ENERGY WORLD

The magazine of The Institute of Energy

Number 222
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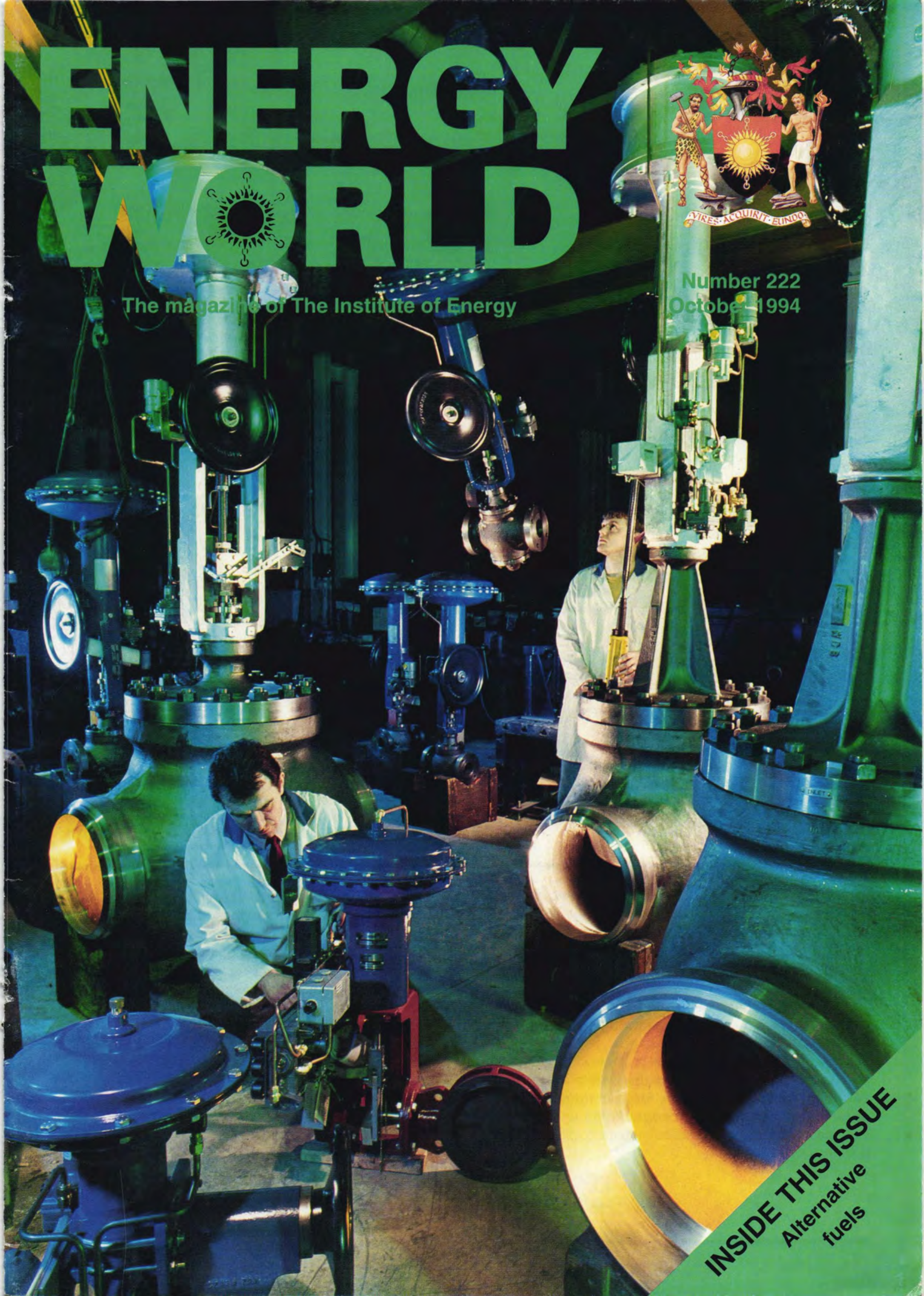

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Alternative fuels

Your invitation to

An Institute of Energy Conference

INTERNATIONALISATION

Power & Energy Services

THE BUSINESS OPPORTUNITIES FOR UK COMPANIES

Organised by The Institute of Energy *in association with*

Department of Trade and Industry | The Institution of Gas Engineers | Parliamentary Group for Energy Studies | BEAMA

The Speakers:

David Jefferies CBE, Chairman, **The National Grid Co plc**

Tim Eggar MP, Minister for Industry and Energy

Edmund Wallis, Chief Executive, **PowerGen plc**

Cedric Brown FEng, Chief Executive, **British Gas plc**

Bryan Townsend CBE, Chairman, **Midlands Electricity plc**

Graham Hadley, Managing Director, International Business Development, **National Power plc**

Douglas Ebdon Director of Operations, **Global Gas**

Bernard Dewe Mathews Senior Director, **J Henry Schroder Wagg & Co Ltd**

Sir Alan Cockshaw, Chairman, Overseas Project Board

Dr Terence Harrison, Chief Executive, **Rolls-Royce plc**

John F Hood Managing Director, **Weir Pumps Ltd**

Peter Hensman, Managing Director, **Gilbert Gilkes & Gordon**

John Cull, Development Director, **AMEC Mechanical & Electrical Services Ltd**

Graham Atkinson, Head of Projects, Export Division 2, **DTI.**

Increasingly UK energy utilities are moving into overseas markets. A direct result of the restructuring and privatisation experience in the UK and the effect of regulatory constraints and competition on the main business at home.

The world industrial power market has expanded rapidly in recent years offering exciting new prospects for independent power projects overseas. Utilities are actively developing international projects in collaboration and partnership with ***financiers, providers of power plant, engineering concerns, instrumentation and equipment manufacturers, consultants and energy service companies***, to take advantage of these new business opportunities.

This important conference will specifically consider the new prospects for suppliers to the industrial power market. There will be strong emphasis on practical issues with key players discussing their own experience and future plans. Demonstrating how going international not only offers tremendous benefits to individual businesses but also to UK plc.

For further details please contact:
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Thursday 1 December 1994

The Café Royal, 68 Regent Street, London W1.

See booking form, centre pages

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CONTENTS

COVER

This month's front cover picture shows process valves for oil systems and turbine duties at a combined cycle gas turbine (CCGT) power station. The valves were produced by the Blakeborough Control Valve Division of Hopkinsons Ltd — a member of the Weir Group.

Management buy-outs in the energy sector

THE PRIVATISATION of the coal industry has provided the first substantial opportunity for management buy-outs in the energy sector. Privatisation of gas and electricity by way of the creation and flotation of public companies afforded no scope for smaller-scale management or employee-led businesses in these sectors. The emerging independent suppliers in those industries are currently investing for future growth and have not thus reached the maturity necessary to make an MBO viable for management or attractive to venture capital backers. The oil and gas industry is traditionally vertically integrated from exploration to the filling station — not the type of diversified group structures likely to contain 'non-core' or self-sufficient businesses ripe for MBOs. Because of the capital-intensive nature of the energy sector, the acquisition of business in this sector will be a costly one requiring investors with deep pockets to back the management team.

The Government's determination to break up the coal industry, first by way of lease-licensing of closed pits and now by offering British Coal's mainstream businesses in five regional parts, and its subsidiaries by separate sales, has sparked substantial interest in the venture capital industry looking to back management teams.

As with any management buy-out the venture capital-backed management teams bidding for parts of the coal industry must compete for the prizes against purchasers who are already substantial industrial operations. Even the Government's stated desire to see employee participation in the privatised coal industry will not give the management team a favoured position in the bidding.

What is a management buy-out? The venture capital industry is rife with jargon: MBO, MBI, BIMBO, MEBO. These are all variations on a theme.

An MBO involves two separate aspects. First, a new company ('Newco') is formed. Both the management of the target business and their venture capital backers invest money in Newco by subscribing for shares. A bank may also lend money to Newco. Then Newco uses the money to negotiate the acquisition of the target business from the seller.

An MBI ('management buy-in') has the same structure, but the management who invest in Newco will be new people, not previously connected with the management of the target company, who are brought in because existing management are not available or are not satisfactory to the venture capital investors. A BIMBO is a linguistically-contorted combination — buy-in management buy-out — involving some existing management and some new management brought in from outside. A MEBO is a buy-out by management, together with a substantial investment by employees ('management and employee buy-out'). MEBOs are often popular for public sector buy-outs.

What is the venture capital investor looking for? The single most important factor will be the quality of the management. While top quality management cannot guarantee success it is certainly true that even in the most favourable economic times poor quality management is a fair guarantee of failure. Depending upon the stage of the economic cycle, the venture capital investor will be prepared and able to include more or less 'leverage' or loan financing. The recent recession has concentrated the minds of most venture capital investors on sustainable cashflow. Unless a good cashflow can be demonstrably sustainable over the life of the investment, it is unlikely that a venture capital investor will be interested in the opportunity.

Although there are exceptions, for the most part venture capital investors are not there for the long term. Even long-term venture capital investors, such as the recently floated 3i plc, do expect to exit from the investment in three to five years if possible. A steady flow of dividends is not usually sufficient to appeal to a venture capital investor. Venture capital investors are themselves answerable to their own investors, usually pension funds and insurance companies as well as the individuals who will want to see a capital return. Energy sector businesses may not lend themselves to this rapid growth rate and capital return value.

Prior to coal privatisation, energy sector buy-outs had been few and far between. One of these few was the £20m MEBO of Coolkeeragh power station in N Ireland, which took place in April 1992. It was backed by 3i, Prudential Venture Managers and Ulster Bank, all of them known to be prepared to take a medium to long-term view of their investments. Around the same time R J Budge Mining was bought out from the family company A F Budge for £102m, with backing from Schroder Ventures, Montagu Private Equity, Charterhouse Development Capital and Prudential Venture Managers, all but Schroders being 'captive' funds. Success came swiftly for RJB with a flotation just over a year. Now RJB has put in bids for all five of the regions being offered for sale by British Coal.

The coal privatisation has spawned interest from no less than three MEBO teams. Celtic Energy, backed by Charterhouse is bidding for BC's South Wales operations. English Coal, led by BC's opencast director and finance director with venture capital backing are bidding for all three English regions. And Northern Coal, another venture capital backed buy-out led by the BC Northern Group director, is bidding for the Central North region.

In addition to the MEBO teams, Coal Investments, the quoted company run by BC's former marketing director, is making a joint bid for the two Central regions with the Union of Democratic Mineworkers, which suggests that if successful, there will be substantial employee participation. One of BC's major subsidiaries, Coal Products Ltd, is expected to be the subject of a MEBO bid. Other MEBO teams may come forward as British Coal's other subsidiaries come up for sale during the privatisation process.

One venture capital-backed coal industry MBO is already up and running. Hatfield Colliery, one of BC's closed pits near Doncaster, was reopened after an MBO by the former colliery manager, backed by ECI Ventures, was successful in the lease-license tender in June of this year.

Only one non-coal related MBO has surfaced recently and that was the £41.5m BIMBO of Charrington Fuels from Anglo United which took place in March 1994. It was backed by a group of venture capital investors, including 3i, Apax, NatWest Ventures and Foreign & Colonial.

The venture capital industry has discovered the energy sector, thanks largely to the coal privatisation. It is more than likely that they will look for further opportunities in the energy sector now their appetite has been whetted. Will they find these opportunities?

Lynn McCaw
Partner, Nabarro Nathanson

Gold medals presented by Amir of Bahrain

HIS Highness Shaik Isa Bin Salman Al-Khalifa, the Amir of the State of Bahrain, generously provided six gold medals, awarded to five outstanding scientists.

The awards, presented in September, were for contributions to promoting science, technology and education in the field of renewable energy, and for the recipients' active involvement in the World Renewable Energy Network. The presentation was made by H E Karim Ibrahim Al Shakar, the Ambassador of Bahrain at the World Renewable Energy Congress in Reading.

The Amir of Bahrain has done much to promote education in Bahrain. He opened the Gulf Technical College in 1968 and the University College of Bahrain in 1978. The two colleges merged to form the University of Bahrain in 1987, when His Highness became the Patron of the University's Higher Council. He also established a Chair at the University in the field of energy, and donated a generous prize for the best energy research presented at the International Energy Conference in Seoul last year.

The World Renewable Energy Network (WREN) was formed after a congress held two years ago. The network now has a membership of 105 in over 70 countries.

The Prime Minister of India, Narashimha Rao is pictured above, laying a foundation stone at the site of an Indo-British joint venture to build a £1.2 billion independent power project. The ceremony marked the progress achieved in the development of the coal-fired plant by Ashok Leyland, a company of the Hinduja Group, and National Power. The need for the 1000 MW plant was established by the Andhra Pradesh State Electricity Board, and given priority by the Indian Government. Subject to all the necessary agreements and approvals being concluded, work is planned to start in 1996, and the plant should be producing power in 1998, fuelled by coal from India's Talcher coalfield.

Cross-party group visits Venezuela

TRADE relations were the major topic of conversation on a recent visit by a cross-party parliamentary group from the UK to Venezuela.

The cross-party group consisted of six British MPs: three Conservatives and three Labour members. Dr Michael Clark, chairman of the Energy Studies All Party Group and member of the Trade and Industry Select Committee was accompanied by his Conservative colleagues, Roy Thomason, a member of the Environment Select Committee and Matthew Banks, chairman of the British-Venezuelan Parliamentary Group. Martin O'Neill, Labour's shadow energy minister was accompanied by Rhodri Morgan, shadow spokesman for Wales, with responsibility for energy and the environment; and George Foulkes, joint vice-chairman of the British-Venezuelan Parliamentary Group and of the Latin American Parliamentary Group.

The party met Venezuelan ministers of foreign affairs and energy in the Venezuelan Parliament in Caracas. They also visited installations of Petroleos de Venezuela (PDVSA), the state-owned company which co-ordinates the energy industries, and whose UK company markets Orimulsion.

Horizontal oil well in S Louisiana a success

AN OIL well, located approximately 40 miles south of New Orleans in the Bay of Chene Field, marks the first successful horizontal well drilled onshore by Texaco in South Louisiana.

Texaco Exploration and Production Inc (TEPI) has had previous successes with horizontal oil wells in the Gulf of Mexico and in the fractured Austin Chalk carbonate trend in Texas. The well also utilises Texaco's horizontal well technology to recover additional reserves from mature water drive reservoirs.

The well currently produces 1100 bpd of 29 gravity crude oil and no water. Maximum flow rate during reservoir pressure analysis and testing was 1480 bpd using a 11/64 inch choke with 800 pounds of flowing tubing pressure.

The Bay de Chene Field, located in Jefferson and Lafourche Parishes, was discovered by Texaco in 1941. The field has produced a total of 99 m barrels of oil and 146 bn cubic feet of natural gas. The completion has a 517-foot single lateral with a measured depth of 6260 ft and a true vertical depth of 5080 ft. The well was directly drilled with nine and five eighths inch casing set in the top of the sand at 5679 ft measured depth at 86.5 degrees. The horizontal section was drilled out from the casing and completed with a seven-inch slotted liner with a five-inch prepacked screen and a half inch production tubing.

Gas supply agreement

THE governments of the Sultanate of Oman and the Republic of India announced in September the signing of an agreement on principal terms regarding long-term gas supply. Oman Oil Company Ltd, which is responsible for performance of Oman's obligations on this project, is also party to thew agreement. The Oman Minister of Petroleum and Minerals commented:"Considering the energy requirements of the Indian subcontinent, a gas pipeline is the obvious way to deliver clean energy in a secure way."

British Gas's new Gas Research Centre opened earlier this summer.. The centre represents a £100 million investment in research and technology, and is fundamental to the company's development plans. The official opening was attended by President of the Board of Trade, Michael Heseltine (above, centre). BG chairman Richard Giordano appears to the right of the picture.
Work currently being undertaken at the centre includes research on metering, CHP, natural gas vehicles and the recovery of oil and gas. Construction of the complex (pictured below) began in July 1990. A 22-acre science and business park is planned for the adjacent site.

UKAMRA launched

THE UK Automatic Meter Reading Association (UKAMRA) was launched in London in June.

Among the Association's objectives are to promote understanding of technical and economic issues relating to the intelligent, automatic or remote reading systems for UK utilities' meters, and the corresponding interfaces with customer service and billing systems.

The Association will also provide a forum for communication amongst members and other organisations, such as government, regulators, standard-making bodies and utility customers.

The Association already has a membership in excess of 80, comprising representatives from most of the large utilities, meter manufacturers, trade associations and other interested companies and individuals.

Back from the brink —Silverdale and Hem Heath collieries re-opened by Coal Investments

TWO collieries brought back from the brink of extinction have been re-opened and dedicated to search for new, wider markets which could ensure their continued survival while their 100 years+ reserves last.

Silverdale and Hem Heath collieries — neighbours at Newcastle-under-Lyme and Stoke-on-Trent — have been given official re-opening ceremonies by their new operator, Coal Investments plc. Miners working at the pits were told in detail of the mining and marketing strategies being employed.

Coal Investments chairman and chief executive, Malcolm Edwards, told them the upheavals in the industry of the past two years had thrown up unexpected opportunities. "We now have a chance to try running the business in very different ways. In the past, divisions between the owners and workers dominated the British coal industry. But now, everyone working for Coal Investments' collieries having so obviously the same interest, the simplest way of escaping from the past is for the employees to become part owners of the business."

He outlined the scheme by which colliery workers will have a direct stake in the fortunes of their pits. The Inland Revenue had approved an Employee Share Ownership Plan (ESOP) which would allocate blocks of shares to mineworkers, giving them equal status with other shareholders in the company. The employee-shareholders will be able to elect representatives to seats on the boards of the local subsidiary colliery companies.

Mr Edwards said that Coal Investments was also looking at the introduction of a profit-related pay scheme in the near future.

The company's management policy was to move away from elaborate hierarchies and operate with minimal layers between the coal face and top management. "Throughout the company our philosophy is: choose the right man, give him the responsibility for his own job, acknowledge his ability, and he will make his full contribution to the benefit of everyone in the business knowing that it will be fully recognised and that he will share in the rewards," Mr Edwards said.

Between them, Silverdale and Hem Heath will employ about 300 men on permanent engagement on contracts reflecting their enhanced status as participants in the company's business.

Both collieries were heavily dependent on the electricity generating market. When the market began to shrink alarmingly in 1991/92 the writing was on the wall and closures became unavoidable. "But we plan to sell our entire production to other markets — in particular industrial processes and space heating, commercial and local authority markets, and of course, the domestic market," says Mr Edwards.

"Since the massive closure programme affecting 31 pits, the door has been opened to foreign imports to supply the deficiencies in home supply.We are making a new range of products available by producing much more large coal to meet the needs of a broad spectrum of customers. It is our intention to re-capture those markets for home-produced coal."

Although the two pits will employ only a quarter of the former workforce, output will be about half the historic rate of production. Continuous miner machines, widely used in the US and Australia will operate room and pillar systems. Roof bolting will be the major form of roof support. "With our changed working systems and the new kinds of management, we envisage an output per man year of 3000 tonnes, compared with the current British Coal rate of 1900 tonnes," said Mr Edwards.

Prosecution after incident at Wylfa

THE Health and Safety Executive (HSE) is prosecuting Nuclear Electric following an incident at Wylfa nuclear power station on the island of Anglesey in North Wales on 31 July 1993.

It is alleged that in failing to provide an adequate fuelling machine 'parasol grab' at Reactor 1, and in continuing to operate Reactor 1 after the loss of part of the grab, Nuclear Electric failed to ensure that their employees were not exposed to risks to their health or safety, contrary to Section 2 (1) of the Health and Safety at Work Act 1974.

It is also alleged that, similarly, Nuclear Electric failed to ensure that persons not in their employment were not exposed to risks to their health and safety, contrary to Section 3(1) of the Act.

It is not, however, alleged that anyone was exposed to actual danger during this incident, only that Nuclear Electric did not take all reasonable practicable steps to ensure that any risk of danger was averted.

The case is due to be heard in Gwynedd on 21 October.

● The Nuclear Installations Inspectorate (NII) of the Health and Safety Executive has granted consent for Nuclear Electric to commence loading fuel into the pressurised water reactor (PWR) at Sizewell B nuclear power station.

Adjacent to the Sizewell A Magnox power station, near Leiston, Suffolk, Sizewell B is the first PWR to be constructed in the UK for commercial power generation.

Following a lengthy public inquiry, NII acting on behalf of the HSE, granted a nuclear site licence in 1987 for construction of the plant. One of the conditions attached specified that consent would be required from NII before the first fuel load could take place.

Beyond fuel load, NE will have to obtain further consents from NII to take the reactor progressively up to full power.

ETSU's energetic approach

ETSU'S WIDE ranging expertise on energy, transport and coal, as well as environmental and technology transfer has risen to the challenge of Europe. As one of the first UK organisations chosen by the EC's Directorate General for Energy to help promote energy technologies in Europe, has won a new contract to continue its work in the EU.

In its three years as an Organisation g for the Promotion of Energy Technologies (OPET), working on behalf of the Commission, ETSU has successfully managed a number of promotional initiatives, including seminars, workshops, study tours and training courses, aimed at senior personnel from former Eastern Bloc countries, in cooperation with industry and trade associations.

As part of its new contract ETSU is planning a study tour in cooperation with the Combined Heat and Power Association (CHPA), an international wood fuel conference and several energy-based transport initiatives.

For more information about the OPET network, contact their office on 0235 433327.

Obstacles to energy efficiency

FIRMS with clear policies to improve their environmental performance are substituting energy efficiency for other projects in a strategic way.

This was one of the findings of a study, published in September, investigating the barriers to energy efficiency investment. Industry and commerce appear to assign low priority to retrofit energy efficiency projects, with the result that many cost effective opportunities to save energy are not properly evaluated, and even fewer implemented. Commenting on the report, Robert Jones, Minister for Energy Efficiency, said: "I hope companies will realise the importance of these investments ... otherwise business will not play its full part in protecting the environment and saving our planet."

Pioneer Council offers energy efficiency training

HOME energy training courses are to be offered to city workers who visit people's homes in the course of their jobs. The courses are being organised by Leicester City Council's housing department, as part of its pioneering home energy strategy.

Council staff, health visitors, district nurses, social workers, GPs and others will be given the chance to take part in the courses, which are to be run in partnership with De Montfort University.

The courses are designed to give the workers enough knowledge on affordable warmth, energy efficient heating, lighting and ventilation to help them identify problems, offer advice, or refer people to other agencies for help.

Housing renewal manager, Domini Gunn, who is helping to develop the department's home energy strategy said: "Winter will mean higher heating and lighting bills. For some people this will bring the problems of keeping warm and paying expensive fuel bills. I hope the training will arm visitors with valuable knowledge they can pass on to people who most need it."

Development approval for £25 million Sean satellites

CO-VENTURERS in North Sea Block 49/25a: Shell, Esso, BP and Union Texas, have been granted DTI approval for the first stage in the development of a series of 'satellite' gas accumulations in the vicinity of the existing Sean South and Sean North fields in the southern North Sea.

This stage will recover around 130 (billion standard cubic feet) of reserves from a satellite field named East Sean, for sale to the direct market.

Existing Sean fields' production is contracted to British Gas under a 'peak shaving' arrangement to help meet high demand levels during winter months. Appraisal drilling and extensive 3D seismic surveys have proved East Sean is not in communication with the presently producing reservoirs, allowing the sale of gas outside the current contract.

Each of the co-venturers in Block 49/25a have a 25% interest. The operator is Shell UK Exploration and Production. The Shell and Esso share of East Sean is being sold to Quadrant Gas, the Shell/Esso joint venture gas marketing company, while BP and Union Texas are selling gas shares separately to other buyers.

Project investment is in the region of £25 million, mainly on drilling costs and some production facility modifications. First gas is anticipated around the beginning of November, with an initial flow rate of up to 60 million standard cubic feet per day.

Gas will be produced through two extended reach wells drilled from the existing Sean wellhead platforms. The well drifted from the southern platform, Sean PD, was completed at the end of August, having reached 4545 m long and a horizontal distance from the platform of 3359 m. A well from the northern platform, Sean RD, is planned to commence shortly, and will reach 4655 m long, with a horizontal distance from the platform of 2980 m.

Launched this summer, John Bradshaw Ltd's 'Envirovan' is a battery powered inner city delivery vehicle. It has a 50 mile range, and will carry a load of 680 kg at speeds of up to 30 mph. Bradshaw estimates Envirovan's running costs at 50p per day, based on an estimate of plug-in to the mains for overnight charging. The vehicle's speed and range do limit its use to inner city areas, and for this type of application has the added advantage of no emissions at point of use.

The Envirovan relies on 12 six-volt deep-cycle, rechargeable lead-acid batteries for a total of 72V. An on-board battery charger can be used to recharge the battery packs by plugging it into any standard 240V AC power socket. The entire 72V system requires approximately 9.5 hours to fully charge the batteries from an 80% state of discharge. The battery pack provides approximately 1000 recharging cycles before replacement is required, and at a price of less than £1000, this works out at 2p per mile, with an additional 1p per mile recharging cost.

A quiet, emission free 20 hp General Electric motor has been designed for Envirovan. The maximum load, rolling resistance, air drag, tyre size and gear ratio were all taken into account, and motor current was matched to the controller output capacity. Further information is available from John Bradshaw Ltd, Stibbington, Peterborough PE8 6LW. Tel: 0780 782621; fax: 0780 783694.

Detecting the hot spots

A LEADING South African petrochemical company is using fibre optic sensing technology from York Sensors to detect potentially dangerous 'hot spots' in the most critical part of the manufacturing process.

In 1992 Mossgas started producing petrol, diesel and kerosene from gas recovered some 85km offshore from Mossel Bay.

Onshore, a synthetic fuel process converts offshore gas into oil, which is then processed in a standard refinery. The most critical part of the process is known as methane reforming at which stage gas is heated, then reacted with pure oxygen, in a secondary reformer. A catalytic reaction thereafter creates syn-gas, which is subsequently fed into a Fischer Tropsch process which produces oil.

Temperatures in this secondary reformer reach 1200°C. The shell is protected with refractory material but small defects, either material or burner related, can result in the creation of hot spots which, if undetected, could lead to serious damage being caused to the vessel and eventually to a shut down of the process. For monitoring purposes, the reformer is divided into cone and barrel sections. Due to the proximity of the burner, the cone is particularly prone to fast developing hot spots.

The York Distributed Temperature System (DTS) uses opto-electronics to produce continually updated temperature analyses along the entire length of the optical fibre, making it the only cost-effective way to measure temperature over large surface areas or long distances where fixed point devices would be impractical. In addition, as fibre optic cable is EMI proof, and because no electrical currents are used in data transmission, the York DTS is particularly suitable for hazardous environments.

The stainless steel encapsulated sensor cables were laid around the three reformers at the Mossel Bay refinery, and linked to three controlling DTS units and PC's in the central control room.

ABB to build Humber plant

HUMBER Power Ltd had awarded the turnkey contract for its new 750 MW CCGT to ABB.

Construction of the new plant, on the Humber River estuary, in the north-east of England, begins immediately. Completion is scheduled for early 1997. The power station will be equipped with three ABB type GT13E2 gas turbine generating sets and a steam turbo-set operating in a combined cycle configuration.

A key factor in securing the contract was ABB's advanced low NOx EV burners, which give high fuel efficiency and low emissions.

Consolidation

THE MATERIALS Handling Division of Babcock International has announced that all the companies in the Division, including Claudius Peters Group, Consilium and the PHB Someral group of companies, will be consolidated into a single multinational organisation under the name BMH (Babcock Materials Handling).

Rainer Herold, divisional managing director, explains: "Combining our technologies and expertise enables us to offer global competence in a wide spectrum of industries. We now have a virtually unparalleled range of services, from contracting turn-key plants to the supply of advanced systems and world-proven products.

The full resources of the Division are now available through a network of 24 BMH regional companies in 14 countries with representation in a further 40.

In line with the changes, Babcock Materials Handling Ltd, the UK and Eire regional company, will be renamed BMH Ltd. It will continue to be based in Reading under John Scott — formerly UK Business Development Manager — and Stan Pound — formerly financial controller — as joint general managers.

Contract energy — 30 years on

CONTRACT energy is a concept which can mean all things to all people. It has been a generic term used to describe the contracting out of energy services. For the purposes of this article, 'contract energy' is loosely defined as the supply of useful energy (usually in the form of heat, steam or electricity) and may include provision of replacement/additional plant but always includes operation and maintenance services, together with fuel supply.

There is no doubt that the concept does save energy (between five and 33% in the majority of cases) and is regarded by the EC as an important element in the Commission's policy of reducing Europe's energy usage.

In the UK contract energy was pioneered in the mid 1960s by the (then) National Coal Board, who founded Associated Heat Services Ltd (AHS) to provide trouble-free operation for its customers' coal-fired boiler plants. AHS pioneered the concepts of partial manning, alarm monitoring and 'fixed price' fuel contracts.

During the late 1970s and early 1980s the main rivals to AHS's national dominance came into being, including Cofreth, B P Energy, MCL Energy et al. There came subsequently the investment-type organisations, such as Emstar, Inenco and First Energy, whose forte was to fund energy-saving schemes and recover the costs over a term period, or through shared savings agreements, all of which added further dimensions to the basic service. Additionally a number of geographic/sector specific companies proliferated, many of whom were basically the maintenance/service arms of building services contractors.

The contract energy supplier will offer the client a package, usually incorporating energy and cost savings, tailored to the client's needs. This package will include the provision of energy together with any scheme designed to produce energy savings.

The overall benefits to the client are:

- financial savings in the order of five to 25% net;
- provision of capital for any scheme put forward by the supplier;
- transference of commercial and technical risk;
- no direct input of management time required;
- and, of course, convenience.

Market size for 1993 as estimated by Enterprise Consulting was £120 million pa, and was dominated by AHS Emstar, although several major players are making inroads into the rapidly developing market. There have been estimates from various sources for current market potential, ranging from £1 to £4 billion — indeed the major competitor to contract energy suppliers on many occasions is the in-house operation.

The market is changing rapidly, with the provision of capital projects becoming increasingly important, particularly in the case of cogeneration schemes. Increased interest in the sector has been shown by the RECs. It is likely that existing major players will continue to grow strongly and profitably for some years to come given the market potential and relative importance of fuel as a resource. Other major players may be tempted to join the market over the next few years, although the potential to do so using an existing market supplier as a vehicle has been considerably reduced by recent consolidations in the industry.

Oranges ARE the only fruit

A 'GREEN' solvent, made from waste orange peel, could be the answer to a major source of river pollution.

'Pronatur' will clean hydrocarbon deposits from any surface, and the resulting 'soup' is safe enough to discharge straight into rivers, without fear of comeback from the National Rivers Authority.

The range of solvents are made from a blend of natural oils squeezed from waste orange peel, and they are so safe that they can even be used to clean human skin.

Depending on whether the oily contamination is to be cleaned up in water or on porous solid surfaces, Pronatur Orange Solvent or Pronatur Aqueous Solvent would be used to make the mineral hydrocarbon residues collectible or accessible. Following the application of the appropriate solvent, the Pronatur Oily Water kit is used. This dual-package product is composed of a culture of specially selected, naturally occurring micro organisms and an activating catalyst. The micro organisms are bacteria which utilise mineral hydrocarbons as a food source, and convert them into CO_2 and water. The bacteria are dormant in liquid form until combined with the Pronatur catalyst and water. They become active and multiply exponentially until the food source is exhausted, at which point they die. The dead cells then become a food source for other naturally occurring bacteria.

Over and above the environmental advantages the Pronatur environmental management system has other benefits, such as vastly reducing the cost of clean-up operations. Director of Pronatur, Paul Richardson estimates that a clean-up project costing around £20 000 can be reduced to as little as £2000.

In scientific terms the solvent is nothing new, but because of the length of time involved in the process, it was commercially unviable, and it is this where Pronatur's 'catalyst' comes in.

A 'DIY' solution, Pronatur does not require any form of protective clothing, with a minimum of training.

British Rail have recently concluded a study of the product with very pleasing results. Pronatur also has received approval from PowerGen, Nuclear Electric, Scottish Power and Eastern Electricity, among others.

Further details are available from Pronatur Products Ltd, Orrell Mount Industrial Estate, Hawthorne Road, Bootle, Liverpool L20 6NS. Tel: 051 933 2282; fax: 051 933 2210

Green shoots boost NEMEX

THERE are positive signs that recovery is on the way for the energy management industry. NEMEX, the UK and Europe's leading energy management exhibition is the biggest it has ever been.

Dr Glenn Brookes of Energy Systems Trade Association (ESTA), who organise the event, is optimistic about the future of energy management: "The Industry has come through the recent recession reasonably intact, and there are clear signs that investment in energy efficiency is now on the upturn. We expect NEMEX '94 will provide the platform for the most prestigious displays ever mounted. Visitors will be able to see how to improve their own market positions, and respond to environmental pressures and impending legislation. Companies want to be seen to be green, and if this can be achieved at the same time as becoming more efficient, so mush the better!"

On display will be an extensive range of products, services, and management techniques designed to improve energy and facilities utilisation, and assist with energy purchasing decisions, including power suppliers, metering and monitoring equipment, building management systems, lighting controls, CHP, efficient heating, boilers, software, consultancy, financial services and much more.

NEMEX '94 will be held at the Birmingham Metropole Exhibition and Conference Centre, NEC on 29 and 30 November. Fur further information call the organisers, ESTA on 0453 886776 of fax: 0453 885226.

Alternative transport fuels

by Roger Green MSc PhD CEng MInstE FIPENZ
and Steve Pearce BE(Hons)

The first of two articles on alterative transport fuels by Roger Green and Steve Pearce of the University of Canterbury in New Zealand, deals with gaseous fuels. The second article is concerned with liquid fuels, and will appear in the November issue of *Energy World*.

THE WORLD'S transportation system is virtually totally dependent on petroleum-based fuels: a resource that is finite and whose reserves are diminishing. The oil crisis of the 1970s and the increased awareness of the adverse environmental effects of exhaust emissions has provided the developed world with the motivation necessary to explore the possibilities offered by various alternative transport fuels. In addition, the developing nations of the world are also interested in such alternative transport fuels. Such fuels may allow these countries to become partially self sufficient in transport fuels and hence reduce the enormous cost burden they face by importing crude or refined petroleum products.

This article will investigate the alternative gaseous fuels which are currently recognised as being the most likely fuels of the future. Their performance will be compared, where appropriate, to the conventional hydrocarbon fuels, petrol and diesel fuels, used in spark ignition and compression ignition engines respectively.

Alternative fuelling may be achieved by converting an existing engine to operate on an alternative fuel only, or by allowing it to operate on either the original fuel and the alternative fuels. This latter process is known as 'dual fuelling'. Alternatively, rather than converting an existing engine to an alternative fuel, an engine may be specifically designed for alternative fuelling by a motor manufacturer. Generally speaking a specially designed engine will offer superior performance than that achieveable by the addition of a retrofit kit to an existing engine.

Gaseous fuels generally offer cleaner burning combustion due to improved fuel-air mixture preparation and a higher hydrogen to carbon ratio than is found in conventional liquid fuels. Reciprocating engines are normally converted to gas operation by means of a gas carburettor sited at the inlet manifold. An engine may be operated as a dedicated gas engine or, more commonly, as a dual fuel engine. A major drawback when operating an engine on gas is a decrease in in-cylinder air since a gaseous fuel displaces a higher percentage of air than a liquid fuel. This reduction in air flow to an engine will normally result in reduced power output. Changes in engine management procedures, such as ignition timing alterations, are often required if the engine is to operate at an optimum condition.

The alternative gaseous fuels that are currently either in use and/or under investigation are: natural gas; biogas; liquid petroleum gas (LPG) and hydrogen.

Natural gas

Composed mainly of methane (typically 80-95%), natural gas also contains carbon dioxide, ethane and propane, depending on the particular gas field of origin. Natural gas has for some years been widely used as an alternative fuel in spark ignition engines and to a lesser extent in diesel engines.

Methane has a high octane number which reflects a good resistance to auto-ignition (knocking) under high combustion temperatures and pressures. As a consequence, when fuelling a vehicle on natural gas, the compression ratio may be increased from that of a petrol engine, at approximately 9:1, up to 15:1. This will increase both an engine's

Table 1: Selected properties of gaseous fuels

Fuel:	Petrol	Diesel	Methane	LPG	Hydrogen
Energy density MJ/kg*	44.5	42.5	50	46	120
Specific density (kg/m^3)	700	840	0.65	540	0.084
Octane number (RON)	90-100	10	130	110	high
Stoich. air fuel ratio (kg/kg)	14.6	14.5	25	15.5	34.3
Volume of air displaced by fuel for stoich. combustion (%)	1.76	2	9.48	4	29.53
Laminar flame speeds (stoich) (cm/sec)	37-43	-	37-45	42	265-325
Autoignition temp K	501-744	520	813	450	858

*Lower calorific value given   Note: properties may vary according to composition and temperature power output and thermal efficiency.

The heat released by the combustion of a stoichiometric, or chemically correct, mixture of natural gas and air is similar to that of a petrol-air mixture. However natural gas displaces approximately 10% of the in-cylinder air compared to about 1% for petrol. The power output of a natural gas fuelled engine is therefore reduced by nearly 10%.

An engine's power loss may be overcome by taking advantage of the higher octane rating and operating at higher compression ratios, although this adds to the cost and complexity of conversion of an existing engine to natural gas. Factory produced, dedicated, natural gas engines are the only ones likely to operate at the maximum possible compression ratios. The power loss may be overcome without increasing the compression ratio by direct injection of the gas into the cylinder after the closure of the inlet valve. This method is mainly at a research stage and the increased levels of hydrocarbon emissions resulting from this approach.

Natural gas exhibits lower flame speeds when compared to conventional fuels, especially under lean operating conditions. In a converted engine it is therefore necessary to advance the ignition timing by approximately 10 degrees in order to optimise engine performance. In factory designed engines the slower flame speed may be overcome by increasing turbulence levels and reducing flame travel within the combustion chamber.

Natural gas, being a gaseous fuel, does not require vaporisation prior to combustion hence cold start fuel enrichment is not required and pollutant emissions are reduced. Overall a natural gas fuelled engine offers lower emissions of CO and HC. NOx may be greater, but may be controlled by employing either a catalytic converter or employing lean burn operation. Lean burn operation can be achieved by conventional means or by employing stratified charge techniques. In such a system the air-fuel ratio in the vicinity of the spark plug is rich and this allows easy ignition and good flame growth of the bulk of the in-cylinder mixture which is operated far leaner. This technique is till mainly at the research level for natural gas fuelled engines.

Operating an engine at lean air-fuel ratios has advantages in reducing emissions but also suffers from reduced power output compared to operation at stoichiometric conditions. This is commonly overcome by the use of a turbocharger to increase the mass of air-fuel mixture in the cylinder and produce an increase in power per cycle. In a petrol-fuelled engine, auto ignition of the pre-mixed charge can easily occur when employing a turbocharger and an engine's compression ratio may have to be reduced. Because of the fuel's higher octane rating this is not normally considered a problem when operating on natural gas.

Since natural gas has a high octane number the addition of lead compounds is unnecessary. This further results in even 'cleaner' exhaust gases and associated longer life of engine componentry that is in contact with the exhaust gases.

Compression ignition engine

Diesel engines are designed to operate lean, with between 1.5 and 1.8 at maximum power, in order to minimise the production of smoke and particulate matter. Such engines are therefore suited to lean burn operation on natural gas. Operation at conditions closer to stoichiometry leads to higher combustion temperatures and associated overheating problems, hence most natural gas operated diesel engines use the lean burn approach. There are two major methods for the utilisation of natural gas in compression ignition engines.

The diesel injection equipment is removed and a spark ignition system and a gas carburettor installed. The combustion chamber is also modified to reduce the compression ratio to approximately 12:1. Hence the diesel engine operates effectively as a spark ignition engine. With the diesel injection equipment removed, diesel or dual fuel operation is not possible. With the lowered compression ratio and with previously unthrottled intake air being throttled, engine efficiencies are consequently reduced.

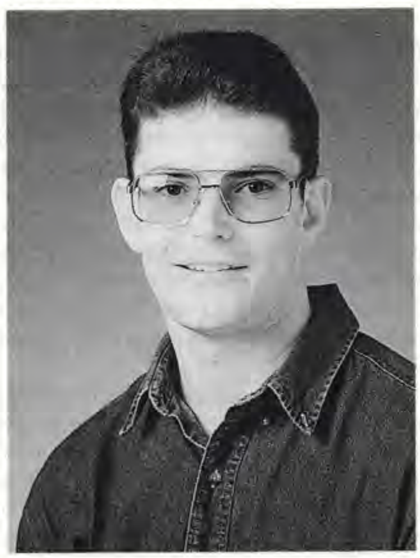
In dual fuel operation, natural gas is fumigated into the intake air to the engine. Late in the compression stroke, a pilot injection of diesel provides the ignition source for the natural gas-air mixture in the cylinder. The engine is normally set to idle on diesel fuel only, with natural gas being added in greater quantities as increased power is required. The maximum level of substitution of diesel fuel with natural gas is approximately 90%. The main advantage of using this system is that no major engine modifications are required, only the installation of a gas carburettor at the air intake and the appropriate control system to ensure correct metering of both diesel and gas under all operating conditions. Other advantages offered by this system to ensure correct metering of both diesel and gas under all operating conditions. Other advantages offered by this system are the retention of high power and thermal efficiency, whilst reducing exhaust pollutant levels. This conversion system also retains the capability of operating the engine on 100% diesel fuel. The main drawback is that an infrastructure is necessary in order to provide two independent fuel systems.

When a diesel engine is fuelled on natural gas there is a reduction in particulate emissions that are produced by the engine. In the case of 100% substitution of diesel by natur-

The authors

Roger Green (pictured above) is currently head of the Department of Mechanical Engineering at the University of Canterbury, Christchurch, New Zealand, where he has been working for the past 13 years. He previously held lecturing positions at universities in England and Kenya, and has industrial engineering and research experience in the British gas industry and German automotive industry. He is author of numerous publications related to the combustion of alternative transport fuels, and is presently engaged in research into hydrogen fuelling systems and charge stratification combustion techniques.

Steve Pearce (pictured below) graduated from the University of Canterbury with a First Class Honours degree in Mechanical Engineering in 1993 and is now studying for his doctorate. He is currently working with the Alternative Fuels and Combustion Research Group at the University of Canterbury, where his research interests relate to hydrogen enhanced combustion of low cetane rated alternative diesel fuels.



al gas the particulate level will be zero. In general, at high load conditions when the majority of engine power is being provided by a lean air/fuel mixture of natural gas, the emissions are similar to those of a lean burn spark ignition engine, namely lower HC, NOx and CO.

Natural gas may be stored on board a vehicle in one of two ways: as a high pressure gas or as a liquid. The most common way of storing natural gas is as compressed natural gas or CNG, at pressures of up to 200 bar. Such high pressures are required to ensure that a reasonable energy density, compared to hydrocarbon fuels, is achieved. However the required pressure vessels are excessively heavy so that a weight penalty is imposed on the vehicle. The range of a vehicle operating on natural gas using this technology will normally be less than half of that achievable on petrol. Current research technology has produced cylinders manufactured from high strength composite materials capable of storing gas at pressure up to 300 to 400 bar pressure, reducing both the weight and volume of gas storage. In most countries, however, legislation will have to be approved before such high pressure gas storage can be allowed to operate on the public highway.

Natural gas can be liquified by refrigeration at a temperature down to -160°C and stored cryogenically under moderate pressures as liquified natural gas or LNG. Although such technology is expensive and the necessary infrastructure complex, it will allow a vehicle to operate over a similar range to that provided by petrol. Because of heat leakage into the cryogenic storage vessel, a certain amount of the stored liquid continuously boils off which requires venting to avoid excessive pressure build-up in the storage vessel. A safety problem of how to utilise or dispose of the vented natural gas requires further research and development.

Biogas

Biogas is produced by anaerobic decomposition of organic material most commonly associated with refuse dumps and sewerage works. The composition of raw biogas is typically 60% methane and 40% CO_2. The CO_2 can be scrubbed relatively simply and economically from the raw gas by pressurised water, producing a gas of high purity methane. The chemical composition of this scrubbed biogas is similar to that of natural gas, so the technology that has been previously described for natural gas also applies to scrubbed biogas.

For transport applications scrubbed biogas will provide similar power and vehicle operating range as natural gas. Raw biogas is not normally used for transport since the high percentage of CO_2 in the fuel produces no power and is wasteful of compression energy used in the production of high pressure gases necessary for transport. The raw fuel consequently delivers greatly reduced vehicle operating range. It is however satisfactory of use in stationary engines so long as the reduced power output of the engine is adequate for its intended task.

The production of raw biogas for use as a fuel is especially attractive in remote areas of countries where electricity and diesel supplies are unreliable or nonexistent, not to mention expensive. Here small biogas plants fermenting cattle dung, or similar biomass source, can be used to provide gas for a single or dual fuel diesel generator set. The electricity produced is often used in rural areas due to their relatively high efficiencies, simplicity, reliability and lower fuel costs compared to petrol. In a rural situation, the raw biogas is most commonly utilised in dual fuel diesel engines so in the event of a halt in gas production, the engine will still operate on 100% diesel with no interruption to service.

LPG

Liquified petroleum gas, or LPG, is derived from natural gas and, depending on the source, contains approximately 60% propane and 40% butane. At ambient temperature and pressure, LPG occurs in its gaseous form but can be liquified by compressing to a pressure, above its vapour pressure, or approximately 7 bar. LPG is stored, at this modest pressure, to greatly increase its energy storage density and therefore provide a vehicle with an operating range similar to that provided by petrol. Although stored in its liquid form LPG is supplied to an engine's intake manifold in its gaseous form. Hence conversion equipment and operation of both spark ignition and compression ignition engines is similar to that previously described for natural gas operation.

In a spark ignition engine the recommended compression ratio is between 9:1 and 10.5:1 when fuelled by LPG. This is approximately the same as for petrol, but significantly reduced over the maximum possible compression ratio that may be used when operating on natural gas. For general transport applications vehicles are usually equipped so that they can run on either petrol or LPG by means of a simple solenoid switching system operating between the two fuel lines. This allows for flexibility of operation in situations where LPG may be unavailable.

The major pollutants from the exhaust of an LPG vehicle are substantially lower than those from an equivalent petrol fuelled vehicle, due to excellent mixture formation and burning characteristics of the gaseous fuel. Once again the fuel contains no lead or sulphur compounds so that these cannot appear in the exhaust. The main disadvantages of an LPG fuelled vehicle is slightly lower performance with increased fuel consumption when compared to petrol.

Methods used to fuel diesel engines on LPG are the same as those given in the previous section for natural gas, namely dual fuelling or conversion to spark ignition. Dual fuel operation is knock limited to around 60% LPG substitution.

The storage cylinder although considerably lighter than that required for CNG, because of lower storage pressures, is only filled with liquified gas to approximately 80% of total cylinder volume as the remaining volume is necessary to allow for expansion of gaseous fuel. Hence the storage cylinder is approximately 20% larger than the volume of liquid fuel actually stored.

Hydrogen

Hydrogen is the most common element, but is rarely found in its raw state, H_2. Being a highly reactive element, hydrogen most commonly occurs combined with other elements in the form of hydrides, water, hydrocarbons etc. Hence it is necessary to separate the hydrogen from the source before it can be used, and this requires energy. Hydrogen, once separated, can be used in engines and fuel cells to produce power. Consequently, hydrogen should be considered to be an energy carrier rather than an energy source.

Hydrogen is seen by many to be the fuel of the future. It is considered to be an excellent energy carrier for use in the transportation sector as it can be utilised by all the current modes of transport. When burnt conventionally in air the main product of combustion is water, with NOx the only significant pollutant. Appropriate choice of a lean air-fuel ratio and/or catalytic treatment of the exhaust will render this pollutant to virtually zero. Hence the combustion of hydrogen does not produce other pollutants associated with hydrocarbon fuels, such as CO_2, CO HC and other particulate matter. Furthermore if H_2 is used in a low temperature fuel cell to produce electric power, no measurable pollutants are emitted during the electro-chemical conversion process. The addition of small amounts of hydrogen, in the order of 15%, to natural gas produces a fuel known as 'hythane'. The enhanced combustion properties of hydrogen help overcome the decrease in engine performance when operating only on natural gas. Reductions in exhaust pollutants, 50% or better, have also been recorded.

As well as being almost non-polluting, hydrogen can be produced from almost any primary energy source. The possibility of manufacturing hydrogen from a variety of sustainable energy sources makes a compelling argument for its use as a fuel. Potential sources include wind power, solar power, geothermal power or hydropower.

Engine fuelling systems

Currently there are no commercially available hydrogen fuelled engines, although a number of motor manufacturers have developed, and are testing, prototype units. Although conventional spark ignition and compression ignition engines can be converted to hydrogen operation the dedicated hydrogen engine is likely to be an amalgam of the two. There are several methods that can be used to fuel an engine on hydrogen.

External mixture formation is a method commonly used with CNG or LPG and can also be applied to hydrogen operation. There are however some major disadvantages with this method. Hydrogen has a high specific volume and therefore displaces a large amount of the air normally induced into the engine. This reduces the volumetric efficiency and consequently the power that can be obtained from the engine.

Hydrogen's wide limits of flammability coupled with a very low ignition energy can lead to pre-ignition and backfiring in the inlet manifold. Pre-ignition can occur when a fresh fuel-air mixture charge comes into contact with hot residual gases in the combustion chamber.

The high flame speed of hydrogen combustion promotes a rapid rise in pressure which can result in engine 'knocking'. This phenomena occurs when operating hydrogen engines close on to stoichiometric air/fuel ratios.

Various techniques have been employed to overcome some of these problems, for example, supplying the air and fuel to the inlet valve in an unmixed state and the use of water injection. A recently adopted solution employs a lean burn mixture, > 1.8, to overcome both combustion and NOx emission problems. Turbocharging is used as a means of recovering the power lost when a lean mixture is employed.

In low-pressure injection with internal mixture formation, hydrogen is injected just after the closure of the inlet valve when pressure within the engine cylinder is low. It has the benefit of overcoming the problems of low volumetric efficiency and backfiring but does not solve the problem of pre-ignition or auto-ignition.

This method has the added complexity of direct injection without solving all of the problems. It may however be usefully employed with lean burn combustion.

High-pressure injection of hydrogen occurs late in the compression stroke when the pressure within the combustion chamber is high. Injection pressure will be in the order of 70 to 100 bar. High pressure injection has the advantage that pre-ignition is eliminated and knocking combustion can be controlled.

This method has the potential to provide a fuelling process with the greatest level of flexibility. Developing a valve seat that will give zero leakage of the high pressure hydrogen gas in an engine operating environment over a long period of time could prove to be a challenge for engine designers. Research to date indicates that a compression ratio up to 12:1 may be employed with this technique.

Once the prepared mixture is ready for ignition an appropriate source of energy must be supplied. The most common method is to ignite the hydrogen-air mixture by means of spark ignition although pilot injection of diesel fuel may also be employed.

Storage methods

There are three generally recognised ways to store hydrogen, as a high pressure gas, as a metal hydride or as a liquid.

The storage of hydrogen under high pressure as a gas has the advantage of being able to easily supply high pressure hydrogen to an engine. The major disadvantage with this system is that the current storage systems are very heavy and occupy a large volume to achieve the same operational range as conventionally fuelled vehicles. The future deve4lopment of advanced composite high pressure storage vessels could bring storage volumes and masses down to close to those required for liquid hydrogen storage. However, such a system would be unsuitable for use with the high pressure direct injection method since a pressure of approximately 100 bar would indicate an 'empty' cylinder.

Metal hydride storage systems offer advantages in volume over high pressure gaseous systems but still have a very high mass compared to conventional liquid fuel storage systems. The metal hydride system requires an input of heat in order to release the hydrogen gas from its metal matrix. This heat can be supplied from an engine's hot exhaust gases. Current hydride storage systems are not able to release hydrogen gas at the pressure required for high pressure direct injection.

Liquid hydrogen storage at -253°C provides an equivalent amount of energy with the lowest mass and volume values of any of the hydrogen storage methods. A cryogenic pump is an energy efficient means of compressing liquid hydrogen to a high pressure prior to high pressure gaseous injection into an engine cylinder. It has also been proposed that low temperature hydrogen gas could be used to cool the inlet charge of air in order to improve volumetric efficiencies, reduce NOx emissions and combustion-related problems such as pre-ignition and auto-ignition. An undesirable feature of liquid hydrogen storage is that a small percentage of the liquid continuously boils off due to heat transfer into the storage vessel. Unless this hydrogen is carefully vented, or transformed into a safe energy form, it presents a potential hazard. The cost of liquefaction is considerable and this is a major factor when considering the use of a liquid storage system. ❑

CHP at De Montfort University

by Dr Philip Few CEng FIMechE FInstE
*and Mark Connell BEng**

THE NEW Queen's Building at De Montfort University now houses the school of engineering and manufacture. It is one of the largest naturally ventilated buildings in Europe and could become a seminal example of a flexible and environmentally friendly building. In addition, the new building will serve as a tool for improving energy conservation.

This article reviews the role of a combined heat and power system on the Queen's Building. The assessment is based around the theoretical energy requirements of the building and information from the building management computer. This work was the subject of a final year project for BEng (Eng Tech) students, and further highlights the new building as a source of learning for those students with a special interest in energy-related topics.

Heating

The theoretical heating requirements for the Queen's Building were calculated on a zoning basis, using empirical and factual data. Each part of the building is used for a different purpose, and factors such as occupancy and heat gain vary. Five zones were identified as follows:

Zones one and two — electrical laboratories which project from the main building.

Zone three — the main building has a unique geometric shape, which forms a single zone, together with the computer node.

Zone four — auditoria — separate from the rest of the building. The ventilation air is drawn from outside and expelled through ventilation stacks.

Zone five — mechanical laboratory: separate from rest of building and having unique occupancy.

Empirical data
hot water requirements
ventilation loss
u valves

Factual data (measured from the building)
air volume heated
hot water requirement
occupancy

**De Montfort University, Leicester*

Following his article *Test facility for Energy Studies* published in the October 1993 edition of *Energy World*, Dr Few elaborates on the role of the new engineering building at De Montfort University, reviewing the CHP system for the University's Queens Building.

fabric heat loss
thermal gain from computers
thermal gain from lighting & OH projectors

Electrical

The average electrical requirement of the Queen's Building will be reasonably constant except during the vacation periods where the load will fall to that required for academic and research staff. This requirement was estimated by using the information relating to lighting, OH projectors and computers.

The complete installed heating plant was considered so as to establish the relevance of CHP. The Queen's Building is heated by means of a CHP package, a condensing boiler and two conventional boilers, in that order of firing, with the conventional boilers on alternate operation. Hot water is generated by two calorifiers. As long as there is a large enough demand for heat and electrical power, the CHP package will take the lead

In practice the actual demands on the building heating and electrical systems may be different from initial predictions. The following parameters were chosen to assess the building performance: heating water, gas consumption and electricity consumption.

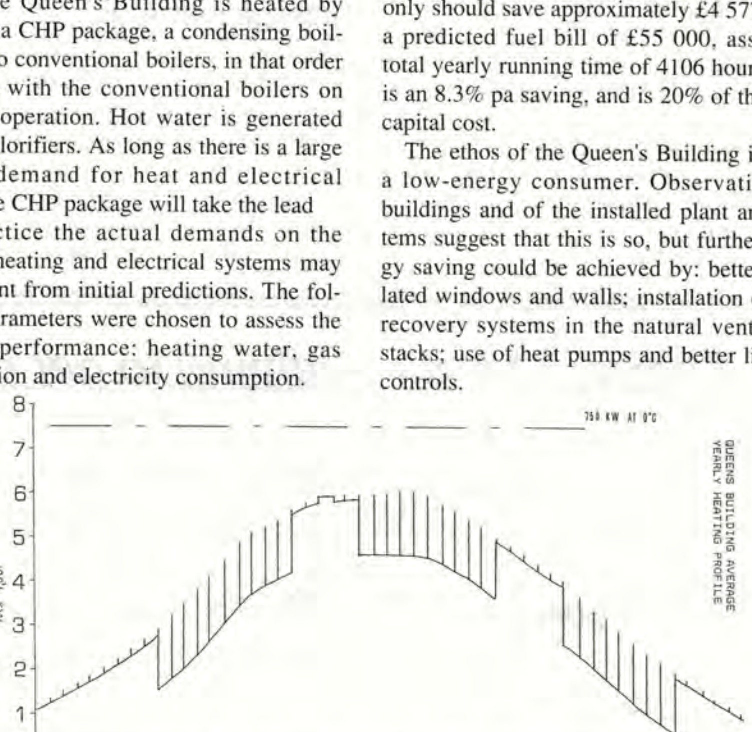
The building has a computerised building energy management system (BMS) which logs data for over one thousand individual monitoring points throughout the building. Each of these points is logged on a continuous cycle and the average, maximum and minimum values are calculated for each minute, hour and day. For the purpose of this study it was only necessary to consider data on a daily basis in the interest of keeping the number of calculations required to an acceptable level.

Observations

In the course of this project a number of methods for modelling the heat required throughout the year by the Queen's Building was considered. The basic theoretical method of calculating the heating requirement were compared to the calculations undertaken by the building plant contractors and these were in turn compared to measurements taken from BMS.

There were two measurement techniques employed — heating water energy transfer rate to the building and the gas consumption rate. Analysis of the CHP system which is sized to match the hot water requirement only should save approximately £4 577 pa on a predicted fuel bill of £55 000, assuming total yearly running time of 4106 hours. This is an 8.3% pa saving, and is 20% of the CHP capital cost.

The ethos of the Queen's Building is to be a low-energy consumer. Observations of buildings and of the installed plant and systems suggest that this is so, but further energy saving could be achieved by: better insulated windows and walls; installation of heat recovery systems in the natural ventilation stacks; use of heat pumps and better lighting controls. ❑



Queen's Building: yearly heating profile

Landfill gas — can the challenge be met?

*by Dr Robert Eden, CEng**

Landfill sites represent a not inconsiderable contributor to greenhouse gases — most notably in the form of methane, a far more potent greenhouse gas than carbon dioxide. One option is incinerate the waste, with heat recovery. Another, outlined in this article, is to burn the unwanted gas for power generation. Dr Eden discusses the feasibility of such projects.

THE USE of landfill gas as a commercial energy resource will shortly pass another historic milestone. By the end of October this year, the third round of the government-sponsored renewable energy funding scheme will be complete. Known as the NFFO (non-fossil fuel obligation) in England and Wales, and the SRO (Scottish Renewables Obligation) in Scotland, the scheme provides support funding in the form of elevated purchase prices for electricity generated by non-fossil fuel means.

After contract signing the successful bidders will be preparing the projects for which considerable planning and effort has been expended over the last two years. Those others, who have expanded similar amounts of effort and planning but failed to secure funding, will now be reviewing their options. In many instances there will be only one. Collect the gas and burn it off.

It has long been a cherished desire of many engineers responsible for landfill gas to see it used rather than disposed of. On the face of it, calculations on the back of an envelope demonstrate the opportunity to be significant.

One tonne of domestic refuse may produce up to four-hundred cubic metres of landfill gas during its decomposition. With a typical 50% methane concentration this volume of gas would have a value of £28.97 if sold by British Gas to a domestic user. A typical landfill will be measured in units of one million tonnes. This equates theoretically to a commercial resource worth around thirty millions pounds!

In practice, however, the reality is somewhat less attractive than the dream. From the initial conceptualisation of a power station, through to the achievement of commercially viable revenues, there are many pitfalls for the unwary. Bank managers are generally keen to see a statement of the risks involved in their customer's investments. They will remain shocked, regardless of the progress made in recent years.

A fundamental problem, which may never be resolved, is involved in estimating the exact gas potential from a specific site. Methods have been developed to reduce the margin for error. As with combustion engineering, however, the subject remains almost a black art, subject to the intuition of an experienced eye.

As a result of failures in previous rounds, the NFFO application procedure in this round involved a due diligence procedure to confirm the estimated volumes of gas. This estimate is used to select the electricity export capacity. Simultaneously, but no doubt independently, the Energy Technology Support Unit (ETSU) based at Harwell commissioned a review of modelling methods.

Simply put, the problem is that many models provide the wrong answer. Many would question whether the right answer can ever be obtained by such means, except with the intervention of providence. Maybe those responsible for administration of the NFFO have discovered a technique that has yet to be released to the rest of the world.

Long-term viability

A recent court case in Australia involved a landfill gas generator and his consultant. A scheme of several megawatts was found once fully installed, to have an unintended and inbuilt 200% standby capacity. Whilst greatly assisting with the surety of the supply it fell to the courtroom to offer some hope of long-term viability, by means of a different kind of gas.

In practice there is only one way to ensure viability, with regard to the size of the resource, and that is to work with wide margins of safety. Having been provided with a good solid curve showing gas production over the next 15 or 20 years, it involves a difficult-to-obtain restraint to forego the full revenue and opt for a capacity less than may be achievable.

Having swallowed this bitter pill, gas from the 1 million tonnes landfill will have been reduced to a resource with a value of around seven and a half million pounds.

The next set of problems to be encountered falls within the realm of the engineer. The application of technology for the conversion of landfill gas into electricity has developed to the point where equipment may be expected to reliably operate for the duration of a project without the need for replacement.

In the early years of landfill gas electricity generation many lessons were learned. One scheme in Germany ran for less than 24 hours after start-up before it seized. This appeared to be as a result of rapid corrosion. It is well known that landfill gas contains a cocktail of some 140 trace gases. These include chlorinated and fluorinated hydrocarbons. Such gases can sometimes be found in almost inexplicably high levels in landfill gas. They are also the primary reason for engine component failure.

Because of such failures, one company in England has developed and patented a water-wash system to clean landfill gas before the engine intake. Engine manufacturers have taken a more direct approach and made engine warranties subject to the inlet gas quality and condition. This requirement has led to landfill gas feed-plant growing to include a range of pre-treatment equipment.

One particular engine supplier, as well as specifying limits to chlorines and fluorines, has specified minimum and maximum feed-gas temperatures. Depending upon specific plant configuration, and given the extremes of the British climate, this may result in the need for equipment to both cool the gas in summer and heat it in winter.

Whilst it is possible to achieve all of the requirements of a technical nature there is an undeniable impact upon costs. The early entrepreneurs who took the gamble of entering uncharted territory did so on the basis of the 1983 Energy Act. The old electricity boards were required to publish a tariff at which they would purchase electricity from private generators. Prior to the privatisation

**Managing Director, UKPS Ltd*

of the electricity industry, the tariff, which varied throughout the year, dependent upon peak demand, averaged about 2.8 pence per kWh. At this level schemes were barely viable. Costs then excluded the extras developed as result of bitter track record.

The last round of NFFO funding resulted in a price of 5.7 pence per kWh. May viewed this as unusually high because a cut-off date in 1998 was introduced to meet European free competition regulations. Schemes had only a brief period in which they could pay off the capital investment.

It is, therefore, somewhat surprising to hear the range of prices that are being considered for the current round. One large operator, with connections to the cement industry, and a well respected and successful operator of landfill gas power stations, is reported to be of the view that landfill gas could be generated at Pool price rates. Pool price is that obtained in the unregulated commercial market and has been in the region of 2.2 pence for several years.

Others are not so sure. With a typical installed cost of £700 000 per MW, Pool price would generate a revenue of around £160 000 each year. Operating costs would be in the region of £100 000. In simple terms this equates to a pay-back of at least ten years, excluding finance costs. Given the nature of the risks, which include running out of gas, there will not be many takers at this sort of price.

With an electricity price of 2.2 pence per kWh, the 1 million tonne landfill will be further reduced to a resource with a gross value of £1.5 million. If the running costs are taken into account the actual profit will be in the region of £500 000 over a period of some ten years.

Financing

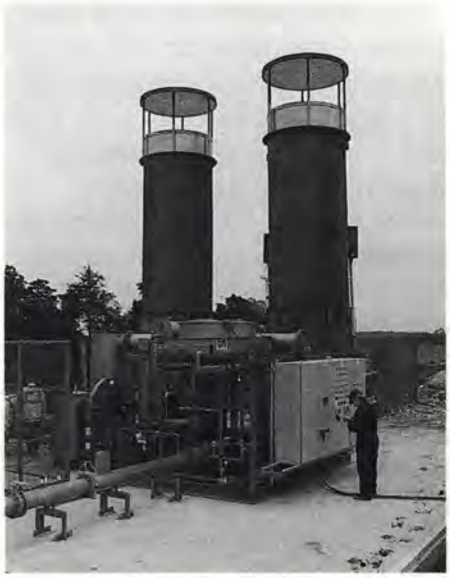
This simple calculation does not allow for finance costs. With a slight reduction in plant availability there is a good chance that the whole scheme will run for the benefit of the bank. With a substantial reduction, or a few years off the depreciation period, the scheme will require subsidy by the operator. Such reductions have become a substantial and recognised hazard in predicting revenue streams from landfill gas-fired generators.

This highlights the problem with extended-payback financing. After many years of successful running the project may still fail. Landfill gas production modelling is particularly weak at predicting the shape of the inevitable decline in gas availability.

Based upon the same premises that led to a bid price of 5.7 pence in the last round of the NFFO a price of around 4.5 pence would be equivalent, depending upon the exact period over which the project is depreciated. In practice, experience to date has resulted in an unavoidable increase in plant capital costs.

It is reputedly the current government's intention to use the NFFO as a means of assisting renewable energy technologies to become competitive with more conventional forms of energy. This would mean landfill gas generated electricity entering into the Pool. There is rumour abroad that this round of the NFFO may be the last which landfill gas will be included.

It would not be surprising, should this be the case, if we were to see an end to landfill gas power generation, and a return to landfill gas combustion as the only serious commercial option. As with solar power and heat pumps, the application of landfill gas conversion technologies would become the realm of the inspired enthusiast. The sensible commercial manager would steer well clear. ❑



Gas pump set and dual flares at UK Waste's power generation site at Windmill Quarry.

Combined landfill gas flare and chiller plant at Wimpey Energy power station, Appleby Bridge.

Technology foresight programme

THE RECENT in-depth review of the Institute, culminating in the reorganisation at the Devonshire Street headquarters identified a number of areas where it was felt that members should be better informed about the Institute's work on their behalf. One such area is communication with government, and the Institute's most recent response is published in full here.

In 1992 the Institute responded to a series of questions posed by a Cabinet Office discussion document linked to the preparation of the Government's White Paper *Realising our potential: a strategy for science, engineering and technology* published in May 1993.

The White Paper announced the launch of a Technology Foresight programme in which the aim is to build a consensus on the areas where new developments are likely to yield the greatest long-term social and economic benefits to the UK. An early task is to identify likely trends, market, opportunities and technologies over the next ten to 20 years. The results of the programme will guide government and industry decisions on funding research and development. 15 sector panels cover key market fields, and consultation is central to the Technology Foresight programme. The Institute of Energy, with other institutions and organisations with energy interests, have been invited to make an input to the work of the Energy Sector Panel.

Dear Mr Hayman

Technology Foresight programme — energy

I am writing in reply to Gerald Clerehugh's letter of 16 June inviting an Institute of Energy input to the Energy Sector Panel's deliberations. We note that one of your immediate tasks is to identify likely trends, markets, opportunities and technologies over the next ten to 20 years, and to try to develop a consensus.

This is not a straightforward task for the energy sector in view of diverse and often conflicting interests, and the still rather unstable nature of the energy market as it adjusts to the shift from mainly public to private sector and faces uncertainties over the continuation of the Non Fossil Fuel Obligation (NFFO).

The legacy of the past leads us to believe that the future markets for technology and equipment in this sector of the UK economy will depend not so much upon the push of new technology and ideas, but upon the extent to which Government is prepared to adopt a proactive rather than a reactive stance to the environmental concerns about energy production and use.

We have now a situation in which the principal engine for legislation to control environmental pollution from energy sources is the European Commission, and our own response, although eventually admirable, tends to fall into line with positions previously adopted by others. This has advantages and disadvantages. It gives our industries a breathing space to consider the technology that is available to meet tighter controls — and rarely is this of UK origin — but this has the disadvantage that it fails to give the clear signals and the time needed to encourage the development of home-grown technology to meet both UK and overseas needs. A good example is provided by the equipment available for removing sulphur and nitrogen oxides from power plant flue gases. All the processes presently available commercially have their origins in countries where their governments have placed a high priority upon reducing emissions from combustion plant, have set clear targets and timescales and made support available to ensure these targets are met, viz Japan, Germany and the USA. Our own plant manufacturers have usually acquired licences for these processes and adapted them for UK circumstances.

1 Identification of major issues for energy (UK and global)

The principal issues appear to comprise the following:

- the need to achieve higher conversion efficiencies: a) from from primary to secondary energy, viz coal, oil or gas to electricity; b) renewable energy; c) in transport; d) through energy conservation measures;
- growing legislation pressure upon the energy sector to reduce the environmental impact of its activities, viz CO_2, sulphur and nitrogen oxides emissions, toxic trace elements, and waste disposal from both domestic and industrial sources including waste from flue gas treatment;
- public acceptability or otherwise of broader environmental aspects, viz visual impact of low energy intensity technologies — wind, active solar — disposal of radioactive wastes;
- the need in developing countries for simple yet efficient energy technologies that may have only a restricted appeal in developed societies.

2 Markets resulting from these issues

2.1 Increasing conversion efficiency

a) Fossil energy in electricity generation.

The most effective proven way to increase the conversion of a primary fuel to electricity is the combined cycle gas turbine power plant (CCGT) fuelled by natural gas. Modern coal-fired steam plant achieve an efficiency of about 39% (net CV basis), and CCGT with the latest advanced gas turbines are approaching 55%. The replacement of ageing steam plant — say 36% efficiency (net CV) with an equivalent capacity of the latest CCGT plant would, in a UK situation, reduce CO_2 emissions per kW generated by about 60%. The so-called 'dash for gas' was inevitable, given the lower installed cost per GW and shorter construction time of the CCGT compared with the equivalent steam plant, the zero SO_2 and very low NO_x emissions of the former, and the availability of natural gas at attractive prices. Regrettably, the advanced gas turbine technology, the prime mover for the CCGT plant, is either American, German or Swedish/Swiss in origin, and further major developments will come from those sources. The balance of the plant, waste heat boilers, steam turbines, alternators, switchgear and transformers are available from competitive UK manufacturers.

That is the short-term picture for new investment. The medium term introduces the prospect of rising natural gas prices, and the question of the contribution from new plant (natural gas-fired CCGT, nuclear, renewables and advanced coal) and existing coal-fired plant to meet rising electricity demand. The question of whether existing coal-fired plant can continue to operate without major expenditure on emissions control equipment will emerge from the current review of the EC Large Combustion Plant Directive, and is outside the influence of normal market forces. It can be said, however, should the need for further emissions control equipment arise, the older and least efficient plant are likely to be closed, and the cheapest processes needed to meet new standards will be installed. This leaves little room for R&D on new and improved processes.

Rising natural gas prices would lead to thoughts of alternative synthetic gaseous fuels for the CCGT plant, and open the door to heavy oil, Orimulsion and coal gasification, probably in that order. The capital cost of oil/Orimulsion gasification plant is lower than the coal equivalent, and increasing environmental pressure to reduce the sulphur content of fuel oils will create a demand for hydrogen within the refinery. Economies of scale and the liberalisation of the electricity supply market will encourage oil companies to instal gasification plant to dispose of heavy residues, produce the hydrogen needed for desulphurisation of their lighter products and use surplus gas from power generation on site or sell it to utilities. Away from the refinery there is the prospect of installing coal or Orimulsion gasification plant at or near existing CCGT plant fired by natural gas to provide an alternative supply of fuel gas. Some modifications to the gas turbine combustor system would be necessary to accommodate this change, but the gasification retrofit offers the prospect of maintaining efficient CCGT at high load factors protected to some degree from rising natural gas prices.

So far as technology is concerned, most of what would be required in the medium term for the fossil fuel sector is already in commercial use in the oil and chemical industries, or coming into use with electricity utilities overseas. For most practical purposes, Orimulsion and heavy residue gasification are identical with similar investment costs. The choice between coal or Orimulsion as a gasification feedstock would be a matter of simple economics. Some coal gasification processes are used commercially, eg, Texaco, whilst others are the subject of major demonstrations, eg, Shell, Krupp Koppers and the British Gas Slagging Gasifier. Entrained gasification — Shell, Krupp Koppers Prenflo — is best suited to new plant, whilst moving bed gasification — BG Slagging Gasifier — has advantages for retrofit applications. In all cases, the sulphur and nitrogen oxides precursors together with toxic trace elements in the gas phase would be almost completely removed from the fuel gas by established wet scrubbing processes.

The coal-fired pressurised fluidised bed combustion combined cycle plant is being demonstrated successfully by ABB, and that company is now marketing vigorously an advanced version which promises to compete with the installation costs and efficiencies offered by the latest integrated coal gasification combined cycle plant (IGCC). The desulphurisation and dentrification performance is impressive but not quite so good as IGCC.

For the longer term, hybrid partial gasification systems, such as British Coal's Topping Cycle offer higher conversion efficiencies than IGCC, and the potential advantage is preserved to a degree as gas turbine efficiencies improve. Processes are under development in the UK, USA and Germany. The ones that eventually reach the market place will be those which offer high conversion efficiency with the least technical risk, and can secure the substantial levels of financial support necessary for successful pilot and pre-commercial demonstration programmes. The present situation in the UK electricity supply industry, the imminent privatisation of the coal industry, and the past reluctance of Government to provide financial support for such major projects raise questions over the UK's will and ability to compete successfully in this field.

Both major UK utilities are participating in advanced coal-based power generation projects, PowerGen in the British Coal Topping Cycle programme, and National Power in the IGCC demonstration project in Spain supported by the European Community. Both have minor shares in project financing consistent with their objectives of being informed prospective purchasers.

Indeed, with the sharp reduction in R&D programmes, the closure of laboratory facilities and the disbandment of expert teams following the privatisation of the nationalised energy industries, the general thrust of technological thrust within much of these industries is to limit R&D to the level necessary to be an informed purchaser of technology developed elsewhere. R&D in the coal sector is bedevilled by uncertainty as the new private companies are unlikely to be sympathetic to medium or long-range research, as it falls outside their immediate customer service needs. However, there is a brighter spot in the case of the gas industry, which retains a more vigorous and forward-looking R&D effort. The plant manufacturers are facing a difficult time, and apart from work sponsored by the DTI, their R&D efforts are constrained by shortage of orders.

b) Renewables

Another area where energy conversions might be improved is in the field of renewables. The substantial Government supported R,D&D effort on renewables has its origins in the oil crisis of the early 1970s, and the perceived need for 'politically stable' sources of energy. The low energy density of renewables allows only a limited contribution to UK energy needs, but it is seen by Government to be important for making a significant contribution towards providing diversity in electricity generation.

The fossil fuel levy of the Non-Fossil Fuel Obligation (NFFO) which provides the subsidy to offset the higher generating costs of renewables both assists and bedevils the contribution of renewables by distorting the energy market. However the duration of the NFFO is still under discussion and uncertainty over the continuation of subsidy, and the technologies that will continue to be used, creates problems over selecting areas where scarce R&D resources should be focussed.

In the area of wind power, there are environmental objections to the visual impact and noise of wind generators. Much of the impetus of the early UK development programme has been lost, but there may be scope for research aimed increasing public acceptability by reducing the audible noise of wind generators.

c) Transport

The transport sector is a major contributor to atmospheric pollution and CO_2 emissions, and the principal culprit is the internal combustion engine. Great strides have been made in recent years in increasing efficiency and reducing emissions but total emissions continue to rise with the increase in the number of motor vehicles. Restraints upon the use of the private car would be unpopular and, if Government is to make an impact upon this problem, alternatives to the petrol or diesel internal combustion engine, need to be brought forward. Further development of 'lean burn' petrol engines, engines designed specifically for natural gas, diesel designs to minimise particulate emissions, and modified petrol and diesel fuels would provide a stepping stone for the medium term, but the electric vehicle seems to be the longer term solution for both private and public road transport. This would link road transport to electricity generation as is increasingly the case with rail, and reap the benefits of the increasing efficiency and emissions reduction in power plant.

d) Energy conservation

This is an enormous field in which much has already been accomplished, mainly through Government action of one form or another. Improving the efficiency of energy use remains a priority for the Energy Efficiency Office (EEO), through a variety of schemes to promote and develop energy efficient practices. A broad range of technological advances has been achieved, and the energy efficiency of the economy is improving steadily and making a contribution to the reduction of CO_2 emissions. However, progress is slower than desirable if the CO_2 stabilisation targets are to be met, many schemes are not being proceeded with even though the normal cost effectiveness and payback criteria would be met. There is no shortage of new technology to improve energy efficiency and, accepting that resources are limited, R&D within this field needs to be targeted in areas where significant advance and an encouraging rate of take-up could be expected. We regret we have not found it possible to identify specific projects meeting these criteria within the time available.

3 Products required to meet opportunities in these markets

3.1 Large-scale electricity generation from fossil fuels

In UK power generation from fossil fuels, much of the technological advance will come from activities outside the UK, eg, gas turbines, and the scope for R&D to enhance our competitiveness in this area appears to be confined to a few areas where we can bring to bear the expertise in university departments and the remaining industry groups. There appears to be little scope for original work in flue gas treatment, either SO_2 or

NOx, in view of our ageing stock of coal-fired plant, and the dominant position of our overseas competitors. Even so, the power sector does offer opportunities for potentially profitable work in the fields below:

i) the means to minimise both fuel and thermal NOx formation in combustion systems with special reference to the 'reburning' technique.

The UK possesses capabilities ranging from fundamental research through to large-scale test facilities to attack the market for retrofits of improved low NOx burners to existing and new boiler plant.

ii) coupled with i) above, the development of systems which can accurately measure and control the flow of finely ground solids, viz pulverised fuel, in multi-phase flow systems. The particular area of uncertainty appears to lie in the accurate modelling of flowing systems in which the solid particles are irregularly shaped. Precise solids flow control becomes important in low NOx operation.

iii) if the shift to IGCC power generation occurs as predicted above, there will be a need to find outlets for the considerable tonnages of sulphur and/or sulphuric acid which will be produced by clean-up of the gasifier fuel gas. This suggests efforts should be directed to sulphur chemistry in an attempt to develop new compounds with commercial possibilities.

iv) improved high temperature materials — metal alloys, ceramics or combination of both (cermets) — will be needed to maintain reliability of gas turbines or other heat engines as operating temperatures and hence efficiency increase with further development.

3.2 Renewables

There is already a broad range of experience in renewable energy technology in the UK, a focussed R&D programme sponsored by the DTI through ETSU, European Community support, and international collaborative projects. The field is too wide to cover adequately in this letter, but there are some areas which appear to warrant particular attention.

i) Photovoltaics are already used widely in sunny countries and there is a continuing industry interest here. Whilst still a relatively expensive technology, further research can be expected to bring down costs, broaden its appeal abroad, and extend its use beyond the few specialised applications in the UK.

ii) biomass is a promoting energy source and valuable in containing CO_2 emissions, but seems to be held back in the UK by the structure of current agricultural subsidies rather than technological problems; there appears to be considerable scope to use biomass as a supplementary fuel, and studies of combustion characteristics of blended fuels and the optimisation of blending and multi-fuel burner systems appears suited to home and overseas applications.

3.3 Transport

As suggested in 2.1c above, the electric road vehicle offers an attractive longer term prospect for reducing exhaust emissions from the transport sector, with further development of the lean burn petrol, natural gas and diesel internal combustion engine in the interim.

These developments could also feed through to hybrid systems in which a battery driven electric motor provides motive power, and an internal combustion engine running at optimum efficiency drives a generator for battery charging. Such systems would extend the current limited range of the simpler battery vehicle, by the scope for the hybrid would be reduced by a breakthrough in storage battery technology.

Specific areas for R&D in the transport sector appear to be:

i) greater efforts to devise improved storage battery systems for electric vehicles, focussing upon increasing capacity, rate of charge and reduction in weight;

ii) development of small, high-efficiency, low-emission internal combustion engines for powering lightweight generators for hybrid systems;

iii) the possibilities for changes to fuels specifications to minimise emissions from leaner burn spark ignition engines, and reduce diesel particulate emissions.

There are excellent combustion research facilities and considerable expertise in the UK available to tackle successfully the combustion work in i) and ii) above.

The scope for hydrogen-powered vehicles appears limited unless the high energy requirements for the manufacturers of hydrogen, and the associated CO_2 emissions are avoided by nuclear power.

4 Legislative pressures on the environmental aspects of energy production and use

The idea of legislative pressure as the major instrument for technological change in the energy sector is a relatively new one in the UK. The UK Government usually adopts a defensive stance to international energy-related environmental initiatives — the Rio agreement on CO_2 emissions was an exception — taking time to assess the implications of new environmental targets against a set of not always consistent Departmental priorities. This does not help to create a UK climate which encourages R&D to bring forward new products and processes to meet new environmental limits, and the absence of clear targets often fails to provide the timescales needed by UK organisations for research, development and demonstration. An example is that present circumstances suggest there is little scope for R&D into flue gas desulphurisation or denitrification other than to support imported technology, although R&D on low NOx combustion systems does seem to offer some opportunities for UK Ltd.

5 Further advice

The Institute of Energy welcomes the initiative of the Technology Foresight Programme in filling an important gap in Government thinking on technological advance. We hope that the ideas above will prove helpful, but we are conscious that we have not covered all the major issues in Section 1, and have tended to concentrate upon factors which will influence the market for new technologies rather than the technologies themselves. There is more we could have done had we had more time. Amplification could be provided by individual members of the Institute who have particular expertise in different energy sectors, and who would be pleased to meet the Energy Sector Panel to express their views. These are: Professor Brian Brinkworth (renewable energy); Professor James Harrison (energy and the environment); and Mr Michael Roberts (energy efficiency). All are recent past-Presidents of the Institute and have a good perspective on energy matters at large.

Yours sincerely,

H F Ferguson (Honorary Secretary)

The Technology Foresight Panel has reached a vital stage in its programme. The main consultation phase is currently underway, with the Office of Science and Technology (OST) sending around 450 questionnaires to industrialists, academics and public sector officials in the energy field. They will be asked for their opinions on market opportunities in those industries that will be the most important to the UK over the next 10 to 20 years, and the scientific, engineering and technological advances that will underpin or influence them.

The responses will be combined with the results from regional workshops, and consultations with trade associations, professional institutions, academic bodies to inform the panel in reaching its final conclusions. This letter from the Institute of Energy is one such response, and will be taken into account. The panel's conclusions will be brought together in a final report to the Technology Foresight Steering Group in January 1995.

The results will be used to guide long-term priorities for Government-funded science in the energy sector, and for R&D in the private sector. It is hoped that the consultation programme will strengthen the academics-industry networks, which are seen as an important part of the foresight process. ❑

The Scottish nuclear family

by Eur Ing F John L Bindon

UNLIKE the English and Welsh equivalents, the two non-nuclear Scottish utilities had their own identities before privatisation of the electricity supply industry (ESI) in 1989. They have kept those identities more or less intact. Only the exclusion of the nuclear component differentiates Scottish Power plc from its predecessor, the South of Scotland Electricity Board (SSEB). The other utility, the former North of Scotland Hydro-Electric Board was very parochial in style.

This structure has changed dramatically since 1990, with a new management team which launched the new company fast into the commercial world of the privatised electricity market, by expanding activities outside its geographical area. An example of this new direction is the company's involvement with a combined cycle gas turbine (CCGT) project at Keadby in Yorkshire.

As was the case with the English and Welsh situation with nuclear power, the Scottish nuclear component was transformed in 1989 into a new company: Scottish Nuclear Ltd (SN). The company's assets stem from the nuclear assets of the old SSEB. SN own and operate two advanced gas-cooled reactors (AGRs), at Hunterston and Torness, together with a closed Magnox station, Hunterston A, now approaching the end of the first stage of decommissioning.

Vertically integrated

The old SSEB was formed in 1955 by the Electricity Reorganisation (Scotland) Act of 1954. It was an autonomous body responsible for the three functions of generation, main transmission and distribution. In fact, a vertically integrated organisation very different from that south of the border, where the Central Electricity Generating Board (CEGB) established under the Electricity Act of 1957 was responsible for all generation and the bulk transmission of power. The other statutory bodies up to the time of privatisation were the old Area Boards, whose responsibility was for the distribution and sale of electricity to all its consumers. This general structure in England and Wales was overseen by a body known as the Electricity Council.

When the government of the day announced its intention to develop nuclear power in the UK in a White Paper of 1959 (Cmnd 9391), eight nuclear sites were chosen. One of these was for a Magnox power station at Hunterston in Scotland.

Hunterston A came into operation in 1964, operating successfully until closed permanently for economic reasons in 1990. The station was constructed and commissioned within seven years, a record not repeated until recently with the completion of Sizewell B. The licensed electricity output from Hunterston A was 300 MWe net.

First stage decommissioning

Closed for the past five years, the station has almost completed its stage one decommissioning programme by the removal of fuel. To date more than 96% of the fuel from the reactors has been removed. Although government grants are available for Hunterston A decommissioning, all the work so far has been funded from the cash flows from AGR generation. At the time of closure this station had supplied some 54 902 591 MWh to the Scottish power system.

Hunterston B, with its capacity of 1150 MWe net, continues to maintain a most successful record of performance. This station was commissioned in 1976/77. In a drive to enhance the station's operational efficiency, the most extensive in-vessel programme of work anywhere in the world was completed in the last 12 months. The station was visited by the International Energy Agency Operational Safety Review Team (OSART) in April 1994. In their final report, the overall comment was that Hunterston B has an experienced, dedicated and enthusiastic management team and staff. This commendation is indeed well earned when one examines SN's Annual Reports published since 1990.

No less worthy are the high performances being achieved by the Torness AGR, which came into operation in 1988/89. A great deal of engineering work has been undertaken to introduce on-load refuelling by the enhancement of the most modern technology. The station capacity of 1250 MWe net is contributing to SN's financial success.

Engineering studies are being continually carried out aimed towards reducing unit costs and ensuring both stations have economic lives and a life management programme. Confidence at present points towards Hunterston B operating until 2011, while Torness could expect a life until 2023. Life management is vitally important to SN, because it will influence the date upon which construction of a replacement station will be needed.

Under a nuclear energy agreement (NEA), the output from Hunterston B and Torness is adjusted in three periods. The first ran from 1990 to 1994, and was at a premium set price, but with a retail price index adjustment. The next four years sees the unit price move progressively towards the average market price in England and Wales. Thereafter, until the end of the Scottish contract, already mentioned above, the price is to be set at the average market price for England and Wales in supplying baseload electricity.

SN are keen to reduce operating costs of their two stations. Fuel reprocessing currently makes up 23% of the total unit costs and significant savings can be made by the dry storage of irradiated fuel, rather than sending it for reprocessing. Following a public inquiry which ended in 1993, to build a dry storage facility at Torness, SN awaits the Government's decision.

The future: privatisation

During 1993/94, electricity sales from SN rose to 14.2 TWh. This generation was produced at a cost of 2.83p/unit. Since 1990 this figure represents a reduction of 12%, while output of electricity has increased by 16%. The aim is to achieve a unit price of 2.5p/unit by 1995.

To secure a long-term future for nuclear power in Scotland, SN needs to be placed on a commercial footing which can only be realised by privatisation. SN believes such a change would bring benefits to Scottish customers, the Government and the nuclear industry as a whole. ❑

Valves for power plant life extension

ARISING from the power station building boom that Britain had during the 1960s, there are a number of power stations all in a similar state with regard to their running hours. This means that various items of equipment are coming up for renewal all at the same time, and for things like main steam isolation valves which they originally supplied, Hopkinsons are having something of a repeat boom.

Traditionally, a creep life of 150 000 hours was specified for the main steam isolation valves operating at the high superheated steam temperatures of power stations. It is testimony to Hopkinsons valves that the design lives have been far exceeded, but customers are now expecting even more from the replacements.

Hopkinsons, a member of the Weir group of companies, is winning orders in the power station replacement valve programme. Pictured above are main steam isolation valves, safety valves, and a non-return valve. All are to a higher specification than the valves they will replace.

Increased output

Ever mindful of operating costs, engineers are of course aware of the small but nonetheless discernable pressure losses that occur as steam flows through pipes and valves. If a valve can be made to be even more streamline and produce a lower flow loss, this can mean increased output for the power station.

Hopkinsons are now supplying replacement main steam isolation valves which have lower flow losses, but this entails providing bigger valves which in turn means increased operating loads. The extra operating effort could imply that some perfectly satisfactory existing actuators would not be able to be used on the replacement valves, but re-using actuators is one of the areas where Hopkinsons have gone to great lengths to collaborate with power stations. The company has been custom designing valves and cooperating with power stations on valve refurbishment programmes, and the background of the photograph shows low-loss valves to be used with some existing actuators, with their by-pass valves positioned more conveniently for the particular power station layout.

Also visible in the photograph are some full lift safety valves. Hopkinsons are leaders in the supply of the safety valve anti-simmer device, which enhance the operation of boiler plant by both reducing emissions to the atmosphere, whilst at the same time allowing operating pressures to be increased. A number of stations are retrofitting their existing safety valves with this equipment, which can be either the patented 'servo-loading' system of supplementary loading, or pneumatic assistance.

A number of power stations are also in the process of replacing superheater headers that have reached the end of their design life, and Hopkinson are producing uprated safety valves to fit the new headers. It is well known that Hopkinsons have an enviable reputation for reliability on safety valves, but they put their current success down to being able to collaborate with customers and provide them with whatever type of valve is required to suit the particular application. ❑

Towards a European framework

THE INSTITUTE is co-sponsoring a conference on training and career development for energy managers, together with the University of the West of England and DG XVIII's SAVE programme.

Towards a European framework aims to raise awareness of the significance of the energy manager's role in all organisations. In addition, it will examine current, limited, training provisions, and will look at how these can be improved — a major step forward towards encouraging companies to be more efficient in their use of energy.

Further information can be obtained from Mr S Simpson, Faculty of the Built Environment, University of the West of England, Coldharbour Lane, Bristol BS16 1QY. Tel: 0272 656261; fax: 0272 763839.

Branch events

Please note that these events are subject to change. For up to date information contact the person named for the event. If refreshments are planned, please advise the contact of your attendance.

February 1995

Midland

Thursday 2 February, 7pm

Alternative Energy Options by Mr M Waldram (Greenpeace) Snr Common Rm, University of Aston, Birmingham. *Contact: Mr D E A Evans, tel: 0384 374329*

North Eastern

Tuesday 7 February, 6pm

Joint meeting with The Institution of Chemical Engineering. *A fuel for cement kilns* by CEMFUEL, Mertz Court, University of Newcastle upon Tyne. Tea & biscuits prior to the meeting. *Contact: Mr A W Potts, tel: 0670 712861*

Northern Ireland

Tuesday 7 February

Greenhouse Gas seminar. Bangor Town Hall, Bangor, N Ireland. *Contact: Mr A McCrea, tel: 0232 454336*

S Wales & W of England

Wednesday 15 February, 5.30pm for 6.30pm

Joint seminar with IEE, IMechE & Welsh Office, Cardiff. *Energy systems for the millennium — the competitive energy market* by Prof W F Fairney, Director, Project Development & Construction, National Power. *Contact: Mr S Wilce, tel: 0454 201101*

March 1995

Midland

Thursday 2 March, 7pm

Demand-side management by Mr P Benstead (Manweb plc) Snr Common Rm, University of Aston, Birmingham. *Contact: Mr D E A Evans, tel: 0384 374329*

Northern Ireland

Tuesday 7 March

Joint seminar IoE & Institute of Physics, *Energy options in the next 50 years* by Prof Ian Fells, University of Ulster at Coleraine. *Contact: Mr A McCrea, tel: 0232 454336*

S Wales & W of England

Wednesday 8 March

Young Persons Paper Evening, SWEB Aztec South, Almondsbury, Bristol. Contestants from industry and academe will present current projects for a prize of £150. *Contact: Mr S Wilce, tel: Almondsbury 0454 201101*

Northern Ireland

Thursday 16 March

Annual Dinner, Culloden Hotel. *Contact: Mr A McCrea, tel: 0232 454336*

North Eastern

Wednesday 22 March, 5pm for 5.30pm

Joint seminar with Institution of Gas Engineers. British Gas Engineering Research Station, Killingworth. Speaker and title to be confirmed. *Contact Mr A W Potts, tel: 0670 712861*

S Wales & W of England

Thursday 23 March

The THORP Reprocessing Plant at Sellafield by Mr R Warren, Group Manager THORP Division, BNF plc, School of Chemistry, University of Bristol. Arranged by Society of Chemical Industry, Bristol section. Followed by optional buffet supper which must be booked in advance. *Contact: Mr S Wilce, tel: 0454 201101*

Erratum

The S Wales & W of England event 'Tidal and Hydro Power in Wales' will be held on 17 January, not 18 January as previously stated in September's Institute News page.

Free membership offer for BNES

THE British Nuclear Energy Society, BNES, was established in 1962 and is the leading learned society for individuals interested in nuclear energy. The society provides information to its members on nuclear energy issues, opportunities for members to meet and debate issues, as well as to publish and present papers. In addition, BNES contributes to the public education activities of the nuclear industry and promotes nuclear energy specific training in the UK.

Membership is open to all who have an interest in nuclear energy matters. No specific academic or professional qualifications are required.

Each member receives three bi-monthly journals: *Nuclear Energy, Nuclear Europe Worldscan* and *Atom*, plus a BNES newsletter. BNES organises conferences and seminars to which members can go at reduced rates. Local events, such as lectures and visits, are available throughout the country, via a local branch network and special interest groups.

If you join now, you will be entitled top free membership for 1994. Usual membership rate is £25 per year, with reductions for students and retired people.

For further information, contact Peter Bacos, the BNES Secretary, tel: 071 839 9838; fax: 071 799 1325.

Appointment

COLIN RIGG (Member) has been appointed as a Careers Advisor at the Chelmsford Campus of Anglia Polytechnic University. His major areas of activity are engineering, computing, the built environment and business studies.

Mr Rigg would welcome the opportunity to learn about employment and the needs of employers from members in East Anglia and the London area.

He can be contacted at the University, tel: 0245 493131.

Midlands AGM

THE 1994 AGM and works visit of the Midland branch was held at Birmingham International Airport by kind permission of the Managing Director, Brian Summers.

Ms Menna Rees-Steer, Community Relations Manager, gave a brief introduction to the airport to open the meeting and Mr Colin Truran, the Airport Energy Manager, then followed with a resume of energy consumption on the site, before leading a tour of the Airport buildings and facilities.

The airport, with an annual energy bill approaching £2m, has made a corporate commitment under the Energy Efficiency Office's scheme, and were the 100th company to do so.

Electricity is the prime source of energy for the site, costing more than 75% of the total bill. It is used largely for air conditioning of terminal buildings and lighting, where many simple but effective controllers have been installed. The on-site hotel is also supplied with electricity from the airport.

Heating is the major cost, and is provided by gas-fired boilers with a comprehensive building energy management system installed. A modern CHP unit of 370kW capacity is operating.

The airport has about 100 tenants on site to whom energy is supplied and some 4500 people are employed. More than 4m passengers pass through the airport each year, with a further 2 million plus visitors and sightseers also using the airport.

An excellent report

'Cutting costs in business' by Mitch Beedie. Published by Financial Times Management Reports, London, 1994, 172 pp, £280.00 (UK) £290.00 (overseas).

THIS highly readable document is subtitled: *A quality approach to improving energy management and environmental performance* and therein lies its strength.

It approaches the hackneyed, established principles of energy management from a new direction and gives them new life. Those principles, however hackneyed and however established, are nevertheless still ignored by a depressingly large number of organisations, large and small.

Mitch Beedie's report, coming as it does from an unusual and authoratitive direction, stands to reach some of the unconverted. It further debunks some of the mystique of those who try to make out that energy management is a complex, technical matter. 'Energy saving is not a technical problem but a management one' is the underlying philosophy established on page one.

The report follows a progression through the logical cycle of activity: evaluate; plan; do; check; amend/adopt. It does so from a thorough basis in quality management principles — Dr W Edwards Deming being the most quoted source. In doing so it quite rightly points out that 'total quality management' (TQM) is only 'partial quality management' if energy is excluded.

Throughout the report immediacy is given to the text by frequent references to case study examples at an international level. The messages are international. Each chapter is introduced by a quote from the philosopher Lao Zi. One such quote: 'The wise have no minds of their own. They use the minds of the people they talk with' is taken as a working and effective principle for the report. Practitioners, many of whom are Institute of Energy members, are frequently quoted. This is another wise move by the author to add credibility to what could otherwise be simply personal opinion. There is also useful cross-reference to much additional data especially that produced by the Energy Efficiency Office, the Energy Technology Support Unit and the Building Research Energy Conservation Support Unit. Their acronyms (EEO, ETSU and BRECSU) as well as energy management jargon are well explained.

One main area is mildly disappointing. The section covering practical guidance for a series of industries on equipment types, building processes and fuel inputs, inevitably suffers from omissions and over simplification. This is inspite of the fact that this particular section comprises over 40% of the total. For example, each industry is reviewed in a slightly different way, and a more consistent approach would have been preferable. In general, however, the reports reads easily because it does not contain a mass of numerical data.

In practice there are few energy managers whose responsibilities exclude water. The argument that TQM should embrace energy and its environmental implications are matched by arguments to include water. Water is included here, considered specifically in only half a page. The cost of bills associated with water has escalated, and will continue to do so. Even ignoring the environmental implications, this should justify greater coverage.

The overriding impact of the report lies in its TQM slant. This link to quality works, and is expressed in a way which should spread the energy efficiency gospel to a new audience. The evangelism of the enthusiast is tempered by a realism which recognises that 'teams and quality circles are not an automatic panacea'.

I wish this FT venture success. Anyone responsible for energy, or quality and therefore energy, should benefit from this new fund of common sense. I hope the high price will not put people off — they should recover its cost within an hour of implementing the ideas contained therein.

Alan Williams

Extensive coverage

'World coal-fired power stations', published by IEA Coal Research, London, 1994, in three volumes.

THE THREE volumes of the long-awaited IEA Coal Research world survey of coal-fired power stations are now all available from the organisation's London office, and represent the most comprehensive catalogue of data and information available. Based on *World coal-fired power stations* published by Mannini and others in 1990, the IEA review is a complete update and expansion of the original information. The three volumes are *Volume 1 North and South America, Volume 2 Africa, Asia and Australasia,* and *Volume 3 Europe.*

Much of the new information has become available as a result of political changes around the world since 1990, and new links have been established on most continents, particularly with the newly independent states of the former Soviet Union, where more extensive coverage than hitherto possible has been attained.

The range of installation covers not only conventional generators but also includes district heating, CHP stations and demonstration plants designed around new technologies. But in order to make the information more readily digestible, only stations with an installed capacity of 50 MWe or more have been included.

Each country has a separate section introduced by a general survey of its electrical power generating industry, which sets coal firing in perspective with other fuels.

Other supplementary information includes the addresses of all utilities and their head office addresses, coal burning capacity of each utility, an alphabetical index of all plants referred to in each volume.

Copies are available from Publications Officer, IEA Coal Research, Gemini House, 10-18 Putney Hill, London SW15 6AA.

Peter Heap

Well written

'Composition and analysis of heavy petroleum fractions' by K H Altgelt and M H Boduszynski (Chemical Industries Series, vol 54), published by Marcel Dekker, New York, 1993, 512 pp, $175.00.

THIS book refers to crude oil heavy fractions and bitumens which may boil above 345°C, where there is a parallel to be drawn with the analysis of coal. In the US the quality of oil seems to be worsening and getting heavier, whilst the demand of light fractions and environmental friendliness is increasing. This leaves the petroleum industry with a problem of what to do and how to achieve it. Among the many obstacles are the chemical complexity and the limitations of measurement.

There is an excellent exposition of polycyclic acyclic molecules to be found, and the need for separation before attempting their resolution, identification and quantity; one or two atoms per molecule from oxygen, nitrogen, sulphur or metal and isomerism indicate a simplification of the acyclics. The difficulty increases as the fractions become more solid. As with coal, solvent extraction is one way forward. A chapter is devoted to distillation and the concept of atmospheric equivalent boiling point scale in distillation.

The cost of obtaining information is recognised in terms of measuring techniques. Structural group classification, nuclear magnetic resonance spectroscopy (a technique for which Richard R Ernst was awarded the 1991 Nobel Prize for Chemistry), chromatographic separation by various means, and molecular characterisation by mass spectrometry are discussed at length. Several characterisation formulae are proposed.

The final chapter is devoted to composition of heavy fractions. Throughout the subject is well written with convenient summaries and is amply illustrated.

Nigel Gwyther

Potential impacts

'Global warming — the complete briefing' by John Houghton. Published by Lion Publishing plc, London, 192 pp, H/B £16.99, P/B £12.99

THE THREAT of global warming and other climate changes, due mainly to the burning of fossil fuels, has been greatly exaggerated by environmental pressure groups, the media and, sadly, by some scientists who ought to know better. This has provoked other groups and some other scientists to dismiss the threat as minimal or non-existent. This highly unsatisfactory state of affairs, very confusing to the layman, calls for a reasoned and balanced assessment by a senior scientist well acquainted with the complexities and uncertainties involved.

In the first part of this attractive book, Sir John Houghton summarises, in good order and at about New Scientist level, the present state of knowledge and understanding of the climate changes that may result from enhancement of the natural greenhouse effect by man-made emissions of infra-red absorbing gases, predominantly carbon dioxide and methane. He follows quite closely the views and recommendations contained in the 1990 and 1992 reports of the International Panel on Climate Change, which he chaired.

In six short chapters he discusses the nature of climate changes; the physics of the greenhouse effect; the radiative properties, sources and sinks of atmospheric carbon dioxide, methane, nitrous oxide and the CFCs; evolution of past climates; and simulation of the global climate and the changes that may result from the enhanced greenhouse effect by computer models.

Although one may hesitate over the occasional exaggeration and non sequitur such as: 'The imperative of the global warming problem will help us use the world's resources in a more sustainable way', this is a very readable, balanced and accurate account of the main issues with proper stress on the uncertainties in our current understanding of climate change and in the model predictions, which are the main source of the current concern about global warming.

In the second half of the book, which deals with the impacts of climate change and possibilities for remedial action, the author adopts a more evangelical line and thereby becomes less objective, less realistic and less convincing. Arguments are based largely on the trite notion of sustainability whereby a rapidly growing world population is supposed to live on only the income of the Earth system, leaving the capital largely intact for future generations. This seems quite unrealistic, particularly as Sir John is reluctant to contemplate major changes in our western material living standards. This makes it difficult to imagine an effective response to his appeal for mankind to 'act in partnership with God as stewards and gardeners of the Earth in order to achieve a balanced, harmonious relationship with the environment', the more so because his reference to Lovelock's *Gaia hypothesis*, Hawking's, *A brief history of time*, and Al Gore's *Earth in balance*, serve to obscure rather than clarify the self-evident proposition that there is a strong interdependence between living systems and their environment.

Science, politics and religion rarely blend; the mix may sometimes produce new insights, as Sir John believes, but is more likely to emulsify and lose coherence. Exhortation cannot substitute for realistic and critical analysis, difficult economic and political decisions, and major technological advances (which, curiously, Sir John dismisses as 'neither balanced nor sustainable'), if mankind is to face up to the consequences of an inevitable doubling of the world's population and major increases in energy demand during the next century. In all probability, the latter can be met only by coal, with a concomitant increase in CO_2 emissions, and by nuclear power, which Sir John does not positively endorse in his brief discussion of the subject. His proposals for the exploitation of sources of renewable energy involving, for example, 40 000 windmills, solar power, and the afforestation each year for 40 years of an area the size of Ireland at annual cost of 4 billion dollars, seem impracticable. He doesn't acknowledge that renewable sources are generally very diffuse, intermittent and, being located mainly in remote, sparsely populated areas, difficult and expensive to harness and transmit. They may fill useful niches but are unlikely to contribute more than a few per cent to global energy demand.

What, then, should be the response of governments at this stage? In the short term, Sir John endorses the usual recommendations for energy saving and conservation, use of less carbon-rich fuels, reduced emissions of methane and CFCs, and a brake on deforestation. These are mainly technical fixes which should enable many developed countries to implement the Rio Conference target of reigning back CO_2 emissions in the year 2000 to 1990 levels, but will have little impact on rapidly industrialising countries such as China, India, Mexico, whose emissions will increase far into the future. This leaves open the much more difficult question of what to do in the longer term if and when global warming becomes detectable above natural climate variability and climate models become more convergent and convincing in predicting substantial changes. Without major expansion of nuclear power, the scope for reducing CO_2 emissions may be quite limited and highly unlikely to stabilise atmospheric concentrations at around the year 2000 levels. We may well have to live with, and adapt to, a warmer world, which will have benefits as well as disadvantages because the present climate is not optimal everywhere. There are many possibilities, barely mentioned in the book, for adoption on a 50-100 year timescale, for example, in agriculture, building, transport, distribution and use of water, and should be explored in order to make the world less vulnerable and more resilient to climate changes, whether natural or man made.

All abatement and adaptive strategies need to be costed and compared with the damage that may result from unabated global warming. Recent studies indicate that the damage accompanying a doubling of present concentrations of CO_2 might amount annually to 1-2% of GWP and be comparable to the abatement costs. Such economic estimates involve large uncertainty, but there is no gainsaying the fact that the benefits of electricity generation vastly exceed the ensuing environmental damage and will ensure a continually increasing demand, especially in the developing world. It is important to judge the potential effects of global warming not in isolation but in proportion to other global problems that will be in competition for limited resources, and this calls for research to acquire a much better understanding of the scientific, social and economic issues.

Returning to the book, interested readers with A level Physics will greatly benefit from the authoritative account of our current knowledge and understanding of the scientific aspects of global warming. The second part is likely to provoke mixed reactions. but it should stimulate many to think more deeply about the potential impacts of global warming and what realistically might be done to mitigate them. If this be so, this clearly written, cleverly illustrated and moderately-priced book will have largely achieved its purpose.

Sir John Mason CBE FRS

Recently published

'Macmillan Dictionary of the Environment'

Edited by Michael Allaby, 4th edition, published by The Macmillan Press Ltd, London and Basingstoke, 1994, 377 pp, £13.99.

'The changing organisation and management of local government'

By Steve Leach, John Stewart and Kieron Walsh, published by The Macmillan Press Ltd, London and Basingstoke, 1994, 276 pp, £11.99.

'Flexi-valve' wins Young Engineer title for Plymouth four

FOUR 17-year olds from Plymouth became the Young Engineers for Britain 1994 in September, in a hard-fought contest, beating nearly 1000 other young inventors.

Christopher Cooper, Paul Brenton, Stuart Newsham and Eve Richards, all from Plymstock School, won the trophy, £1000 to share and £1500 for their school by inventing 'flexi-valve' — an automatic flow control system for a waste water treatment works.

61 finalists, aged from 11 to 19, competed in the national final of Young Engineers for Britain competition, which is organised by the Engineering Council. The 1994 awards were held at the National Westminster Hall in the City of London, and as in previous years, were presented by television celebrity, Carol Vorderman.

Amongst the other winning projects were powered secateurs, a shuttlecock for the visually impaired, a new sling to rescue a person fallen overboard from a boat and a portable device to detect high voltage earth leakage.

Runners up received prizes of study visits to companies, cash prizes for themselves and their schools and the opportunity to discuss projects and career prospects with eminent engineers.

This year's WISE (Women Into Science and Engineering) award plus £800 from the Engineering Council for the best project by a girl or team of girls was awarded to Sarah Freese, aged 17, Chinenye Iwuji, aged 16, Kanako Minami, aged 18 and Helen Wilson aged 17, all from St Felix School in Suffolk. Their winning entry was a device to remove shives from beer casks. A second WISE prize of £400, sponsored by Thames Water, went to Elizabeth Bulleyment, aged 11, from Dronfield in Yorkshire, for her electrical flex cable 'tidy'.

The two principal sponsors of Young Engineers for Britain are Lloyd's Register and National Westminster Bank. Other major sponsors include: Adwest, BICC Group, British Aerospace, BP Oil, Courtaulds, GEC, IBM, ICI, London Electricity, The National Grid Company, Ove Arup Partnership, Rolls-Royce, Shell UK Exploration and Production, Tarmac Construction, The Scientific Instrument Makers Company, TI Group, Unilever and Vickers.

Key judging criteria were the originality and enterprise demonstrated, engineering and design skill, and the application of relevant scientific principals, as well as the visual, oral and written presentation of each project.

Above is Richard Walkington, winner of the 1994 Mountbatten Award for his earth leakage detector. Below are Stuart Newsham, Eve Richards, Christopher Cooper and Paul Brenton (left to right), winners of the 1994 Young Engineers for Britain award. Below left is Elizabeth Bulleyment, who won the second WISE prize for her flex cable 'tidy'.

October 1994

CoalTrans '94

Conference, 24-26 October, Hamburg. Details from Susie Constable, CoalTrans Conferences Ltd, Nestor House, Playhouse Yard, London EC4V 5EX. Tel: 071 779 8945; fax: 071 779 8946.

Housing investment, landlord benefits and energy efficiency

Workshops, 25, 31 October, 3, 8, 9, 15 & 17 November, throughout the country. Details from the BRECSU Events Unit, Building 17, BRE, Garston, Watford, Herts WD2 7JR. Fax: 0923 664787.

CHP — Ensuring Affordable Warmth with Community Heating

Seminar and exhibition, 26 October, Newcastle. Details from BRECSU Events Unit, Building 17, BRE, Garston, Watford Herts WD2 7JR. Fax: 0923 664787.

Energy efficient steam generation in boilers

Free workshop/seminar, 26 October, Warrington, Lancs. Details from Janet Hutchings, ETSU, tel: 0235 433942.

Landfill completion

One-day seminar, 27 October, London. Details from Amanda Wright, IBC Technical Services, tel: 071 637 4383; fax: 071 631 3214.

November 1994

Probabilistic safety assessment for nuclear power plants

3rd annual conference, 1-2 November, London. Details from Sarah Ashmore, IBC Technical Services Ltd, tel: 071 637 4383; fax: 071 631 3214.

Foundation course in Rheology

1-2 November, Harwell, Oxfordshire. Details from Dr Neil Alderman, AEA Technology, Harwell, Didcot, Oxon OX14 0RA. Tel: 0235 435677; fax: 0235 432548.

Air quality: control, monitoring & improvement — local and global considerations

Two-day conference, 7-8 November, London. Details from Amanda Wright, IBC Technical Services, tel: 071 637 4383; fax: 071 631 3214.

Explosion prediction & mitigation

Short course, 7-9 September, Leeds. Details from Miss Julie Charlton, Dept of Fuel & Energy, University of Leeds, Leeds LS2 9JT. Tel: 0532 332511; fax: 0532 332511 / 440572.

Competition in the UK gas industry

Conference, 14-15 November, London. Details from AIC Conferences Ltd, Ground Floor, 63-67 Carter Lane, London EC4V 5DY. Tel: 071 329 4445; fax: 071 329 4442.

Recovery, re-use, recycling and re-manufacture

Two-day conference, 15-16 November, London. Details from Amanda Wright, IBC Technical Services, tel: 071 637 4383; fax: 071 631 3214.

Offshore structural design — hazards, safety and engineering

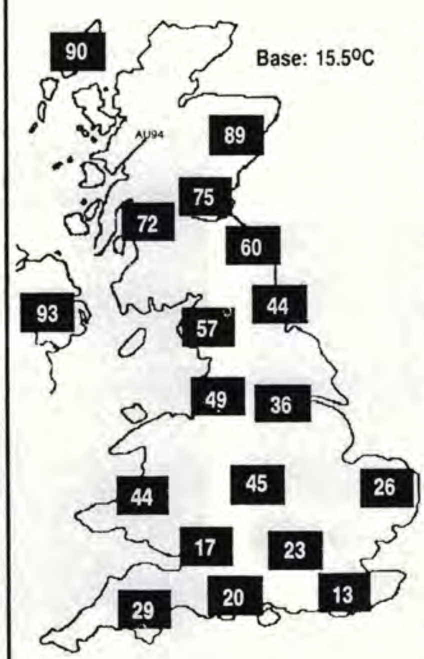
International conference & exhibition, 15-16 November, London. Details from Janine Stook, ERA Technology Ltd, Cleeve Road, Leatherhead, Surrey KT22 7SA. Tel: 0372 367027; fax: 0372 377927.

Global LPG supply developments

Course, 21-25 November, Oxford. Details from Ms Nicola Hull, Overseas Project Coordinator, College of Petroleum & Energy Studies, Sun Alliance House, New Inn Hall Street, Oxford OX1 2QD. Tel: 08865 25500521; fax: 0865 7991474.

DEGREE DAYS: AUGUST 1994

Source: **Degree days direct**



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

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

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

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

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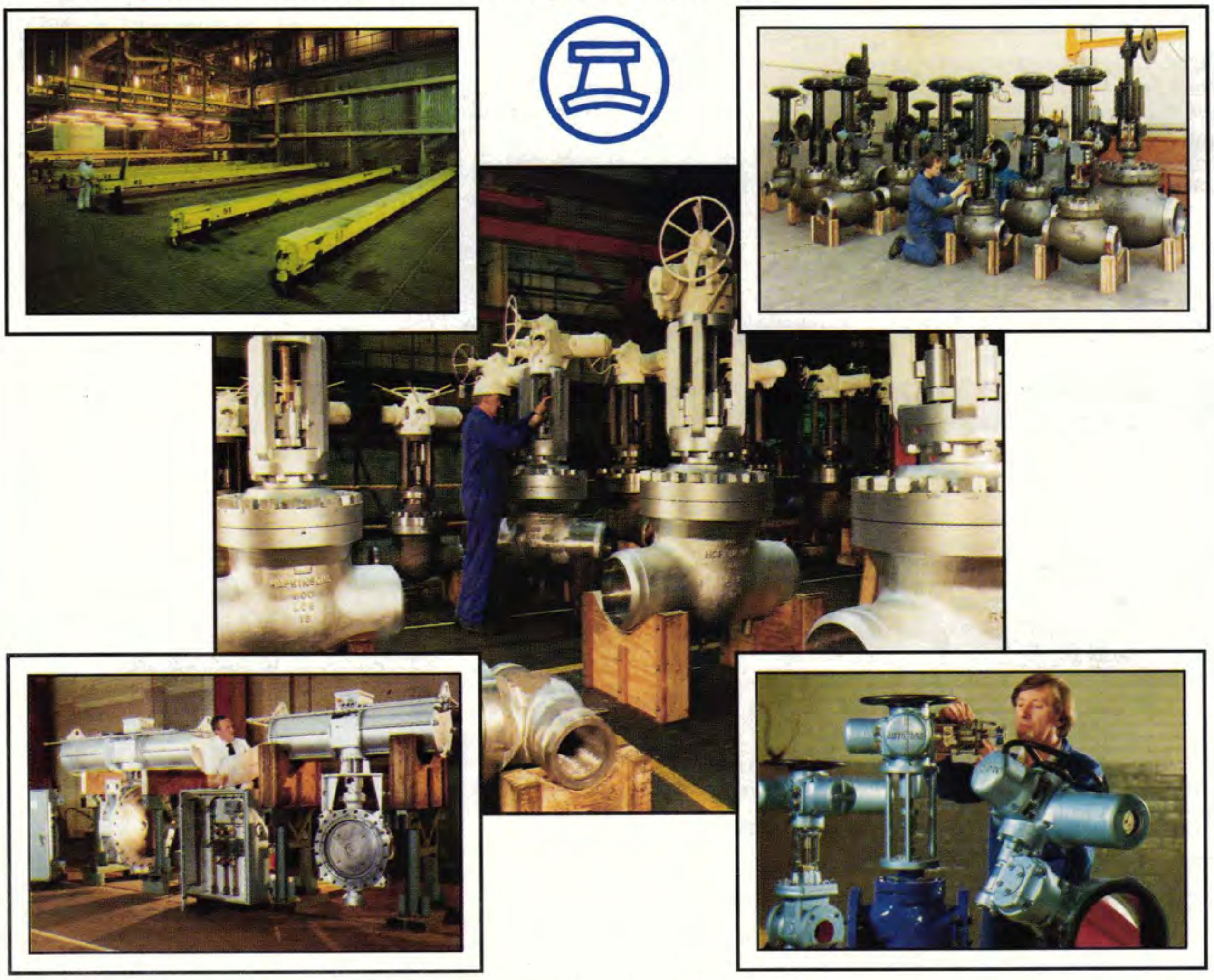

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