oil fuel boiler/turbine/generator set rated to produce 480 MWe. Ormond Beach, unit two is a Foster Wheeler, opposed fired gas/oil fuel boiler/turbine/generator set, rated to produce 800 MWe.

Previously considerable success had been achieved by the utilities having to comply with restrictive NOx regulations applying to existing gas/oil fired units by implementing off-stoichiometric firing. In this mode of operation, fuel is shut off to a pattern of burners and compensated by increasing the flow to remaining burners. As a result, the active burner combustion process is fuel rich and consequently NOx formation operation is a deterioration in boiler performance and reduction in efficiency.

This is due to the fact that the excess air has to be increased in order to maintain acceptable levels of CO emissions as well as plume opacity and particulates when firing fuel oil.

The basic concept of low NOx combustion is to achieve fuel-rich combustion, and hence reduced NOx formation, by controlling local mixing of fuel and air.

The Todd Dynaswirl-LN burner relies upon control of the combustion air in several component streams, as well as the controlled injection of fuel into the air streams at selected points, for maintaining stable, attached flames with low NOx generation.

For gas firing, fuel is introduced through six pokers, fed from an external manifold. The pokers have skewed, flat tips, perforated with numerous holes and directed inward toward the burner centreline. Gas is also injected through a central gas pipe with multiple orifices at the furnace end. A single oil gun is located along the burner centreline, inside the gas pipe.

Primary and secondary air streams flow from the surrounding windbox plenum through an annular orifice regulated by a slide damper. The primary stream flows through an annulus around the central gas pipe and inside a primary/secondary air sleeve. The secondary air component flows outside the air sleeve and inside the venturi cowling, where the gas pokers are located. The tertiary air stream is controlled by a separate slide damper and flows between the venturi cowling and the burner throat quarl. Piezo-ring static pressure taps are provided at the inlet and throat of the venturi section to provide indication of the primary/secondary air flow rate.

The oil gun is a conventional constant-differential, pressure-atomised burner. The original single orifice swirl tip was replaced with a multi-orifice showerhead design to reduce boiler vibration while maintaining good flame quality and low NOx emissions. A swirler impeller is attached to the oil gun support pipe just at the end of the primary sleeve section.

In performance of the retrofit contract, Todd Combustion carried out computer and flow model analyses of the windbox air flow distribution. Based upon those analyses, baffles and turning vanes were installed at selected points in the windbox to improve the uniformity of air flow to all burners.

Test methodology

Comprehensive measurements of gaseous emission species (NO, CO, O_2) were made for the pre and post-retrofit testing phases of both boiler retrofits. The scope and conduct of both boiler test programmes were essentially identical.

Gaseous emissions were measured by an extractive sampling/conditioning/measurement system contained within a mobile van. Instruments included chemilluminescent (NOx), non-dispersive infrared (CO, CO_2) and fuel cell (oxygen) types. All measurements were made after drying the sample gases.

The sample flue gas was extracted through stainless steel probes located in a matrix across the economiser exit ducts. Measurements could be made of any single probe sample or a composite of any combination of probes. Composite samples ensured an equal portion from each probe by passing each individual sample through a valve/bubbler prior to mixing within a common manifold.

At Alamitos, a similar matrix of probes was located in the air supply ducts between the air foils (FGR injection) and windbox. At Ormond Beach the FGR/air mixture was measured by sampling from pressure-tap tubing located adjacent to each burner air register.

The FGR rate was calculated as the volumetric percentage of the flue gas extracted from the exit ducts and injected into the combustion air. The calculation was made based upon the dilution of gas species caused by the mixing process, ie, the com-

**Project Engineering Manager with Credfeld Camtorc*

parative concentrations of O_2, CO_2 and NO within the flue gas alone, and the flue gas/air mixture supplied to the burners.

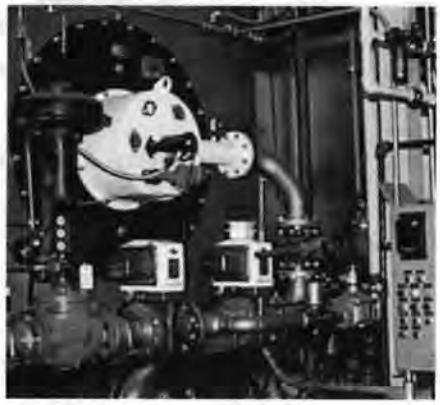
Since the Ormond Beach permit required a demonstration that particulate and hydrocarbon emissions did not increase following the burner retrofit, tests were conducted pre and post-retrofit. TSP was measured using a modification of EPA method five, in which the back end catch was analysed in addition to the front end catch (filter plus probe washing). Volatile organic compounds (VOCs) were measured by capturing flue gas in Tediar bags and analysed for C_2 to C_8. Triplicate measurements were made for each of the four load levels, from 250 to 700 MWe. Analyses were made to determine the carbon content of the filter catch and the organic hydrocarbon content of the back-end catch.

Each test was conducted with operation as close to steady state as possible, with the load blocked on manual control. The boiler fuel, air and steam controls were generally on 'automatic', except that excess air trim and FGR settings were manually controlled. In general, each test lasted from 30 minutes to two hours, depending upon the complexity of gas measurement desired. In addition to the emissions measurements, considerable data were recorded regarding operating conditions (eg, fuel and air flows, pressures and temperatures, control/damper setting, steam conditions, motor amps, boiler excess O_2 and stack opacity).

Test results

The testing of both units was constrained by the necessity to continue to comply with the regulatory NOx limits of 125 ppm and 225 ppm respectively on gas and oil fuels. This constraint prevented testing to determine the NOx reduction capability of the Todd burner by itself in the absence of the utilisation of FGR at higher loads, since emissions compliance could not have been maintained. This same constraint applied to the pre-retrofit testing relative to demonstrating the individual control capabilities of FGR and off-stoichiometric firing on the two units.

Alamitos Unit 6 — In general, the data reflects the maximum NOx reduction capability of the installation. The indicated O_2 levels of 0.6% at the higher loads (>260 MW) are the minimum achievable within the SCE constraint of maintaining exhaust gas CO concentration below 300 ppm. The lower load minimum O_2 levels of between 3.0 and 10.0% are constrained by the necessity to maintain a minimum level of air flow as dictated by safe operating procedures. The indicated FGR rate of 16% at the highest loads is near the maximum capability of the FGR system for test conditions.



Todd Variflame low NOx burners with flue gas recirculation fitted on a typical boiler.

At the lower loads, the FGR rate is constrained by flame stability concerns although no flame degradation in this regard was noted for the indicated levels.

At 480 MW with all burners in service, which is the intended employment for Todd burner installations, the level of NO_x emissions achieved represents a reduction of 87% for the combination of burner and 16% FGR from the uncontrolled level of approximately 700 ppm (best estimate based on historical data.) At 19% WFGR, the maximum capability of the FGR system, NOx emissions would have been in the range of 75 ppm (extrapolated from data) representing an 89% reduction from the uncontrolled baseline. The results are with off stoichiometric operation with eight burners out of service. Although this mode of operation was not intended by Todd for normal employment, SCE was desirous of demonstrating the maximum NOx reduction achievable, since it now must comply with a significantly reduced emission limit. As observed the off stoichiometric mode of operation combined with 19% FGR resulted in a further full load NOx reduction of 35% on gas firing (from 75 ppm to 49 ppm) which represents a 93% NOx reduction from the uncontrolled baseline level. This NOx control mode has been implemented by SCE for normal operation.

The demonstrated percent reductions are measured from an uncontrolled NOx baseline level of 700 ppm. Experience with implementing off stoichiometric firing has shown that the percent reduction achievable on a particular unit is dependent on the magnitude of the initial, uncontrolled NOx emission rate and decreased as this rate is reduced. Therefore, it is likely that lower NOx control capability could generally be expected for Todd burner installations on boilers exhibiting lower uncontrolled NOx emission rates.

Comparing pre and post-retrofit CO/O_2 trends, the Todd burner demonstrated significantly improved performance over that achievable for the pre-retrofit NOx control configuration. This gain in minimum achievable excess rate obtainable with the Todd burner retrofit also offers a benefit in terms of boiler thermal efficiency.

The improved CO/O_2 performance of the Todd burner installation can be attributed in

Two 400 MW gas/oil fired utility boilers being retrofitted with 36 Todd Dynaswirl-LN low NOx burners at a Florida utility.

part to improved air/fuel flow uniformity to the burner arrays on the two firing walls. This was achieved by a combination of windbox modifications made in conjunction with the burner installation and balancing of the burner fuel and air flows during shakedown testing. Therefore, part of the NOx and heat rate gain can be credited against the windbox modifications independently of the burner installation and the remaining part of the burner itself.

In terms of operational performance, the Todd burner installation has satisfied all of SCE's original objectives. Flames are stable over the load range, including minimum load, and do not exhibit any tendency to lift off under normal operating conditions. In addition, operating excess O_2 level has been significantly reduced for gas firing thereby yielding a meaningful improvement in boiler thermal efficiency.

Ormond Beach unit two — Pre and post-retrofit test results over the load range for firing gas fuel indicate that the Todd burner installation reduced NOx emissions to below obtainable pre-retrofit levels for all burners in service mode of operation, and a further increment in NOx reduction was achievable for off stoichiometric operation.

Uncontrolled full load NOx emissions are believed to be in the range of 1200-1500 ppm and therefore the controlled full load emissions for any of the configurations represent a reduction of at least 92%. This magnitude of percent NOx reduction is nearly identical to that achieved on Alamitos. Unlike that unit however, post-retrofit NOx emissions with all burners in service, are lower than the best obtainable pre-retrofit NOx emissions by approximately 10% at full load. The test results in the off stoichiometric mode shows an incremental reduction of 20% from the pre-retrofit level at full load.

The general range of pre and post-retrofit CO concentrations measured verses excess O_2 for gas fuel at loads of 550 MW and above are approximately the same for the pre-retrofit off stoichiometric and post-retrofit all burners in service modes of operation.

A comparison of pre and post-retrofit NOx emissions for oil firing indicate that the Todd burner achieved lower NOx emissions at full load operating in an off stoichiometric configuration than was obtainable for pre-retrofit.

Todd Dynaswirl-LN burners on two 750 MW supercritical Foster Wheeler boilers located in Southern California

For gas fuel there was no increase in measured VOC emissions for operating conditions consistent with lowest NOx (OS operation, low excess O_2 and high FGR rate). Similarly for oil fuel there was no measured increase in either solid carbon or condensible hydrocarbons, again under the lowest NOx operating conditions.

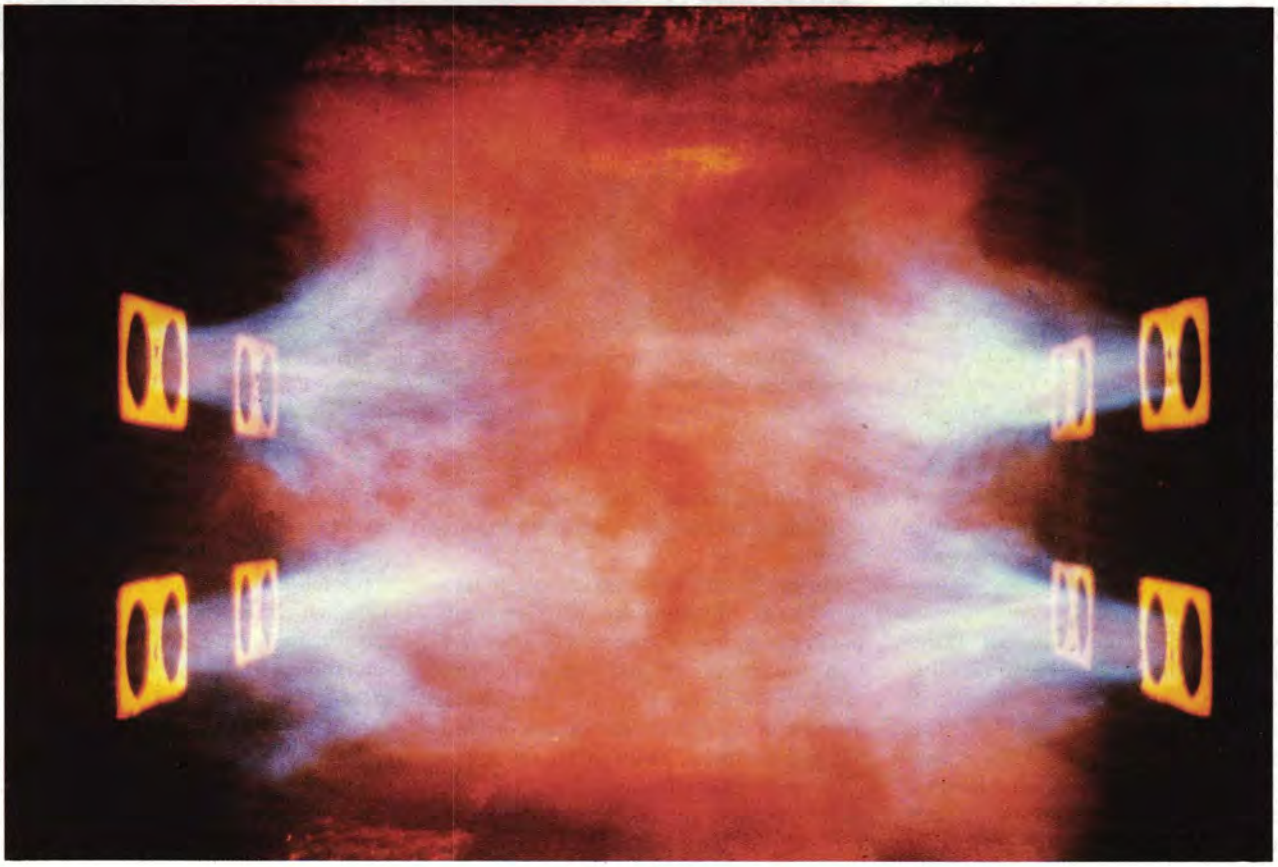
The post-retrofit condition of the flames was substantially better than pre-retrofit under all operating conditions, even at 50 MWe with all air registers open, high FGR rates (up to 40%) and high excess air (25% of rated flow). Under all conditions the flames were closely attached to the burner tip/throat area and were steady and symmetrical. Prior to retrofit the flames were frequently detached from the burner throat by as much as three to four feet, pulsated irregularly and were occasionally irregular in shape.

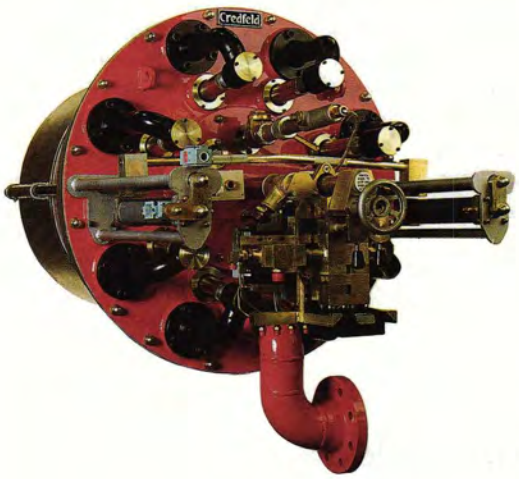
Prior to the burner retrofit, severe boiler vibration (rumbles and furnace wall pulsations) were experienced under certain 'normal' conditions of load, excess air, FGR rate and burner firing pattern. Although the severe vibration could usually be avoided, or corrected by an experienced operator, the condition was of concern to the operating and engineering staff. Following the burner retrofit, the unit generally operates more smoothly and the most severe vibrations no longer occur. It should be noted that simultaneously with the burner retrofit, the FD fans were modified from constant speed with inlet vane flow control to variable speed with no inlet vanes. Although it is uncertain whether the fan modifications contributed to the reduced vibration, the change had definitely reduced the operating noise level and has significantly improved the control and steadiness of the air flow.

Full load NOx levels for both units were considerably reduced up to 93% by operating in an off stoichiometric mode with eight burners out of service. This operating condition was maintained with no increase in VOC emissions on gas fuel and particulates on fuel oil. Additionally, the burner retrofit demonstration significantly improved operational performance relative to pre-retrofit in terms of flame retention, stability and boiler vibration. ❑

Credfeld Camtorc

MEET NOx REQUIREMENTS WITHOUT SACRIFICING PERFORMANCE





THE DESIGN

CREDFELD combustion equipment incorporates design features to produce burner sytems capable of sustaining a continuous ignition source to completely combust all fuel with a minimum excess air and minimal energy losses as follows:

- Aerodynamically profiled air register
- Matched swirl vane flame stabiliser
- Pneumatically operated, tight-shut-off air slide
- Calibrated atomisers and nozzles
- Externally adjustable gas nozzles

THE PERFORMANCE

All CREDFELD burners are designed for:

- Low excess air
- Low NOx
- Low atomising steam consumption
- Low solids emission
- High turndown
- High efficiency

Credfeld – THE RIGHT CHOICE

Credfeld Camtorc Ltd. Forest Road Denmead
Waterlooville Hampshire United Kingdom PO7 6TJ
Telephone: (0705) 257411 Telex: 86809 CREDFD G
Fax: (0705) 241259

Quality Assurance to BS 5750 ISO 9000 EN 29000

BSI REGISTERED FIRM

Thermal energy storage in the transport sector

*by K Darkwa MSc CEng MInstE MCIBSE MASHRAE**
*& Prof P W O'Callaghan MSc PhD CEng FIMechE***

The trend of energy consumption in the UK transport sector and its environmental impact are examined in the following paper. Road transport emerges as the main consumer of energy and contributor of pollutants. Two basic concepts of thermal energy storage are discussed.

ENERGY sources are of the greatest concern because of the socio-economic impact on the whole society. As long as depletable fossil fuels account for a considerable part of total energy supply, thermal energy storage (TES) under energy conservation programmes and the utilisation of renewable energy sources have to be taken seriously. TES is a system of storage of high or low temperature energy for later utilisation which may be achieved in the form of sensible heat, latent heat or in the form of chemical energy using various storage media.

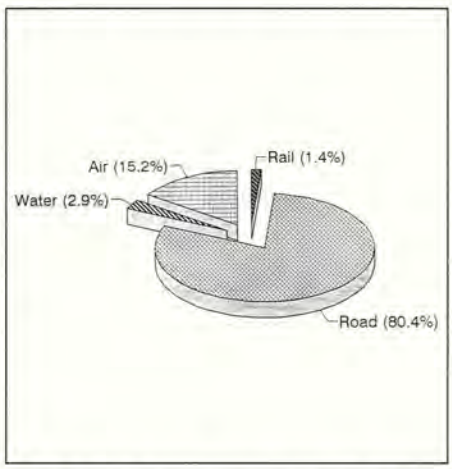
In 1991 the transport sector in the UK alone consumed about 43.46 million tonnes of petroleum[1] with road transport (private motor cars in particular), consuming about 80.4% of the total energy. Transport statistics [2] over the past decade show that the number of licensed motor vehicles rose from around 15 million in 1982 to about 20 million in 1992. This trend could be attributed to the current town and country planning rationale, which separates residential and industrial regions, thus making the private motor car an absolute necessity for many commuters.

Apart from the high energy consumption, the transport sector has also been one of the main contributors to environmental pollution as monitored between 1980 and 1990 [3]. For example, in 1990, emissions of pollutants and greenhouse gases from the transport sector in the UK were about 120.7 million tonnes of carbon dioxide (CO_2), 6.03 million tonnes of carbon monoxide (CO), and about 1.6 million tonnes of nitrogen oxides (NO_x) with road transport contributing the major component. In an effort to control these emissions, the UK government not long ago announced its decision to monitor car pollution and to ensure that all new cars were fitted with anti-pollution devices. Other restrictions announced were that a car first used after 1 August 1983 will have to show not more than 4.5% CO, or 1200 ppm of hydrocarbons (HC) in its exhaust gases, whereas older cars, between eight and 16 years, or cars first used after 1 August 1975 are limited to 6% CO and 1200 ppm of HC [4].

Diesel driven cars are however exempted from these regulations since they offer lower emissions than petrol-driven cars. For example, CO emissions from a petrol-driven car average 2 g/km as compared with 0.7 g/km from a diesel-driven model[5]. Similarly the output of HC falls from 0.3 g/km to 0.1 g/km; and CO_2 emissions from 243 g/km to 189 g/km, due to a higher cycle efficiency.

Even though these devices operate with an efficiency of about 90%, they remain very ineffective at low running temperatures. Also at such temperatures the viscosity of lubricating oil is high, thus resulting in high mechanical friction losses and poor fuel economy. This study is therefore intended to explore areas in the transport sector where TES systems can be applied in order to reduce the levels of emissions and energy consumption.

The formation and destruction of CO, organic compounds and particulates are intimately coupled with the primary fuel combustion process. However, for NO_x and sulphur oxides (SO_x), the formation and destruction processes are not part of the fuel combustion process, but rather take place within the environment created by the combustion reactions. Generally, exhaust gas temperatures from internal combustion engines vary from 330°C to 400°C during idle to about 900°C at high speed but the normal range is from 400 to 600°C and the removal of pollutants from the exhaust gas



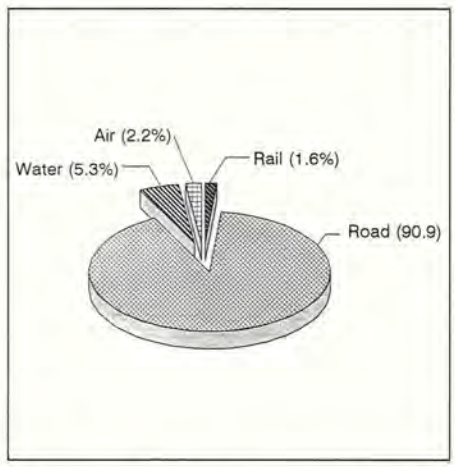


Fig 1: (left) Energy consumption in the transport sector 1991; Fig 2: (right) Emissions of CO_2 in the transport sector.

**Centre for Research into the Built Environment, Nottingham Trent University*
*** Energy Research Centre, Cranfield Institute of Technology*

can however be achieved by using either a thermal reactor or a catalytic convector.

A thermal reactor is an enlarged exhaust manifold whose main function is to oxidise CO and HC by thermal oxidation, after the exhaust gases have passed through the exhaust port at a normal temperature range of 400 to 600°C. However, typical temperatures needed for the thermal oxidation of HC and CO are about 600°C and 700°C respectively, but since exhaust gas temperature in a conventional engine is not sufficiently high, substantial reductions in emissions of such gases cannot be achieved.

In order to achieve high temperatures this system could be improved through spark retard and insulation of the exhaust ports and manifold. In addition to retention of high temperature, other basic functions are to promote rapid mixing of the hot exhaust gases. with any secondary air injected into the exhaust port, and to remove non-uniformities in temperature and composition in the gases. There are, however, practical limitations concerning lean exhaust gas. In a situation where the reactor core gas temperature in 100K lower than other fuel-rich operation, substantial reductions in CO emissions are difficult to achieve and HC burn up becomes marginal for very lean operation. For fuel-rich engine operation there is also a practical limitation of mixing of secondary air and engine exhaust gases in the exhaust port and the reactor core. The fact still remains that, due to incomplete mixing, hundred percent oxidation of HC and CO cannot be obtained even with high temperatures.

A catalytic converter is a device that uses a chemical reaction to convert hydrocarbons and carbon monoxide into harmless water vapour and carbon dioxide. It is more satisfactory than thermal reactor since it is the only proven method for the removal of NO as well as CO and HC and can be achieved within a lower operating temperature range of 250°C to 400°C. There are different types of catalytic converters, but basically they all consist of active catalytic materials in metal casings which receive the exhaust gases.

However, the three-way catalyst is the most effective since it removes about 90% of all the three pollutants simultaneously when it attains its working temperature, ie after about 15 minutes of starting from cold. It is therefore very important that the catalyst is brought to its operating temperature as quickly as possible. Recent reports[6] have indicated that cars with catalytic converters do emit more nitrous oxide (N_2O) than cars without. (N_2O is one of the trace gases that contribute both to global warming and to stratospheric ozone depletion). At high temperatures NO is directly reduced to nitrogen (N_2) but within the catalytic reduction period (ie, from NO to N_2), N_2O forms an an intermediate product at low temperatures.

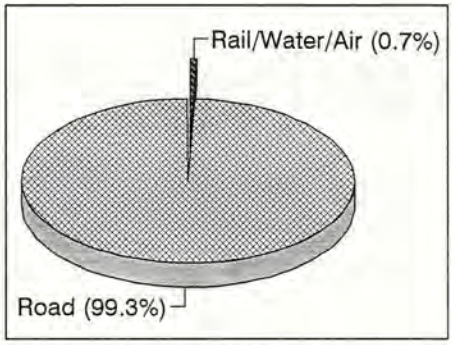


Fig 3: Emissions of CO in the transport sector.

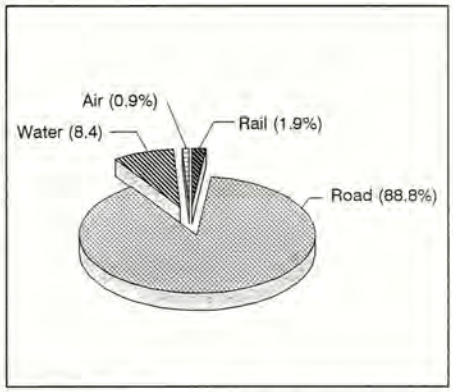


Fig 4: Emissions of NOx in the transport sector.

For example, one study showed that the formation of nitrous oxide increases to a maximum at about 280°C and starts to decompose above 330°C. This fact was confirmed by other measurements carried out by Sigsby [7] and his team, who indicated that formation of N_2O happens during catalyst warm-up and stops after the catalyst has become fully operational. In the past, various methods such as exhaust gas recirculation and pre-chamber stratified engines have been tried without much impact on emissions and fuel consumption levels. For instance, the exhaust gas recirculation system is basically designed to control the production of NOx. In this system, when an engine is first started a time delay switch prevents the system from operating until the engine coolant temperature has reached a pre-determined point. Until then, there is no control over these toxic gases. These facts create very strong environmental issues for concern, in which integrated TES systems with catalytic converters could be used to ensure that the catalyst is brought to its operating temperature as quickly as possible, thus reducing levels of emissions and fuel consumption. In order to highlight the environmental and economic benefits of TES systems in the transport sector, two basic systems will be considered.

Application of TES

Heating application. An integrated TES system could be adopted in an engine cooling/heating circuit as means for pre-heating an engine during cold starting. A high energy density material, preferably a phase change material (PCM) could be used to store enough heat from the combined exhaust and jacket water circuit. Normally engine jacket cooling passages for reciprocating engines, covering the cooling circuits in the block, heads, and the exhaust manifolds, is capable of removing about 30% of the heat input to an engine. However, for the avoidance of thermal stress, the maximum temperature rise through an engine jacket should not exceed 8.3°C, and flow rates should be kept within reasonable design limitations in order to avoid erosion.

The ability of a TES system to store enough waste heat for pre-heating an engine, from cold to an appropriate temperature, means reductions in the in the normal warming-up period, reductions in the levels of emissions and fuel energy consumption and mechanical friction losses which are all attributed to cold engine temperatures.

Comfort cooling application. Air conditioned vehicles are these days very popular in most hot climatic countries since not just

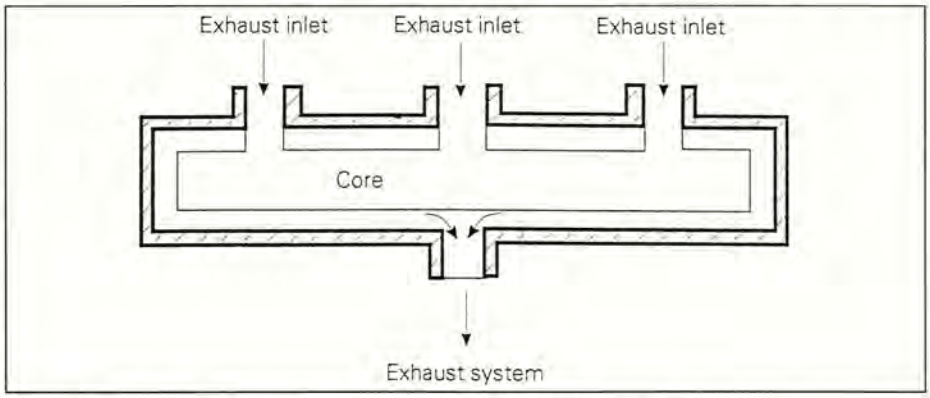


Fig 5: Schematic of exhaust thermal reactor for HC and CO oxidation.

transportation is the main logical reason behind purchasing of motor vehicles but also comfort while driving. For example, in the USA, Canada and other developed countries, many large highway trucks, tractors, taxis and police cars are all equipped with air conditioning systems. Also in many developing countries in Latin America, Africa and the Middle East, air conditioned cars have become a necessity, and virtually a standard feature on all new cars.

Apart from comfort, safety is another important element with potential purchasers and users of vehicles in these countries require whilst driving. For instance, on a sunny day, a driver who has been operating an air conditioned vehicle is much less fatigued than one who has been driving a vehicle without such a system. Another benefit is that the noise level is lower in an air conditioned vehicle, because windows have to be kept closed. These benefits are however paid for in terms of extra fuel consumption, extra basic costs of vehicles and higher levels of emissions. According to L F Goings[8], air conditioning requires extra engine power to operate, and decreases fuel mileage by an average of two miles per gallon depending on the operating conditions.

By adopting an integrated air conditioning/TES system, extra fuel consumption can be saved, since a thermal store could provide the much needed heat input to a generator in a vapour adsorption or absorption refrigeration system, thus eliminating expensive parts, such as the compressor, and reduce the levels of emissions.

In every thermal energy storage system, the overall main objective is to achieve a substantial reduction in primary energy consumption, while meeting the maximum consumption demand. The thermal store must also be able to achieve a high discharge efficiency as well as a substantial reduction in the levels of emissions to the atmosphere. From the discussions of the two areas of application, it is clear that TES systems in the transport sector have a promising future. Apart from emissions of SO_2 and CO_2, which the power generation sector emits most, road transportation alone is by far the main source of smoke, NOx, VOCs and CO in the UK. Their direct effect on humans and the environment as a whole cannot be over emphasised.

Most of these gases are emitted during cold starting of motor vehicles, thus rendering catalytic converters inefficient. With ever-increasing demands of transportation, Governments might apply road tolls and carbon taxes as means of reducing emissions, however the authors believe a substantial reduction in emissions from motor vehicle exhaust can be achieved through the adoption of TES technology. ❑

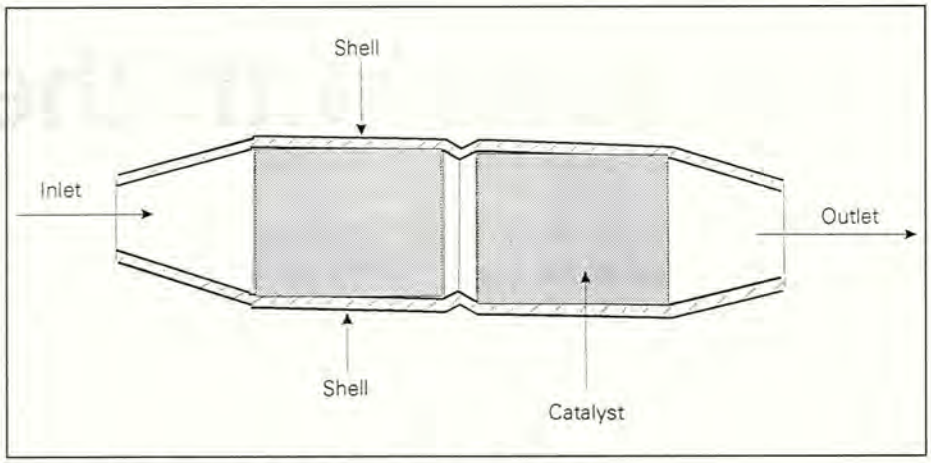


Fig 6: Catalytic converter for spark-ignition emission control.

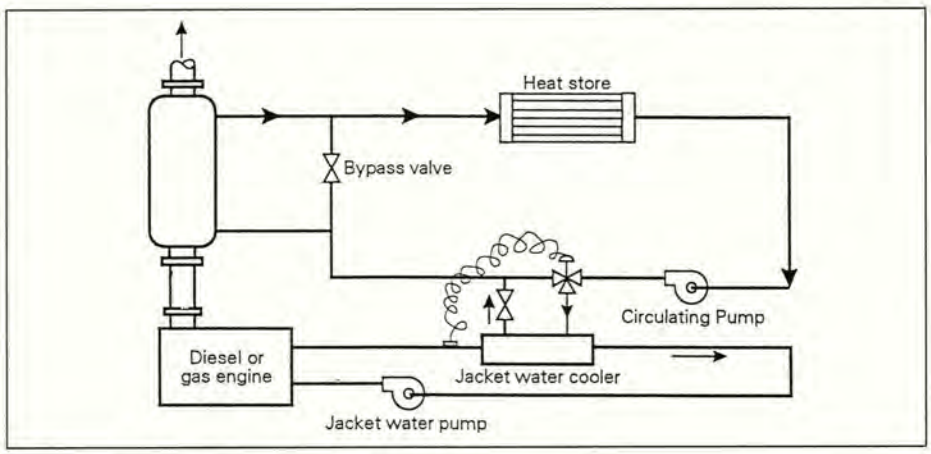


Fig 7: An integrated engine/TES system.

Acknowledgments

The authors wish to acknowledge the provision of a Research Grant by the Department of Built Environment at The Nottingham Trent University for this study.

References

1 *Digest of UK Energy Statistics*, 1990, pp67.
2 *Transport Statistics of Great Britain 1991* (Department of Transport).
3 *Digest of Environment Protection and Water Statistics*, No 13, 1990 (Department of Transport).
4 Sue Barker: *The Observer* newspaper, pp22, 3 November 1991.
5 Reuter textline: *The Times* newspaper, pp33, 24 September 1991.
6 *Air & Waste Management Association Journal*, volume 42, January 1992.
7 Sigsby, McArver & Snow: *Evaluation of a FTIR mobile source measurement system*, March 1989, pp20.
8 Goings, LF: *Automotive Air Conditioning*, pp 2, American Technical Society 1974.

Bibliography

1 'Cheap Heat for Industry', *Electrical Review*, 23 August 1986.

2 Kevin Eason: *The Times* newspaper, pp33, 24 September 1991.

3 Reuter textline: *The Economist*, 12 October 1991.

4 Department of Energy, *Digest of UK Energy Statistics*, 1991, HMSO, London pp45.

5 Gould R, Gribbin, J: 'Green cars may warm up the world' *New Scientist*, 122:34 (1989).

6 Heywood, J B, *Internal Combustion Engine Fundamentals*, 1988, pp658.

7 Amman, C A, 'Control of the Homogeneous-Charge Passenger-Car Engine — defining the problem', SAE paper 801440, 1980.

In tune with the times

'COMBINED heat and power is a technology whose time has arrived' — so said the Director of the Combined Heat and Power Association, David Green, in an Energy World article in 1990. Since then numerous companies have agreed with him, and invested in this energy-efficient plant, helping to save themselves money — in terms of smaller bills — and helping to save the environment, by reducing carbon dioxide emissions.

A specialist unit has been set up within National Power to serve the growing market for CHP. National Power Cogen provides a service ranging from consultation and energy survey to plant installation and operation. Typical clients for such a process are the chemical and petrochemical industries, paper and board, food and drink, manufacturing industries and large industrial users — basically any company that has electrical power and heating requirements.

Backed by their parent company, National Power Cogen are able to offer larger electricity users, from 20 million kWh per year upwards, a flexible and unique pricing package, which includes 100% financing. CHP doesn't offer the solution to all who may wish to benefit from it. There are key criteria which must be fulfilled before a project can be deemed suitable for the CHP solution. The essential proviso is the requirement for heat. This can be in the form of process heating, space heating or hot water — but the demand for heat is fundamental to the economics of any CHP scheme.

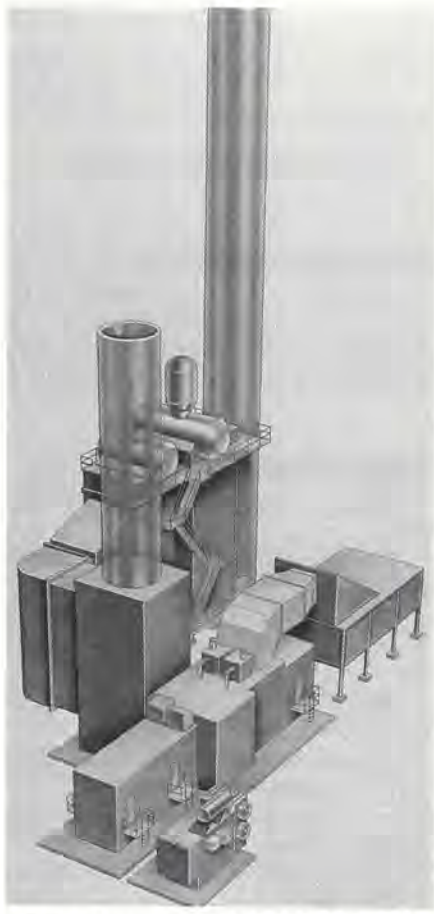
The heat to power ratio is another important factor. This should not change drastically, either during the day or throughout the year, and should be compatible with the output of a CHP plant. Typically a gas turbine CHP plant produces a heat to power ratio of around 2:1, although the ratio can be increased in favour of heat by additional firing.

Full utilisation is crucial to the economics of a scheme. It should run for a minimum of 5000 hours a year. The closer it approaches continuous running (approximately 8000 hours a year or more) the more cost-effective the scheme becomes.

The ideal time to consider a CHP scheme is when existing boiler plant needs replacing, or when you need to increase the capacity of your electricity supply.

One of National Power Cogen's larger projects to date is with the major European paper-products company SCA, at their Aylesford site in Kent. When complete the scheme will have cost in the region of £20 million, and will meet all SCA's present electricity and heat needs.

Hot exhaust gases from a 38 MW gas turbine will be used to raise steam in a heat recovery steam generator. Additional firing brings the level of steam produced up to 120 tonnes/hour, and the thermal efficiency of the plant to around 85%.



Artist's impression of the CHP plant at SCA Aylesford

Cogen will build and own the CHP plant, selling the electricity and steam it produces to SCA over the agreed contract term. National Power will supply back-up power supplies from the grid. When the contract term comes to an end a further contract may be negotiated, or the plant may transfer to SCA's ownership.

The advantages of the scheme to SCA are two-fold. Not only do they make significant savings in their energy expenditure, they also benefit from having new plant on site without capital expenditure on their part.

It is said that the sign of a satisfied customer is one who comes back for more, and Cogen have recently signed a second CHP contract with chemical manufacturers Albright & Wilson Ltd. Their first contract involves a £3 million CHP scheme to be built at the company's site at Oldbury in the West Midlands. The 3.7 MW plant will provide Albright & Wilson with 31 million units of power a year which will be sold at a discount throughout the contract term. An overall efficiency of around 77 % is achieved through to simultaneous production of nine tonnes of steam per hour. The second, and larger contract was signed in April of this year, and involves the building of a 9 MW CHP plant at Whitehaven in Cumbria. Said George Burns of Albright & Wilson "The agreement with National Power Cogen enables us to enhance further our environmental performance and, at the same time, contributes to the controlling of our energy costs." The first of the two contracts, both currently under construction, is due for commissioning before the end of 1993. The second plant is expected to come on line in the autumn of 1994.

Other CHP contracts for Cogen include Lancaster University, where state-of-the-art gas-turbine technology supplies a large proportion of the University's heat and power requirements, and a 4.5 MW project for Sterling Organics, currently under construction, which will generate about 35 million units of electricity each year, along with 75 000 tonnes of steam at their Dudley site in Northumberland.

To find out how a CHP scheme might benefit your organisation, contact Tony Thompson, at National Power Cogen's Birmingham office on 021 702 1113; or Gareth Evans at the Radlett office on 0923 859559. ❑

Partners in power

Combined Heat and Power

National Power Cogen is able to provide you with a tailored CHP package designed to reduce your energy costs. We can design, build, fund and operate the CHP plant on your site and provide all back-up and top-up electricity within the package.

If you are an industrial user requiring a continuous supply of heat and electricity please call **Tracy Brewerton** on **021 702 1133** for further information.

National Power

Cogen

Supplying energy to the Royal Docks

by Johanna Fender

THE ROYAL DOCKS cover an area of 400 acres in the heart of London's docklands, and they are the last major site still awaiting development under the auspices of the London Docklands Development Corporation (LDDC).

Much of the site's infrastructure is already in place, with the recent extension of the Docklands Light Railway (DLR) to Beckton, north of the Royal Albert Dock, and the opening last month by Prime Minister John Major of the Limehouse link, creating a direct through-road route to the City. The Royal Docks also house the London City Airport, which although highly convenient could also restrict the type of development that can take place around this large expanse of water.

The new energy supply infrastructure for the 'Royals' is not yet complete. Less than 30 MW in spare electrical capacity currently available represents a serious potential shortfall. Forecasts of future energy demand for the area have been as high as 500 MW (heat and power), using a conventional approach to supplying energy needs. But a more radical, energy efficient route could reduce this potential demand considerably.

More than five years ago a consortium-led proposal was put forward for the major development of the 'Royal's' energy facilities, along the conventional lines of installing new additional transformers. But Bob Mayer, LDDC's energy manager, sitting in his office on the north side of the Royal Victoria Dock had an altogether different vision for the area. The scheme he envisaged was something quite radical, even unique: to develop the Royal Docks as an independent energy island.

Mr Mayer's basic idea was a smaller, incremental approach, giving greater flexibility — essential given that the infrastructure must be in place before further development can materialise. The overwhelming advantage to a scheme of this nature would be cheaper heat and power for those companies or institutions choosing to locate in the Royal Docks, in addition to the environmental advantages of using small-scale efficient technology, such as combined heat and power (CHP).

In a recent statement former Inner Cities Minister John Redwood referred to 21 possible joint venture projects between the public and private sectors, one being the establishment of an energy company to manage the energy supply of the soon-to-be-developed Royal Docks in London.

It took four years of persuading colleagues to get Mr Mayer's idea from its initial concept to the stage of a full feasibility study, put out to tender and won by a Canadian-based firm of mechanical and electrical engineering consultants: H H Angus and Associates Ltd.

As part of a pre-feasibility study, Mr Mayer and his colleagues examined the relevant legislation and considered opportunities created by the privatisation of the electricity supply industry and their relevance to the proposed project. During this period LDDC looked at various up and running schemes in North America and Europe, as well as visiting numerous sites in the UK, and talking to many influential figures in the energy business. It has taken a lot to convince the sceptics and bring the project thus far, so new was the concept. But as with all good innovations, common sense seems to be triumphing over caution, despite the unfamiliarity of such a scheme.

One of the scenarios under the considera-

Large scale development sites are available in the Royal Docks.

tion of the consultants is the establishment of an energy company in the form of a joint venture between LDDC and the private sector. In fact this was one of the 21 schemes referred to recently by former Inner Cities Minister, John Redwood, when recommending the recent changes in Treasury rules allowing the public financing of joint venture companies between the public and private sectors, as part of the public finance initiative (PFI).

LDDC's brief to H H Angus and Associates is to look at a range of options for both supply and use of energy, to make a comparative study of capital costs, running costs and the toll on the environment. Bob Mayer believes that the cost savings to the eventual consumers — industrial, commercial and domestic — would be considerable. By using energy efficient design in the new buildings — partly under the control of the LDDC as developers of the area — and the use of waste heat from CHP plant, electricity consumption could be drastically reduced. A further cost saving idea is to minimise peaks and troughs of energy demand on a daily, weekly and seasonal cycle, and in addition to balance unavoidable variations in load in individual buildings by aggregation of demand. To this same end, docks' water could be used for thermal storage. An incremental, demand-led approach to energy supply could make an independent-energy-island route in the Royals a pilot scheme for future development areas, such as the East Thames Corridor.

Of course, the energy requirements of an area depend very much on the type of development which takes place. At this stage this is still an unknown quantity in the Royal Docks, although the LDDC does have a series of possible land uses in mind. As a result the consultants have been asked to look at two possible extremes: both minimum and maximum development of the area, or best and worst case scenarios, and to produce a technical and business plan for a period of five years.

It is hoped that potential developers of the area would plough money saved by the scheme on energy costs into energy efficient building design. An 'energy policy' for the Royals is one possibility under consideration, and one that would benefit both residents and commercial interests. There is bound to be a certain degree of resistance to a concept as new as this, but Bob Mayer believes that using demonstration, example and persuasion, uninformed resistance can be overcome, as the project would ultimately be beneficial to all who live and work in the Royal Docks. Consultations have taken place with the DTI and OFFER, both of whom have given great encouragement to the scheme, and await the outcome with interest.

What LDDC has broadly in mind for the Royals at present is an urban village on the south side of the Royal Victoria Dock, and an exhibition and conference facility on the north side; a shopping area in the Albert Basin, with the north side of the Royal Albert Dock suitable for intensive employment development.

H H Angus are now finalising the study, and the report is due this month. It will provide information on the following:

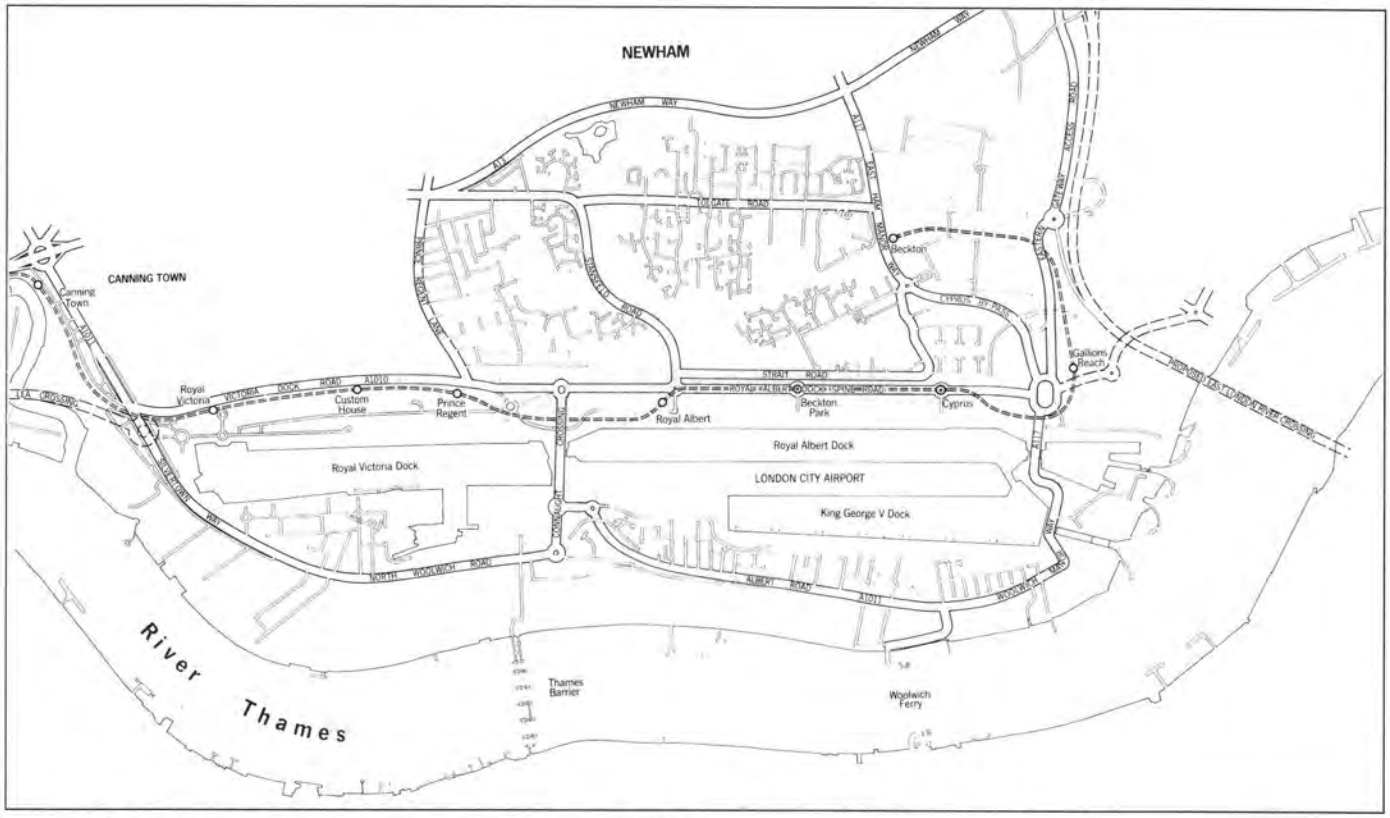
- the legal feasibility of an energy company;
- estimates and profiles of building energy loads;
- preliminary plant and distribution layout options;
- complete financial feasibility scenario for the generation of a company.

Peter Sutcliffe, managing partner of H H Angus and Associates' London office, put together a team of experts to respond to the complex brief set out by the LDDC. This team comprises Creston Financial Group, Gardiner and Theobald, NatWest Markets, Edwards Geldard, Troughton McAslan, L G Mouchel and DTZ Debenham Thorpe.

The most significant difference between the brief LDDC prepared and other CHP feasibility schemes is seen by Mr Sutcliffe to be the absence of any existing loads in the Royal Docks. However, as there is little supply or infrastructure in place, it gives his team the opportunity to study options for supply and use of energy before development takes place.

The team has approached the task in a

Dock edge landscaping on the north side of the Royal Victoria Dock.



Map of the Royals: as an independent energy 'island' the project could be a pilot scheme for the East Thames Corridor.

way which will give their client confidence in the final recommendations for what will ultimately be a speculative venture.

They are identifying plant and distribution costs to match varying development scenarios to project growth of the business over a 20-year time span. They are developing the business plan to mirror the plant construction in a modular way, which allows for flexibility of the operation of the company, as actual development takes place.

The study will also provide building information which could eventually be developed into a handbook for developers on goals for energy usage in their buildings, to help them reduce running costs.

The economic analysis of the complete energy requirements for the area will provide most of the detail required for potential partners in the company to assess the viability of the scheme.

Anyone wishing to find out more about the joint venture energy company proposal should contact Bob Mayer at LDDC on 071 512 3000. ❑

The Docklands Light Railway has now been extended as far east as Beckton.

Fuels for Power Generation

by Johanna Fender

THE INSTITUTE of Energy's most recent conference: *Fuels for Power Generation* proved to be a great success. It was organised in association with the Major Energy Users' Council (MEUC), and held at the Conference Forum in London in April.

The morning session was chaired by outgoing President, Michael Roberts, who welcomed delegates and set the scene for what promised to be an extremely interesting, educational and, at times controversial, session.

The morning's first paper came from John Uttley OBE, who is the group director of finance and corporate administration with The National Grid Company. His topic was *The Changing Electrical Scene*, in which he examined the competitive framework of the electricity supply industry in the light of past and future trends, and reviewed the fuels likely to be used for power generation in the coming years. The environment would be the key driver of future trends in fuel type, he concluded.

White Paper

The next speaker, British Gas chief executive Cedric Brown, regarded the then recent publication of the White Paper as a landmark in the recent energy debate. He remarked that the timing of the conference was most fortuitous, as it gave the industry a chance to take stock of the situation in the light of the coal review. His paper concentrated on the subject of *Gas Availability and Pricing*.

Following a break for coffee, delegates returned to hear an optimistic viewpoint from the chairman of Nuclear Electric, John Collier. In *Nuclear Power — Costs and Competition* he pointed out the difficulties in truly evaluating the costs of power generation fuels, as the whole area, not least nuclear power, is clouded by subsidy and technical fixes. However, any doubt about the Government's commitment to the privatisation process must be dispelled by the White Paper. In conclusion he welcomed the decision to bring forward the nuclear review, the industry, he felt, was now ready to compete.

PHOTOGRAPH: JOHN BAKER

Comparing the Fuel Options: Economic and Financial Analysis **was the subject of Dr Dieter Helm's paper. Dr Helm, pictured above, is director of Oxford Economic Research Associates.**

The final speaker of the morning session, Malcolm Edwards confined his speech to the scope of the White Paper, not surprisingly. He was less happy than the previous speakers, seeing little future for the UK coal industry, he saw "no change in the market" as a result. The one chink of light perceived by Mr Edwards was the White Paper reference to mine licensing. Licensing is, he stressed, a far quicker process than wholesale privatisation of the industry.

The afternoon session of the conference was chaired by Peter Rost, former MP and chairman of the MEUC. The first speaker of the session was PowerGen's chief executive, Edmund Wallis, who in direct contrast to the final speaker of the morning, gave *A Generator's View*. With a reference to the newly commissioned CCGT at Killingholme, Mr Wallis defended combined cycle generation, but went on to point out the essential flexibility of a generator's viewpoint. Orimulsion, for example, largely written off by the environmental lobby, figured large in PowerGen's future fuel mix.

The *Regional Electricity Company's View* was given by John Harris, chairman of East Midlands Electricity, who, like many of the speakers, welcomed the Government's White Paper. He went on to discuss the importance of competition in the ESI, as well as competition between alternative fuel supplies.

Dr Dieter Helm of OXERA gave a paper *Comparing the Fuel Options*, in which he highlighted what he saw as a significant weakness in the pool system.

Prof Stephen Littlechild, director general of OFFER was the final speaker, and the conference was summarised expertly by Peter Rost.

PHOTOGRAPH: JOHN BAKER

During the morning session chaired by Michael Roberts (left), Malcolm Edwards (right) takes questions from the audience on his paper *Managing Coal for the Future*.

Third edition

'Jarbuch 93 — VDI Gesellschaft Energietechnik'
Published by VDI-Verlag, Dusseldorf, 1992, 564 pp.

THIS IS the third edition of the yearbook published by the energy engineering division (GET) of VDI in Germany, an associate organisation of The Institute of Energy. As in the previous edition, the yearbook reproduces a selection of technical papers from the very wide range of conferences and seminars held by VDI-GET in 1992. To highlight a few of these papers at random: a review of primary energy sources for hydrogen generation, the district heating systems of West and East Berlin (7000 MW total); status and prospects for fuel cells; the role of solar heating and structural insulation in reducing CO_2 emissions, energy pathways in the domestic sector, design problems of rotary compressors and limits on the use of regenerative energy.

The subjects of the various conferences from which these papers were drawn include: hydrogen technology, CHP, how to limit CO_2 emissions, energy saving in transport, energy saving in the home, waste disposal laws, nuclear energy and other energy options, electric vehicles and man's influence on climate.

The yearbook also contains information on forthcoming events (1993) organised by VDI-GET, a list of publications (some of these are in English) and notes on current VDI-GET committees. A final section on end use of energy in Germany gives a breakdown into the various sectors in 1991.

Alan Field

A good introduction

'Computational Hydraulics: Elements of the Theory of Free Surface Flows' by M B Abbott. Published by Ashgate, Aldershot, 1992, 326 pp, £39.95.

FIRST published in 1979, this is the third reprint with minor modifications of a book based on research carried out by the Danish Hydraulic Institute. It serves as an introduction to a series of texts involving the modelling of water flow by digital computer.

The first chapter introduces the discrete forms of conservation laws; the second applies to continuous forms, using three dimensional partial differential equations. Chapter Three uses the method of characteristics, setting up equation systems in matrix and determinant formulation. The last three chapters deal, respectively, with numerical methods suitable for digital computer solution; the foundations of computational hydraulics; and last, the applications, including rig and field testing, leading to production models.

The book is well-illustrated throughout by 168 clear diagrams, also matrices and mathematical equations, together with some simple worked examples. Since the book was first published there has been a large increase in the speed and capacity of computers. This has led to many mathematical and engineering publications since its last reference, in 1980.

Nigel Gwyther

Highlights difficulties

'Britain's energy policy and the coal crisis'
Published by The Institution of Electrical Engineers, Stevenage, 1993, 128 pp, P/B £7.50.

IN DECEMBER 1992 a forum was held at the IEE to discuss the major issues behind the coal crisis, organised by IEE jointly with The Institute of Energy, The Institution of Civil Engineers, The Institution of Mechanical Engineers and the Watt Committee on Energy.

Amongst the issues debated by a highly informed panel of speakers, representing private and public industries, academia and related institutions, were the following questions: should Britain maintain a viable coal industry? does the 'dash for gas' make long-term economic sense? what is the environmental dimension to the crisis? what are the real facts underlying energy pricing? and how should we develop a long-term energy strategy for power supply?

The published proceedings include edited discussions which took place at the forum.

Amidst the excited media response to this social and strategic problem, these contributions stand out for their persuasive and soundly based consideration of the underlying science, technology and economic issues. In particular they highlight the difficulties of maintaining long-term national objectives — including security and diversity of supply, and environmental and social needs — within the economic framework and enterprise of the privatised industry.

Recently published

'A Timber-drying System Fuelled by Sawdust' by A P Robinson, R C Marder & H C Coote. Published by NRI, Chatham, 1993, iv + 18 pp, £7.50.

'The Development of a Multi-chambered Brick-built Furnace Fuelled by Sawdust' by A S Tariq, R J Lipscombe & A P Robinson. Published by NRI, Chatham, 1993, iv + 15 pp, £7.50. Available from NRI, Central Avenue, Chatham Maritime, Kent ME4 4TB.

'Fan and Ductwork Installation Guide' Published by The Fan Manufacturers' Association, £12.00 (inc p&p) (payment with orders, cheques made payable to Federation of Environmental Trade Associations (FETA)). Available from FMA, Sterling House, 6 Furlong Road, Bourne End, Bucks. Tel: 0628 531186.

'China Coal Industry Yearbook' Published by Han Ying Shan Consultants, in English, 1992, 135 pp, US $95.00 (inc surface mail postage). Available from Han Ying Shan Consultants, PO Box 71006, Wuhan, Hubei 430071, PR China. Fax +86 27 235628.

'Oil Production Capacity in the Gulf: The United Arab Emirates' First in a series of reports published by the Centre for Global Energy Studies. Available from CGES, 17 Knightsbridge, London SW1X 7LY. Tel: 071 235 4334; fax: 071 235 4338.

'Coal-Use Technology: New Challenges, New Responses' by Walter C Patterson. Published by FT Management Reports, 1993, £248.00 (UK) £258.00 (overseas). Available from FT Management Reports, Customer Services, PO Box 6, Camborne, TR14 9EQ. Tel: 0209 711928.

'The Brown Book' 1993 Annual Report on the Development of the Oil and Gas Resources of the UK. Published by DTI, Ashdown House, 123 Victoria Street, London SW1E 6RB. Fax: 071 222 4382.

'The Entec Directory of Environmental Technology' Edited by J E G Larson, Foreword by Prof Nigel Bell. Published by Earthscan, London, 1993, 1024 pp, £125.00. Available from Earthscan Publications, tel: 071 278 0433.

'Incineration of Hazardous, Toxic and Mixed Wastes' by James H Gill & John M Quiel. Published by North American Mfg Co, Cleveland, 1993, 274 pp, P/B US$25.00. Available from North American Mfg Co, 4455 E 71st Street, Cleveland, Ohio, USA. Tel: (216) 271 6000; fax: (216) 641 7852.

The power of nature

I AGREE with many of the points made by W H Wheeler in his article 'Britain versus Global Warming' (*Energy World*, April 1993), but only on the basis of conservation — they cannot be supported by consideration of the environment, and it is inaccurate to argue that they can.

Recent scientific developments are proving that the popular vision of acid rain, global warming and ozone depletion is, in all cases, nothing more than a delusion.

With reference to global warming, Friis-Christenssen and Lassen (*Science*, ***254***, 652/699, 1991) show the striking correlation between the variations in the solar cycle and in global warming — where attempts to correlate atmospheric carbon dioxide with global temperature have always been dismally unsuccessful. Now, the variations in global temperatures (which some have found worrying and ascribed to human activities) can be explained by a combination of the natural factors — solar radiation and volcanic activity.

With ozone depletion "the walls around the ozone hole are coming down" with the Washington Post's front page article of 15 April. This paper has long been renowned as a supporter of alarmist environmental claims, but in this recent *volte-face* they say that ozone changes present no real danger, and the ozone layer will fix itself — naturally. The changed general outlook, I am sure, is due to the book *The Holes in the Ozone Scare* by Maduro and Schauerhammer — essential reading.

My retirement study of the various alarmist claims has left me convinced of the immense restorative power of nature, and the relative insignificance of human kind and its capacity to cause permanent damage to the environment. I have learnt of the inevitable variability of nature's forces, which existed long before our technological advances recently gave us the means to appreciate and measure them.

Peter Toynbee *(Fellow)*
Wellington, New Zealand

Raising awareness

I AM writing in response to the article entitled 'The Eco House' (*Energy World*, January/February 1993) which refers to the need for energy efficient heating systems in the home. The article states: 'A gas condensing boiler, for example, can have a thermal efficiency of up to 90%, whilst an electric storage heater would have difficulty reaching 30%' and that many countries prohibit electric heating because of this.

The efficiency of a storage heater itself is 100%, but I accept that the author is concerned with global emissions and therefore uses the efficiency of electricity generation, although 30% is still somewhat low for the overall UK mix of generation.

However what does seem unreasonable is the comparison of a state-of-the-art advanced gas heating system with the everyday traditional electric system. State-of-the-art electric heating systems are also available in this country, such as the heat pump heat recovery system which operates with an in-practice seasonal efficiency of 320%. In terms of global emissions that is at least as good as or better than a gas condensing boiler, even when electricity generation is allowed for.

The article cites the aim of the Eco House project as raising awareness. I offer this information in that spirit.

D A Baggs *(Member)*
Head of Energy Markets Group,
Electricity Association, London

'New relationship' proposed for profession

ENGINEERING into the Millennium, the interim report of the Council of Presidents of the Engineering Institutions Steering Group, was published at the end of April.

The report urges the profession to set in hand major reforms to give it more unity, more effective organisation and a more powerful single voice. The report argues for a 'new relationship' between the Engineering Council and the institutions, which could evolve into the formation of a single institution.

The Steering Group, set up in January 1992, was chaired by Sir John Fairclough, who, in his introduction to the report, says: 'We need to unify so that we can speak with a single voice on those matters of general concern, and provide the leadership to take us into the next century with a new-found relevance and sense of importance, not for any reason of aggrandisement, but because we care about society and our role in it.'

The key elements of the 'new relationship' are identified in the report:

- a central body whose Council would have a majority of member elected by individual engineers;
- the 42 institutions grouped into six colleges which would coordinate activities and advise the Council;
- a clear and agreed statement setting out the allocation of responsibilities between the central body to monitor the colleges and institutions and ensure compliance;
- membership of an institution to be a standard requirement for the central register of engineers.

The authors of the report believe that these reforms represent a major improvement on the status quo, and provide a sound basis from which a single body could emerge. They conclude that the Engineering Council should continue to act as a single body, but there should be an independent review of its operation, structure and staffing, conducted by management consultants.

The Engineering Council has strongly backed the report, whilst the Presidents of the 'big four' institutions (IChemE, ICE, IEE and IMechE) have given it a guarded welcome. They believe the proposed colleges to be an unnecessary tier between the central body and the individual institutions, and would hinder the natural alliances between institutions of converging disciplines. In addition they felt that the recommendations failed to build on the growing relationships between institutions, and to recognise the rapidly developing integration of activities between the major bodies.

The President of the Institution of Structural Engineers has also criticised the report, saying that its proposals were based on two false assumptions: that there is one engineering industry in the UK, and that a bureaucratic reorganisation can improve the status of engineers.

Neighbourhood Engineers launched in Northern Ireland

A SCHEME in which post-primary schools receive practical support from professional engineers and technicians was launched in Northern Ireland at the end of April.

Neighbourhood Engineers will be managed in the Province by the industry-education links body, Industry Matters Ltd. The scheme will be part of a wider project supported by the Training and Employment Agency, which aims to promote awareness of engineering and career opportunities within the engineering industry.

Neighbourhood Engineers has already been operating successfully throughout the UK under the auspices of the Engineering Council, and has so far involved more than 10 000 engineers and technicians working in over 2 400 schools.

New awards launch for young engineers

A NEW set of awards intended to promote inventiveness and originality on the part of young people in the field of engineering design and development was launched recently by the Engineering Council.

The Innovation and Inventiveness in Engineering award scheme will run in parallel with the existing Young Engineers for Britain competition. The new scheme aims to identify and reward projects entered for Young Engineers which display particularly noteworthy engineering skill and imagination, but which may lack some of the presentational and marketing attributes that the main categories seek to encourage.

Four winning projects will each receive a prize of £1000 to purchase equipment to improve the teaching of science and technology in their school, £250 for each group or individual, to benefit their education and a certificate from the Institute of Patentees and Inventors.

Selection for the final of the new scheme does not obviate the possibility of a project also being selected for the national Young Engineers for Britain final.

Equal opportunities high on agenda

A CONFERENCE held in May by British Gas and the Engineering Council has challenged more than 300 teachers, school governors, parents, industrialists, careers advisers and academics to 'get WISE'.

The WISE (Women Into Science and Engineering) campaign, run jointly by the Engineering Council and the Equal Opportunities Commission, encourages girls to follow science and technology courses and to take up careers in science and engineering. The conference supports the campaign by focusing on careers advisers, parents and teachers — those who directly advise girls on their future career choices. It also challenges perceptions about the roles that men and women play in society, which tend to discourage girls from opting for those careers.

Several speakers concentrated on equal opportunities, among them Dr Majorie Mowlam, MP for Redcar and opposition spokesperson for the Citizen's Charter and Women; Dr Anne Wright, vice-chancellor of Sunderland University; and Liz Bargh, campaign director for Opportunity 2000. Equal access to education, removal of curriculum bias, recognition and promotion in employment , and 'family-friendly' employment practices were all seen as essential factors for the improvement in recruitment and the status of women in science and technology.

Engineering Council praises science White Paper

THE ENGINEERING Council has praised William Waldegrave, Minister for Science, following the publication of his White Paper on science and technology at the end of May.

"Science and technology have now come to the top of the political agenda with the publication of this important White Paper," said Denis Filer of the Engineering Council. "We are especially pleased that industrial and research communities will get a statement each year spelling out the Government's strategy. We called for such a move in our submission to Mr Waldegrave."

Mr Filer said the annual strategy statement would help industry, academia and research establishments immensely. He seemed unconcerned with the wide-spread criticism of the White Paper: that it failed to provide the funding to carry out its proposals to an effective end. Mr Filer felt it would help encourage more young people into the profession.

June 1993

ENERGY
Conference and exhibition, 22-24 June, Olympia, London. Details from Philbeach Events Ltd, Earls Court Exhibition Centre, Warwick Road, London SW5 9TA. Tel: 071 370 8238; fax: 071 370 8143.

Explosion prediction and mitigation
Course, 28-30 June, Leeds. Details from Miss Julie Charlton, University of Leeds, Tel: 0532 332494; fax: 0532 440572.

July 1993

Fairclough discussion
Meetings, 1, 7, 12, 15 July, Glasgow, Bristol and Plymouth, Maidstone and Cardiff respectively. Details from IMechE, ICE, IEE or IChemE.

Emergency lighting — design & practice
Course, 1 July, London. Details from Alison Murphy, Mid Career College, PO Box 20, Cambridge CB1 5DG. Tel: 0223 880016; fax: 881604.

Environmental aspects of nuclear power
Seminar, 1 July, London. Details from Katie Rayner 071 973 1312.

Transport and the environment
One-day symposium, 7 July, London. Details from The Conference Manager, IWEM, 15 John Street, London WC1N 2EB. Tel: 071 831 3110; fax: 071 405 4967.

Facing the European Challenge — the role of the Professions in a wider Europe
Conference, 13-15 July, Leeds. Details from Mrs Sheila Speedy, Course Secretary, Dept of CPD, Continuing Education Building, Springfield Mount, Leeds LS2 9NG. Tel: 0532 333226; fax: 0532 333240.

The power generation economics workshop — project planning, economics and privatisation
Course, 19-23 July, Oxford. Details from The College of Petroleum & Energy Studies, Sun Alliance House, New Inn Hall Street, Oxford OX1 2QD. Tel: 0865 250521; fax: 0865 791474.

Cake filtration
One-day meeting, 20 July, Manchester. Details from The Filtration Society, 48 Springfield Road, Horsham, Sussex RH12 2PD. Tel: 0403 259419; fax: 0403 265005.

August 1993

Utilisation of wastes as fuels or materials
National meeting of the Fuel Chemistry Division of the American Chemical Society, 22-27 August, Chicago, USA. Details from Dr M Rashid Khan, Texaco R&D, Old Glenham Road, PO Box 509, Beacon, NY 12508, USA. Tel: 914-838-7639; fax: 914-838-7102.

Harmony with Nature
ISES solar world congress, 23-27 August, Budapest, Hungary, Details from ISES Solar World Congress 1993 Budapest, c/o Malev Air Tours, Budapest, 1367 PO Box 122, Hungary.

Laser Anemometry — advances & applications
5th international conference, 23-27 August, Koningshof, Veldhoven, The Netherlands. Details from Ms J Schellingerhout, LA Conference 1993, Dr Ter Braaklaan 1, NL-4002 WN Tiel, The Netherlands. Tel: +31 3440 15763/16384; fax: +31 3440 24103.

EPRI/EPA/DOE 1993 SO_2 Control Symposium
24-27 August, Boston, USA. Details from Pam Turner, EPRI Symposium Coordinator, PO Box 10412, Palo Alto, CA 94303-9743, USA.

September 1993

Unsteady combustion
Advanced Study Institute, 6-17 September, Espinho, Portugal. Details from Instituto Superior Tecnico, Dept of Mechanical Engineering, Av Rovisco Pais, 1096 Lisboa Codex, Portugal. Tel: 351-1-847 34 53/4; fax: 351-1-849 61 56.

Offshore Europe 93
Conference & exhibition, 7-10 September, Aberdeen, UK. Details from Offshore Europe Partnership, Rowe House, 55/59 Fife Road, Kingston upon Thames, Surrey KT1 1TA. Tel: 081 549 5831; fax: 081 541 5657/081 974 8077.

18th Annual Symposium of The Uranium Institute
8-10 September, London. Details from Uranium Institute, 12th Floor, Bowater House, 68 Knightsbridge, London SW1X 7LT. Tel: 071 225 0303; fax: 071 225 0308.

Sensor update: new developments in signal processing
One-day colloquium, 9 September, University of Southampton. Details from Laura Brown, USITT, University of Southampton, Highfield, Southampton SO9 5NH. Tel: 0703 593545; fax: 0703 592738.

1993 European Conference on Power Electronics & Applications
13-16 September, Brighton, UK. Details from IEE Conference Services, IEE, Savoy Place, London WC2R 0BL. Tel: 071 240 1871, ext 222. Fax: 071 497 3633.

Risk management & protection of the environment
IWEM Young Members' Study Tour, 13-17 September, University of Warwick. Details from The Conference Manager, IWEM, 15 John Street, London WC1N 2EB.

DEGREE DAYS: APRIL 1993

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)

 Because different observing stations are used, the figures given here will not necessarily agree exactly with those from other information providers.

INSTITUTE OF ENERGY CONFERENCES

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

How Climate Change Will Change Your Business

Government Strategy & Practical Responses

7 July 1993, London

in association with ETSU on behalf of the Department of Trade and Industry

Speakers include: The Secretary of State for the Environment; Professor James Harrison, Institute of Energy; Peter Bach, Ministry of Energy, Denmark; John Collins, Advisory Committee on Business & The Environment; George Barrett, Environmental Adviser, PowerGen; Dr Kevin Brown, Director, ETSU; Professor Peter Jones, University of Westminster; Paul Davidson, BRECSU; Andrew Warren, Association for the Conservation of Energy.

First International Conference on

Combustion & Emissions Control

21-22 September 1993, Cardiff

Keynote speeches from international figures will precede contributions on the following subject areas: Boilers and Furnaces, Emissions Reduction — Gas & Oil Systems, Emissions Reduction — Solid Fuels, Waste Utilisation and Combined Cycle Power Generation.

Making Energy Privatisation Work

The Future of Regulation

17 November 1993, London

Speakers include: Tim Eggar MP, Minister for Energy; Professor James Harrison, Institute of Energy; Professor Nigel Lucas, Imperial College; John Baker, National Power plc; Malcolm Chatwin, Yorkshire Electricity Group, plc; David Jefferies, National Grid Company plc; Cedric Brown, British Gas plc; Alan Marshall, AGAS; Lady Wilcox, National Consumers' Council; Ian Blakey, British Iron and Steel Producers Association; OFGAS speaker to be advised; Richard Caborn MP, Trade & Industry Select Committee. Conference Chairmen: Mr Ian Powe, Gas Consumers' Council and Professor Nigel Lucas, Imperial College.

2nd International Conference on

Ceramics in Energy Applications

April 1994, London

CALL FOR PAPERS

(closing date 30 July 1993)

The conference will consider material solutions to new and existing applications of interest to energy suppliers and users. Important aspects of materials innovation in energy saving will be explored. We would welcome the submission of abstracts on the following areas: New Developments & Applications; Energy Saving & Heat Transfer; Evaluation & Performance; Power Generation; Sensors & Catalysts; Energy Efficiency. For further information please contact Judith Higgins on 071-580 0008.

Events Co-Sponsored by The Institute of Energy

8 December 1993, Loughborough

Process Combustion Controls & Instrumentation

Contact: David Suthers, Combustion Engineering Association, tel: 0685 879119; fax: 0685 878104

January 1994, Calcutta, India

Combined Cycle Power Generation

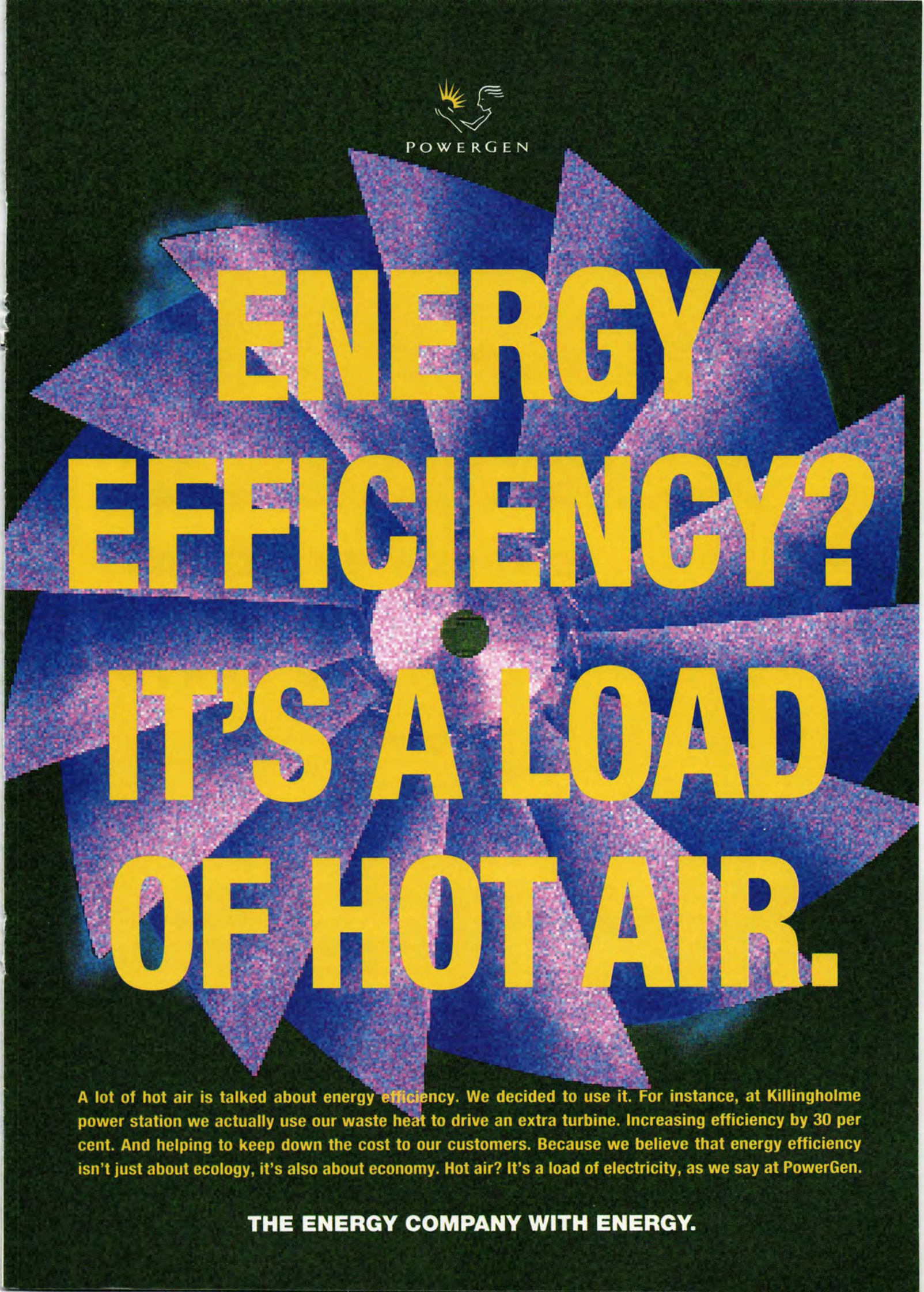
First International Conference on

General Enquiries should be directed to:

Professor Prabir Basu, Technical University of Nova Scotia, PO Box 1000, Halifax,
Nova Scotia, Canada B3J 2X4, Tel: 1-902-420 7531

Paper Co-ordinator for the submission of abstracts from European Countries:

Dr J R Howard, Tel: 44-21-705 1946


POWERGEN
ENERGY EFFICIENCY?
IT'S A LOAD OF HOT AIR.
A lot of hot air is talked about energy efficiency. We decided to use it. For instance, at Killingholme power station we actually use our waste heat to drive an extra turbine. Increasing efficiency by 30 per cent. And helping to keep down the cost to our customers. Because we believe that energy efficiency isn't just about ecology, it's also about economy. Hot air? It's a load of electricity, as we say at PowerGen.
THE ENERGY COMPANY WITH ENERGY.

ENERGY EFFICIENT SOLUTIONS THAT DON'T COST THE EARTH

Most organisations would like to reduce energy consumption. This is not only cost effective, but also benefits our environment.

However, many energy efficient solutions are an additional burden on managers' resources. That's where our expertise in Energy Management comes in, to let you concentrate on your core activities.

Typically consumption can be reduced by 25 – 50%; capital costs are funded by us; participation in bulk purchasing cuts the fuel price; the working environment improves; and your overall energy and operational costs go down. The pay back is swift.

Who can benefit? Industry, office users, hoteliers, hospitals, government, local authorities, schools ... and probably you.

To know more about cost effective, energy efficient solutions, please post the coupon to: Ed Wilson, AHS Emstar Plc, Elizabeth House, 56/60 London Road, Staines, Middlesex TW18 4BQ or telephone: 0784 458431.

I would like more information about cost effective, energy efficient solutions.

NAME .....

JOB TITLE .....

COMPANY NAME .....

ADDRESS .....

.....

.....

POSTCODE ..... TEL NO .....

NUMBER OF EMPLOYEES (PLEASE TICK BOX)

0 – 50 ☐ 51 – 100 ☐ 101 – 250 ☐ 251+ ☐

EW.6.93

AHS emstar

Leading the way in Energy Management