ENERGY WORLD

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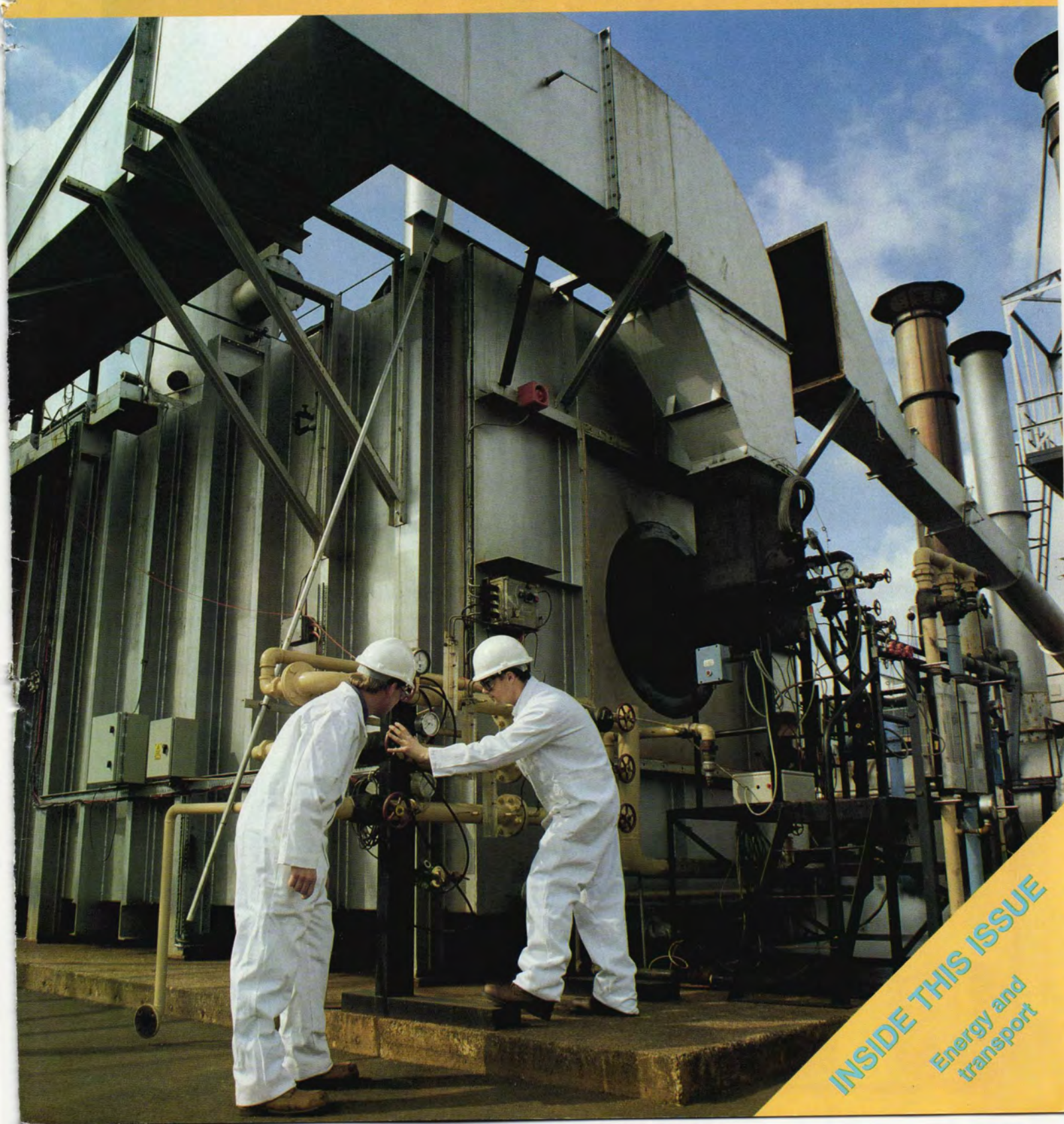

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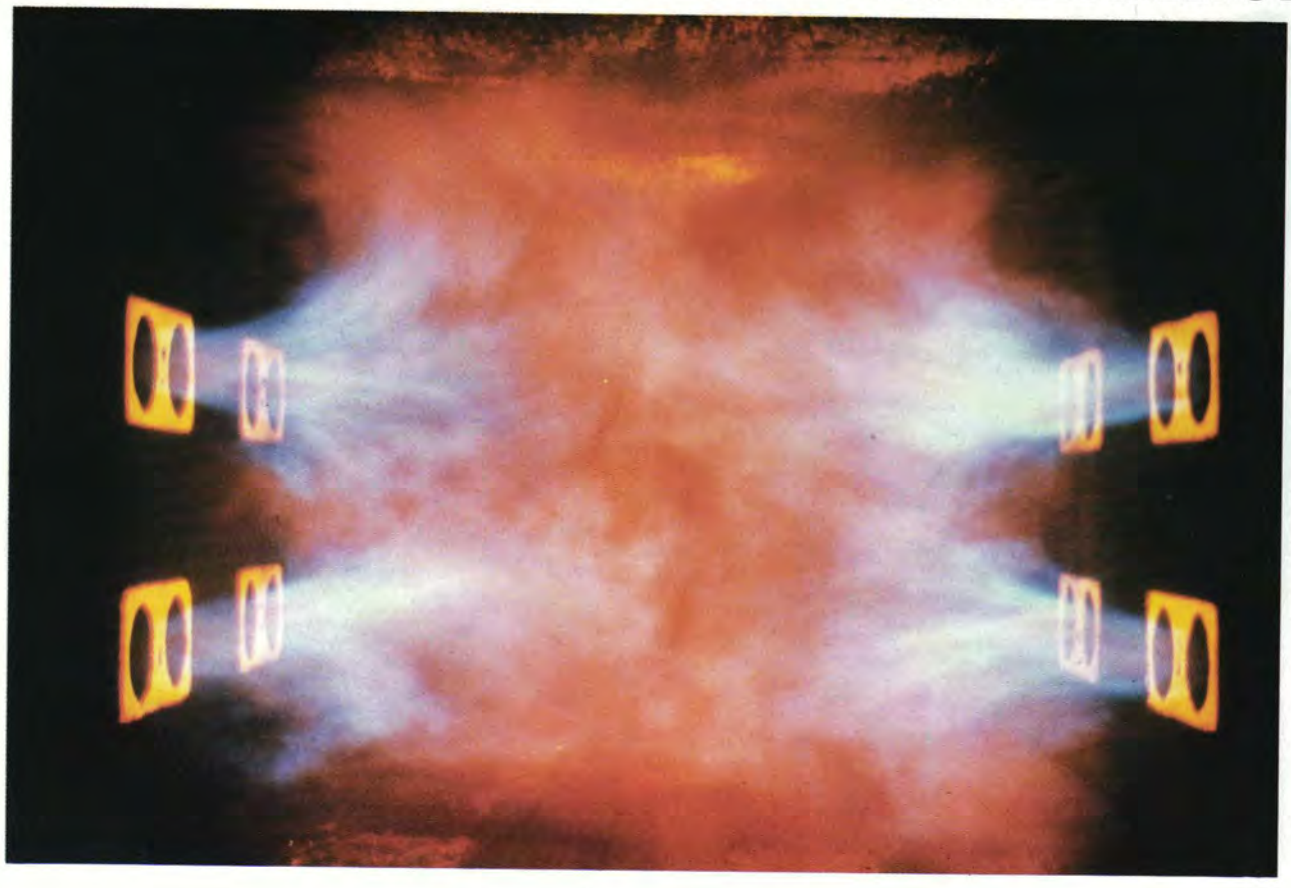

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COVER

The front cover shows Hamworthy Combustion Engineering's £1 million Advanced Technology Centre at Poole, Dorset. It is probably the largest and most comprehensive burner test rig of its type in the world, and plays a core role in the development of new burner technology.

Georgia on their minds

UNDER assistance from the UK Know-How fund, Cheltenham-based CRE Group have designed a special coal-fired boiler for use in the former Soviet Republic of Georgia.

The gas-fired district hot water boilers currently in use in Georgia have fallen into decay and are uneconomic to repair. The ready availability of local coal makes coal-fired boilers the obvious alternative for heating apartments and public buildings in Georgia.

However, local coal contains a high percentage of stone, which gives rise to large amounts of ash when burned. To avoid the associated pollution, CRE designed a special package, comprising both boiler and coal-firing system.

Four boilers will be built this autumn, in time to alleviate the effects of severe winter conditions in the region.. Each will be rated at 300kW, sufficient for an apartment block or school, and will be thermostatically controlled to minimise fuel use. The boilers are designed to be suitable for manufacture under licence within Georgia, with the minimum of imported components.

The project follows some important advisory work, carried out by CRE Group at the request of the Georgian Parliament and the UK Government earlier this year. The local situation was evaluated, and several tonnes of typical Georgian coal were brought to the UK for testing, so the ideal boiler for burning the local fuel could be designed.

The boilers will be tested in Georgia throughout the oncoming winter, with CRE on hand to carry out any required modifications.

Peter Feinson of the UK Know-How Fund said, "I anticipate that this project will both address the Georgian's serious lack of heating and enable them to make more use of their own coal resources. The fund is administered by the Joint Assistance Unit of the Foreign and Commonwealth Office.

Uniform laws sought for nuclear power

THE LEADING lawyers specialising in nuclear and radiation legislation gathered in Helsinki at the beginning of September, to find a solution to the varying questions of nuclear responsibility in the former socialist countries. Efforts were made to clarify the liability issues in order to find better solutions to nuclear and radiation problems in the former socialist countries using Western aid.

Confusion around the question of responsibility has prevented the initiation of several safety projects. Uniform legislation of the nuclear sector and international agreement were sought to block smuggling of nuclear material, to improve control of the non-proliferation treaty, and to accelerate progress of the management of nuclear waste.

180 lawyers from 30 countries converged on the Marina Congress Centre in Helsinki for three days to develop uniform global rules and international agreements for the peaceful use of nuclear power. Improvement in the nuclear liability procedures and control of nuclear material in the countries of the former soviet bloc to correspond to Western standards was seen as a central issue.

The congress sought to pave the way for the countries of central and eastern Europe to join the Vienna Convention on nuclear responsibility, stipulating that the operator of a nuclear plant always bears the ultimate liability for consequences of a possible accident. At present several safety projects prepared in Western countries, and the granted financing for such projects, are frozen until the compensation issue is resolved. Several Western nuclear companies have avoided participating in the risky upgrading projects, since there is no guarantee of the safety of the existing plants, even after improvements. Following an accident, the safety consultant could be held liable to compensate for the accident.

Mr Juhani Santaholma, the Finnish president of the International Nuclear Law Association (INLA), believes that in time a solution can be found to the nuclear liability questions in the former Soviet Union, to make it possible to implement the aid programmes to the full. He sees no obstacles in principle to this issue.: "In 1994, a new nuclear safety agreement came into force, guaranteeing that the signatory states will improve their own legislation and safety regulations up to the Western level."

Lawyers are in the process of preparing a safety convention for the nuclear waste management, to be an international model for appropriate implementation of the nuclear management. According to Santaholma, the procedures applied in the various countries deviate from each other to a considerable extent.

"In certain countries, low-level waste may be kept under the open sky or taken to public dumping grounds, while in other countries, such as Finland, even very low-level waste must be buried deep in the bedrock," added Mr Santaholma.

The congress also deliberated methods of preventing the smuggling of nuclear material and of improving the control of the non-proliferation treaty.

According to the lawyers' statement, the international agreements on the protection of the atmosphere will bring nuclear power a significant role in the energy supply of the future. Mr Santaholma estimates that nuclear power will be of vital importance in achieving the atmospheric objectives in future.

International nuclear contracts and uniform legislation to correspond to Western standards will make it possible to have a wider cooperation between the nuclear experts and companies in the various countries. "Increased peaceful use of nuclear power is possible only if the nuclear legislation and the international contracts are on the appropriate level and the control arrangements are in order. The INLA has a central role in this work," stated Mr Santaholma.

The INLA is a worldwide organisation, covering the membership of some 5000 lawyers and experts working for laws and conventions on the use of nuclear power and radiation protection. The INLA headquarters are located in Brussels. Its aims to advance research on peaceful use of nuclear energy and at increasing the related information, with the environment a central issue of interest.

Venezuelan oil and gas prospects explored

VENEZUELAN plans to re-open foreign investment opportunities in its huge oil industry were the reason for a three-day visit by UK Trade Minister, Lord Fraser of Carmyllie in September.

The Minister spoke at the fourth international energy conference in Puerto La Cruz, followed by a one-day visit to Trinidad. "The opportunities for British companies in Venezuela's oil industry are immense," he said. "One of the world's largest petroleum companies, Petroleos de Venezuela SA (PDVSA), has US$48 billion of investment planned by the year 2002, with US$5.3 billion allocated for imports of goods and services in the next five years.

"Venezuela has among the largest petroleum reserves in the Western world, and recent decisions to open their energy industry to foreign investment make this a very exciting prospect.

"British industry has much to offer there, particular in the oil and gas sector and power generation, plus a competitive edge sharpened by the industry's CRINE (cost reduction in the new era) initiative."

During the visit, Lord Fraser met Dr Erwin Arrieta Valara, Minister of Energy and Mines, and PDVSA executives, as well as visiting BP's Pedernales oilfield.

1998 trials for deregulation

AT the beginning of October, OFFER issued a consultation paper on trials for the deregulation of the electricity market in 1998.

The proposed arrangements are not simply an extension of existing arrangements. The introduction of profiling and the need for other new arrangements, particularly those relating to domestic customers, will mark important developments both from present arrangements in the 100kW market and in the way in which supply to customers presently in the franchise is handled.

OFFERs initial view is that system trials will be an essential prerequisite to the introduction of new systems on 1 April 1998. Prime responsibility for system trials will rest with system providers, with oversight and direction being provided by the Pool in England and Wales and the two PESs in Scotland.

It is for consideration whether trials should involve the early introduction of full competition in any area; the direct contracting of customers supported by bilateral trading agreements or without changing their primary relationship with the local PES.

OFFER is seeking views on the issues raised in their consultation paper and, in particular, the need for and form of any customer trials. In addition they would like comments on the following: what type of trials should be undertaken and what are the benefits to be expected; when will it be practicable to undertake such trials; what steps need to be taken to allow such trials to proceed (in particular would licence amendments and/or changes to the Pooling and Settlement Agreement required); who should be responsible for the implementation of customer trials; and, are there any principles which should guide the choice of locations or customers to be involved in trials?

Responses should be addressed to Chris Litherland, Supply Competition at OFFER, by 19 October 1995.

New energy management Chair at University of Aberdeen

A NEW Chair of Energy Management is to be created at the University of Aberdeen.

The announcement follows the recent establishment of a new Oil and Gas Institute at the University, within the context of which the Chair holder will be expected to make a significant contribution. Schlumberger are providing the sponsorship.

The new professor will work closely with the oil and gas industry to develop further teaching and training programmes in management which are relevant and appropriate within the technical context of the industry.

They will also lead research into management within the oil and gas sector, building on existing work within the University's Centre for Management Studies. The research programme will provide both a valuable facility for the oil and gas sector in its own right, as well as ensuring that training programmes provided by the University remain at the forefront of research.

The University of Aberdeen has strong and varied academic expertise in a number of areas concerned with the offshore industry, including petroleum economics, geoscience, commercial law and offshore safety. This complements the international business expertise of the oil and gas and related industrial sectors in the North East..

Professor John Sewell, Dean of the Faculty of Social Sciences and Law, said: "We are absolutely delighted that the support of Schlumberger has led to the establishment of the University's first Chair of Energy Management. This appointment will further strengthen the capabilities of the University's Oil and Gas Institute, and is an indicator of our links and developing working relationship with the oil and gas sector."

David Ballie, managing director of Schlumberger Wireline and Testing, said: "Fostering strong associations with Aberdeen University is a demonstration of our commitment to the UK, and in particular, Scotland."

The Oil and Gas Institute is based on new and existing centres of expertise in the University. It will contribute towards the high-level research capability that will be needed to maintain and enhance Aberdeen's position at the heart of the International oil business.

Plant disposal

NATIONAL POWER has selected a shortlist of bidders for the purchase of 4000 MW of coal-fired generating plant. Their decision follows clarification by the regulator of a number of issues raised by prospective purchasers. This stimulated renewed interest, and resulted in a number of sufficiently attractive offers, leading National Power to conclude that a suitable purchaser could be found.

Under the tender process selected bidders — which so far include Applied Energy Services (AES), Eastern Group and Enron — are being invited to make final offers for three power stations. They are the 2000 MW plant at West Burton, near Retford, Nottinghamshire and the plants of 1000 MW each at Ironbridge, Shropshire and Rugeley, Staffordshire.

It is envisaged that — subject to all necessary approvals — agreement will be reached by 31 December 1995, and the transaction completed by no later than March 1996

National Power believe the sale will result in a drop in its share of the generation market in England and Wales to approximately 20% to 25% during the 1996/97 financial year, compared with 34% in 1994/95.

Landfill online

THE first of the successful NFFO 3 energy-from-landfill-gas bids began generating electricity at the beginning of October.

Shanks & McEwan's NFFO 3 unit on the Dogsthorpe landfill site near Peterborough in Cambridgeshire, is now delivering its power to Eastern Electricity.

Two latest generation spark-ignition engines, fed methane-rich gas being naturally produced within the Dogsthorpe site, are already producing three quarters of their generating capacity of 2 MW.

Last December's NFFO tranche gave the go ahead for Dogsthorpe, one of 42 successful landfill gas proposals.

Large combustion plant: amendments to national plan

A CONSULTATION paper setting out proposals for limited changes to the Large Combustion Plant National plan were issued on 15 September by the Department of the Environment.

The plan implements the EC Large Combustion Plant Directive in the UK by setting reduction of targets for emissions of sulphur dioxide (SO_2) and oxides of nitrogen (NO_x) from existing industrial plants.

The proposed change results from an agreement by National Power to make a voluntary transfer to Northern Ireland Electricity of some of its emission quota allocations for 12 000 tonnes of SO_2 in 1995 and 17 000 tonnes in 1996 together with 1000 tonnes of NO_x in each of the two years.

The transfers will not result in any increase in overall UK emissions limits under the National Plan. The increased deposition in certain sensitive areas of the UK resulting from the higher emissions from Northern Irish power stations are not expected to exceed 0.5% - 1% in each of the two years of the proposed transfer. This is in the context of the rapid overall reductions in emissions taking place in the UK and in the rest of Europe.

Reducing NO_x without expensive retrofit

HAMWORTHY Combustion Engineering (HCE) has helped Brunner Mond, the only UK manufacturer of soda ash, significantly reduce emission levels from a 40-year-old boiler, without going to the expense of a complicated and costly retrofit.

Brunner Mond have three 31Wth Babcock bi-drum boilers at their Lostock power station in Northwich, Cheshire, built in the 1950s. The company was anxious to reduce its NO_x emissions down to 450 mg/Nm^3 or less (the new legal limit which must be achieved by the year 2001) as quickly as possible. They decided the solution lay in retrofitting low NO_x burners at outages during 1995, and awarded the contract to retrofit the first burner to HCE.

From its extensive range of products available, HCE selected the staged combustion Peabody LNO burner as the most suitable equipment for the job. It has a proven record of achieving low NO_x levels and its design ensures excellent burn out.

The new burners were provided with front plates to fit the existing windbox openings, and only minor make up of the refractory at the furnace opening was required. Burner front oil pipework was unchanged and only minor re-piping of atomising steam supply was required.

The removal of the old, and installation of the new burners, was carried out during a normal short boiler outage and because no major construction work was needed, the installation was carried out quickly and efficiently with obvious savings in both time and money.

Third party emission monitoring verified the NO_x concentration of 380 mg/Nm^3 firing at 0.15% N HFO, and the success of this first installation has led to a contract to retrofit the two remaining boilers at Lostock power station.

Fuel reformer brings practical electric cars closer

A NEW device that could bring electric cars closer to practical use for daily driving has been invented by the US Department of Energy's Argonne National Laboratory.

The device, called an 'on-board methanol reformer', releases the hydrogen bound up in methanol (methyl alcohol). Because it is more compact than other reformers, it could enable fuel cells to power electric cars.

Fuel cells are like batteries with fuel tanks. Unlike batteries, they produce electricity as long as they have fuel, and they never need recharging. The Department of Energy is currently investigating them as possible electric-vehicle power sources.

"Fuel cells are much more efficient and much less polluting than internal combustion engines," said Romesh Kumar of Argonne's chemical technology division. A major problem, according to Kumar, is that they are fuelled by hydrogen, a very light gas that is difficult to store. Currently available hydrogen-storage technologies are so heavy and bulky that they would limit the driving range of any car that used them.

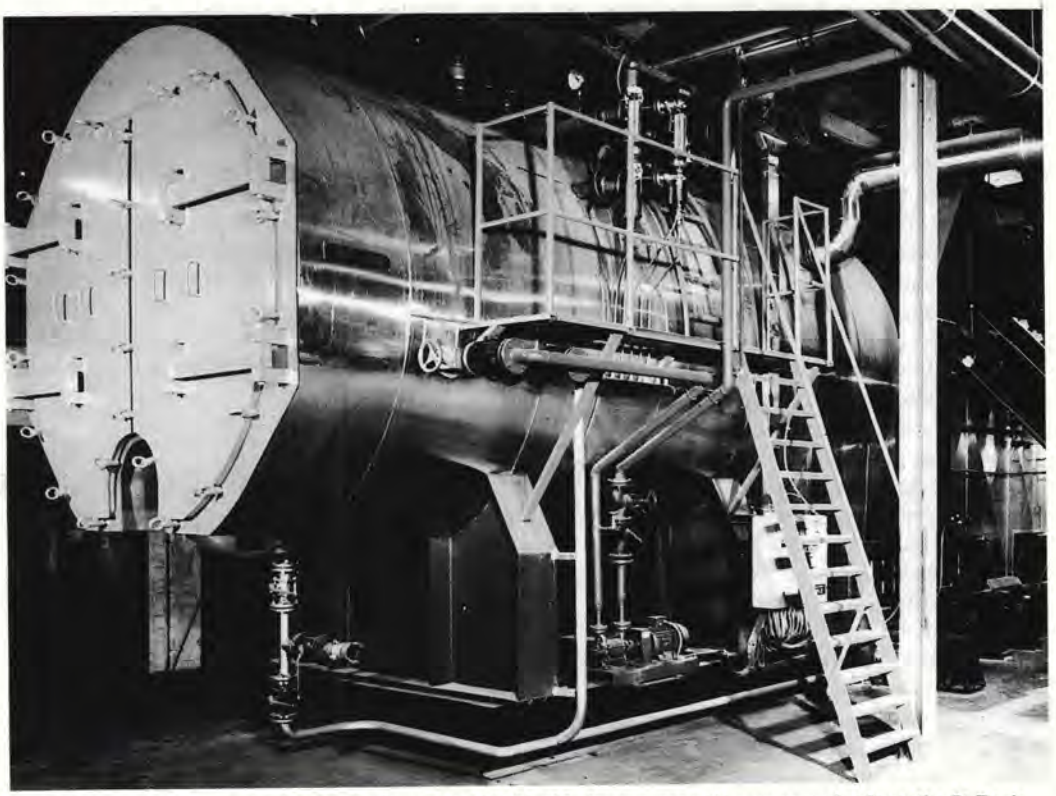
"But an on-board reformer like ours," he said, "Could solve this problem be reforming methanol from the gas tank and feeding the hydrogen into a fuel cell."

The Argonne device takes up less volume than a seven-gallon container. This makes it the first fuel reformer small enough to fit under the hood of a compact car beside a 50 kW polymer-electrolyte-membrane (PEM) fuel cell, DOE's top candidate for an electric-vehicle fuel cell.

Argonne's reformer would combine methanol with oxygen from the air to produce a hydrogen-rich mixture of gases that would be injected into the fuel cell.

Compared to other reformers, Argonne's is lightweight, compact and energy efficient. It is also flexible enough to respond well to frequent startups and shutdowns, and to the rapidly changing engine demands of daily stop-and-go driving.

The design is simple and inexpensive to manufacture. It consists of a cylinder packed with a common and inexpensive catalyst. A nozzle sprays liquid methanol into the cylinder, and an ignition source starts it. A small on-board chemical reactor will convert CO to CO_2.



AP Boilers, the boiler division of Air Plants Ltd (APL) of Leicester, recently won an order from the St Regis Paper Co Ltd for a new, wood-fired, high pressure steam boiler. The new unit is capable of burning up to 1250 kg of waste material per hour from a woodyard at moisture contents of up to 60%, and will operate 24 hours a day, seven days a week. It will supply up to 3600 kg/h of process steam at a pressure of 12.4 bar, for use in the paper mill.

This £500 000 contract for the boiler installation includes controls and instrumentation to monitor continuously and record chimney emissions, as required by HMIP. The boiler is designed to operate within the emission limits set out for boilers firing untreated wood, under the terms of the Environmental Protection Act.

The Vyncke boiler which A P Boilers will install has a specially designed combustion chamber which enables it to meet the toughest environmental standards in the world. Even as the quality and calorific value of the wood waste changes with varying water content, the stoker feed automatically compensates to ensure good combustion and low emissions.

On the road with natural gas

A REPORT commissioned by British Gas, and published earlier this year, concluded that the financial cost to human health created by diesel vehicle m=emissions in urban areas is more than two and a half times greater than that from petrol. When compared to natural gas, the risk is 13 times greater.

These alarming figures were announced at a National Society for Clean Air and Environmental Protection conference on the theme *Greener Fuels for Cleaner Air*, in Birmingham.

The report revealed the financial impact of unleaded petrol, diesel and compressed natural gas emissions on both the environment and society in rural and urban areas. Where UK towns are concerned, the study calculates the cost of pollution at 2.6 pence per kilometre for every vehicle running on diesel, compared to 1p for unleaded petrol, and an impressively low 0.2p for natural gas.

Energy World first reported on natural gas vehicles in November 1992, since when the environmental advantages of natural gas as a transport fuel have become increasingly widely recognised. This article examines the current status of the technology, and looks towards its future development.

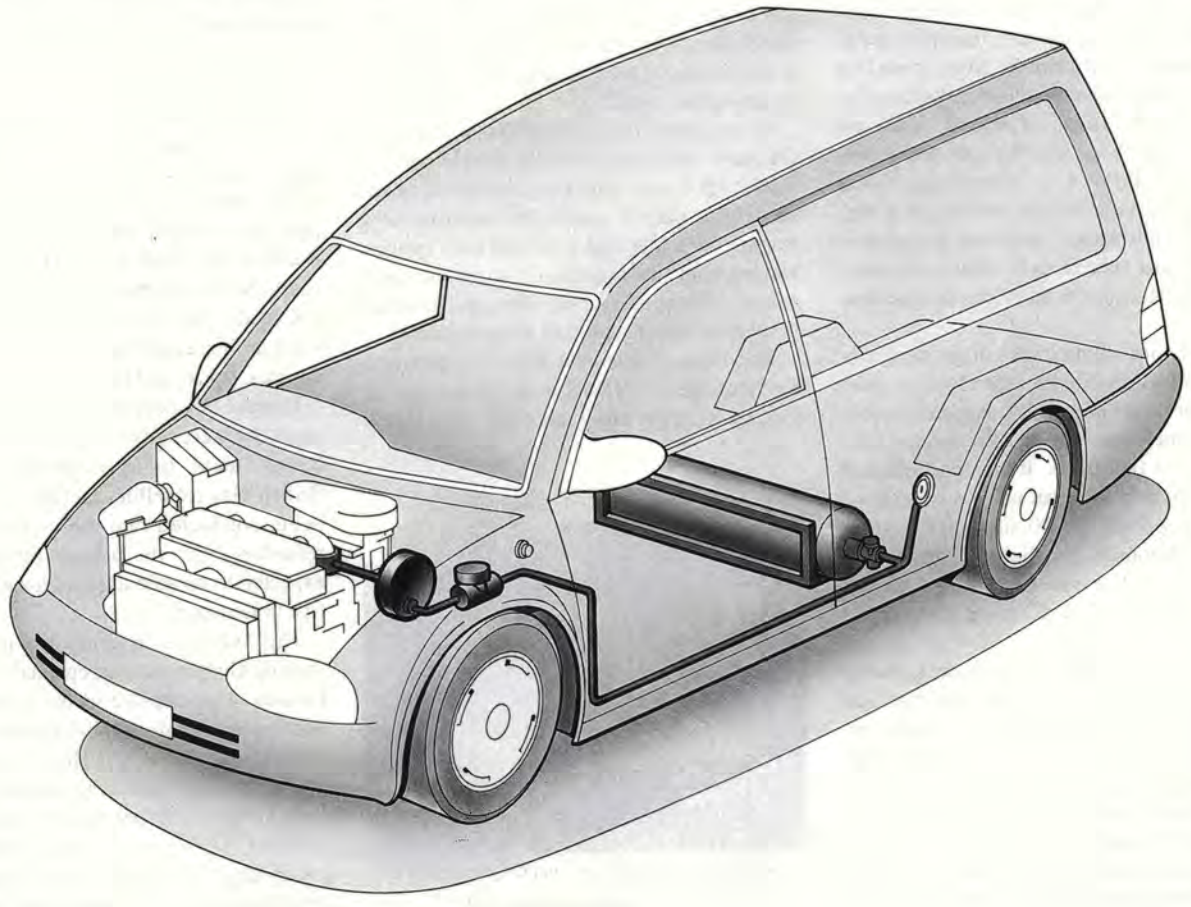
In rural areas the figures were 0.6p for diesel, 0.4p for unleaded petrol, and 0.1p for natural gas.

In the assessment of the three fuels, the largest proportion of the costs incurred by society are on health, building and crop damage. Liquid fuels' biggest impact is on health, while that of natural gas is on global warming. However, the report indicated that natural gas's effect on global warming is still smaller than that created by petrol or diesel emissions.

In a breakdown of the impact of different pollutants from the three fuels, the report claims that particulate emissions in vehicle exhaust, from petrol and diesel vehicles, are largely responsible for triggering asthma. Emissions of particulates are virtually eliminated with natural gas. It also concluded that nitrogen oxides have a major impact on other respiratory difficulties. Diesel emissions of NO_x are five times worse than natural gas, while petrol is six times worse.

Using accepted techniques of social economics, the report is one of the first to attempt to put a monetary value on the effects of pollution from transport emissions. For example, in the case of damage to timber production, the study team was able to calculate the degree to which transport pollution reduces the national timber yield. It was then able to apply market pricing to deliver a monetary value for lost production.

Natural Gas Vehicle Association chairman, Tom Gorman, said at the time of the conference: "In July 1994 we proved that natural gas is a vehicle fuel which makes significant emission savings. We have now completed the picture by realistically



appraising the social on-cost of the continued use of oil-based fuels. The report shows that we have to change. It should also send a strong signal to Government to take action to reduce the tax on natural gas if they want to reduce the spend on damage created by dirty vehicle emissions."

Another call for tax cuts on natural gas as a vehicle fuel came from the House of Lords Select Committee on Sustainable Development. A report from the committee, published in June 1994, recognised the environmental benefits of NGVs, and stressed the need for the Government to respond quickly to air pollution concerns by encouraging its development in the UK. As yet, no Government action has been taken.

The House of Lords report states: " ... we believe that the current tax treatment of natural gas as a road fuel merits early revision. At present the tax is fixed at 404% of the European permitted minimum. The Government should cut drastically as other EU member states have done. Without such action, the undisputed environmental benefits which could be derived from its use, particularly by buses and taxis, will not be realised.

A wide range of natural gas vehicles (NGVs) are currently available, and indeed are now in use across the country. Business Gas is the industrial division of British Gas responsible for NGVs, and it has an expanding network of refuelling stations. The company says it is 'actively encouraging' local authorities, bus companies, transport planners, operators and manufacturers to switch to natural gas as a vehicle fuel. Southampton has taken the idea on board, with its 'ecobus', which carries the gas containers mounted on the roof — a technique which when applied to a vehicle the size of a single-decker bus looks surprisingly unobtrusive. A similar scheme in Newbury uses storage space beneath the floor for its gas containers.

Safety is one of the issues of greatest concern. The NGVA claims natural gas is safer than either diesel or petrol. It is stored in purpose designed pressure vessels, tougher than conventional fuel tanks. It also has a higher ignition temperature than petrol or diesel — 600°C, as opposed to 400 and 250°C respectively. Additionally it is lighter than air, and so in the unlikely event of a leakage, the gas disperses instead of forming dangerous pools.

Gas containers in NGVs are designed to operate at storage pressures of 200 bar, and are tested at 250 bar. Container manufacturers have dropped them, crashed them, tried to burn them, and even shot at them during severe abuse tests. The containers are designed to vent is the pressure inside becomes too great, due to excessive heat. The controlled burn-off of gas means there is no risk of explosion should an NGV be involved in a fire. The sealed nature of refuelling also reduces fire risk — unlike petrol and diesel, natural gas cannot be spilled. By way of proof, an arson attack on a Dutch bus garage destroyed an entire fleet of vehicles. The garage contained both NGVs and diesel buses. The charred remains revealed all the gas containers fully intact. This led to the Dutch fire authorities commenting that gas-powered buses were clearly safer than their diesel counterparts.

A natural gas refuelling station.

To encourage the use of NGVs, Business Gas have developed 'bi-fuel vehicle conversion'. All it now takes to convert a petrol vehicle to natural gas is the addition of a storage container and a second fuel system. Having both fuel systems on board increases overall vehicle range, and offers the flexibility to select the cleaner fuel when available.

The Lane Group and BOC Distribution Services are two fleets using dedicated, or gas only, engines based on the latest technology.

NGV product development programmes around the world are striving for continuous improvements in the technology. Engine management systems, such as GFI (gaseous fuel injection) are standard on Business Gas conversions. GFI ensures the vehicle runs at optimum performance — that is not only clean, but also energy-efficient.

When *Energy World* last covered this subject, some three years ago, we gave the example of Canada as one of the few countries which used NGVs for commercial vehicles. The same can now be said of the UK, where natural gas is commonly used for both light and medium-sized commercial vehicles. Business Gas predict that within the next ten years, NGVs will become a common sight on UK roads. New development is bringing forward an increased range of vehicles, including cars, trucks and buses.

Current UK development of use of NGVs must, by necessity, concentrate on depot-based fleets, using either their own, or British Gas refuelling facilities. Research is being conducted into the concept of home refuelling, but the private motorist is not expected to be able to participate for another five to ten years.

The NGVA is concentrating its efforts on seeking Government acceptance of NGVs. In Canada, where uptake of the technology has been widespread, the Government imposes no tax at at on NGVs. Here the number of conversions of vehicles to natural gas is running at over 100 per month. Business Gas and the NGVA are working together to encourage UK manufacturers to make suitable gas engines available in this country. ❑

Southampton's natural gas Citybus, which carries its gas cylinders on the roof.

Eco2000 — a modular design concept for locomotives

*by Karl-Heinz Buchholz, Dr Joachim Nordmann & Lutz Schwendt**

The Eco2000 family of locomotives is based on a modular design concept to meet the environmental needs of railway operators. The modules can be used to custom-build multipurpose locomotives for passenger and freight services. Electric and diesel propulsion systems with powers ranging from 3 to 6.4 MW are available. Successful trials were recently completed.

INNOVATIVE technology is essential if the railways are to compete successfully with other means of transportation in the future. A locomotive designed for the coming decades must satisfy a wide range of requirements, some of which may be conflicting. Among the issues that have to be addressed are environmental compatibility, reliability and robustness, ease of maintenance, flexibility and versatility, and economy.

Environmental compatibility is rightly given a high priority today. In terms of energy, it means high efficiencies, a power factor close to unity and energy recovery during braking. Rail tractive units are required to operate as quietly as possible, calling for a reduction in fan noise in spite of the need to improve performance. Leaking of lubricants, coolant or liquid insulting media has to be prevented; in addition, such liquids have to be biologically degradable and are not allowed to pose a threat to the ozone layer. Last but least, it has to be ensured that all the employed materials can be disposed of in accordance with the latest environmental legislation.

Eco2000 family of locomotives: at top a multipurpose locomotive with 6.4 MW drive rating; below it a power car; second from bottom, a freight train locomotive with two driver's cabs; at bottom a shunter. In principle all the types can be built with power ratings from 3 to 6.4 MW.

Today' electric power units, especially those for high-speed trains, already perform at a very high level. Regionally and internationally coordinated timetables as well as shorter times for connections depend on trains running punctually. Trouble-free performance has already been markedly improved and will improve further; component failures that do interfere, in extreme cases, with operation, must on no account be allowed to cause outages that could bring trains to a standstill.

With the Eco2000, ABB Henschel has launched a locomotive concept that not only meets all of these requirements but also addresses the wider social and political implications of modern-day transportation.

The modular design of the Eco2000 allows its use as a versatile, multipurpose locomotive for passenger and freight trains, a high-speed power car or a purpose-built unit for freight trains. Electric and diesel drive systems are available with power ratings from three to 6.4 MW. The modular concept unites operational benefits, economy and ecology — if required, in a unit custom-built to a railway operator's own specifications.

The modularity is not only responsible for simpler and more cost-effective vehicle maintenance, but also reduces the cost of development and testing of new locomotives. Intelligent interfaces allow existing technology to be matched to the latest developments, ensuring fast response to ongoing changes in the area of traction engineering.

Design of the carbody

One of ABB Henschel's top priorities during the development of the modular locomotive carbody was a rugged, simple steel construction. Key requirements here were:

- a carbody that meets all load requirements with a sufficient safety margin;
- economical fabrication and maintenance;
- lowest possible weight.

The carbody itself consists of three modules: the side walls with longitudinal beams, the driver's cab(s) and the transoms of the underframe. This concept allows a large choice of key vehicle parameters, eg, the vehicle's length, the cab shape and number, and the loading gauge.

The driver's cab — the train driver's workplace — has to provide the right working environment all year through as well as the required mechanical protection. In addition to a version which can be strengthened for even higher loads (up to 700 kN); incorporation of energy-absorbing structural elements is also possible. Maintenance and servicing of the driver's cab has been kept simple. The outside panels are easy and economical to repair. Large corner radiuses, the rectilinear front and a flat windscreen give the locomotive an advanced, aerodynamic contour.

The standard driver's can has an almost timeless appearance. Thanks to the modular concept, other cab designs, even customers' own unique creations, are possible.

The side walls, which also have a supporting function, consist of 4 mm thick panels in the standard design; this has reduced the reinforcements and also the number of welds to a minimum. The side wall's top flange is formed from the panel itself, while the lower horizontal beam — a welded C-shaped sec-

**ABB Henschel*

tion — is an integral component of the wall.

These and other design features, such as corrugated side panels or alternative materials (eg, stainless steel), can be easily integrated in the standard concept should the design or weight of the locomotive make special demands on its construction. The side walls are welded, together with the standardised underframe components and both the driver's cabs, to the carbody. The underframe itself comprises the following main welded assemblies:

- the frame ends, which can be adapted to the different coupling systems, eg, to side buffers with draw hooks or automatic central buffer couplings;
- the transoms that take up the secondary suspension forces; these can be adapted to the different drive concepts, with the motor mounted either below the carbody or in the bogie;
- the transformer crossmember, in which the pivots for the bogies' weight transfer linkage are inserted.

The central horizontal beam between the frame ends and transformer cross-members and the flat cover plate complete the carbody's structure. Openings in the cover plate are for the traction motor air ducts, the exhaust for the air exiting the system used to cool the liquids, the electrical connections between the transformer and converters and when applicable, the intake air for the braking resistor. Four beams run the full length of the cover sheet, reinforcing it and simplifying the assembly of the equipment installed in the machine compartment.

Bogies

The Flexifloat bogie was integrated in the design of the Eco2000 because its unproven characteristics meet in an outstanding way the specifications of the Eco2000 bogie. Thus, ABB Henschel is able to offer customers identical components, even when the requirements made on the units vary widely.

Flexifloat bogies require only minimal maintenance. For example, the wheelsets are guided in the longitudinal direction by one link per axle box. Given the high demands made on the locomotives, this represents the simplest way of avoiding wear in the guiding system. The links are fixed by simple bolts, which are subjected to tensile stress only, to allow easy checking and replacement. The link's rubber joints are designed to give very long service, ensuring stable running properties over a long period of time.

In the lateral direction, the axle is guided by the primary coil springs. Thus, there is no need for additional components, and the elasticity constant of the coil springs, which has an important influence on the running properties, never changes.

Flexicoil springs provide the secondary vertical suspension and are responsible for the lateral guidance of the carbody. These coil springs require no maintenance. Their central arrangement on the longitudinal bar of the bogie frame avoids torsional stress in the beams and reduces both the number of components and overall weight.

The bogies are guided in the longitudinal direction by a low-lying, easily accessible push-pull rod. To lift the carbody from the bogie it is only necessary to loosen a small number of bolts. When carrying out maintenance on the bogie frame only few axle guide fixing points need to be checked.

Flexifloat bogies are available in many different versions, all of which are designed to the same principles. Two-axle or three-axle bogies are available with:

- axle-hung motors, fully or partly sprung drives and traction motors;
- shoe or disc brakes;
- different gauges and axle loads.

The Flexifloat bogie is suitable for a wide range of applications; for instance, it can handle the high tractive efforts of freight trains just as well as the top speeds of 200 to 220 km/h of intercity trains. Its short wheelbase of 2650 mm was a key factor in its outstanding performance during trials on twisting stretches of line, during which it exhibited excellent running properties even in very sharp bends.

ABB Henschel has also developed a completely new drive concept. Known as the IGA integrated drive system, it allows an output of more than 1600 kW per wheelset; the traction motor and gearbox form a compact drive unit which is not only easy to assemble but also exhibits a very long service life. The gearing is mounted in a strong case made of nodular cast iron. Extensive in-service testing has verified that the gearbox

Table 1: Technical data of the Eco2000 family of locomotives. The four types given are examples. All versions of the Eco2000 can be customised. ABB Henschel can also supply the locomotives as six-axle units.

Type	Multipurpose unit	Power car	Freight train loco I	freight train loco II
Power output (MW)	6.4	4.8	6.0	4.4
Starting tractive effort (kN)	300	300	310	290
Top speed (km/h)	230	230	140	140
Wheelset drive	Integrated system	Integrated system	Axle-hung	Axle-hung
Total weight (t)	86	76	86	84
Axle load (t)	21.5	19	21.5	21
Length over buffers (mm)	18950	19050	18300	18300
Power system			15 kV,162/3 Hz	
Carbody width (mm)			2950	
Bogie wheelbase (mm)			2650	

Standard design of the Eco2000 locomotive with its striking, virtually timeless appearance. Since it is made up of modules, customers can choose from various cab designs, or even create their own, unique cab front.

is leak-proof, thus confirming the environmental soundness of the system.

The traction motor, normally a rugged induction motor, has the drive side of its stator bolted to the gearbox. A hollow cardan shaft transmits the torque from the gearbox to the wheelset. This shaft does not pass through the gearbox.

Main power circuit

The standard power circuit for locomotives today is based on the simple, robust three-phase AC motor in combination with GTO inverters with an intermediate DC link. In the case of AC traction power networks, as operated by German Railways (DBAG) and Danish State Railways (DSB), the power circuit has four-quadrant controllers connected to a transformer. Where direct voltage catenaries are standard, as in Italy and the Netherlands, either a double-star circuit or direct catenary infeed is employed.

The modularity of the multipurpose Eco2000 allows it to be adapted to either type of power supply. In fact, it is possible to build multisystem vehicles based on it.

The power rating is modified to suit the customer's requirements by choosing the number of inverters, input converters and intermediate DC links. The optimal circuit is therefore available for ratings from 1.0 to 6.4 MW.

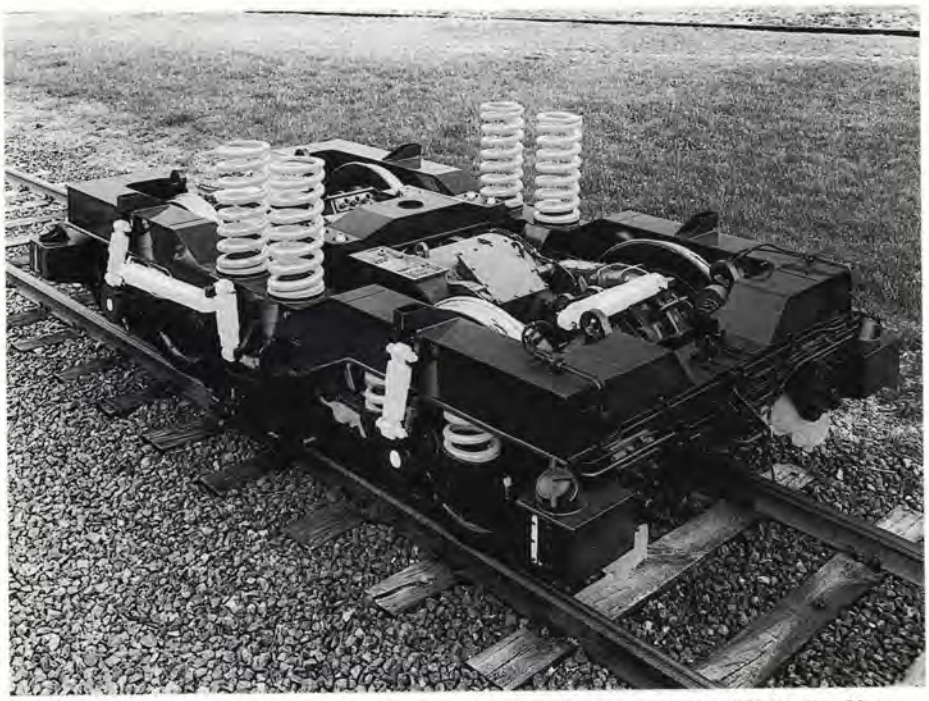
German Railways' class BR 101 locomotive, for example, employs a circuit from the Eco2000 range which is designed for a maximum output of 6.6 MW. This locomotive is intended for use with passenger as well as freight trains. Its maximum starting tractive effort is 300 kN and it can run at speeds of up to 220 km/h.

The locomotive's circuit configuration ensures that, as a rule, three-quarters of the vehicle' power rating remains available in the event of failures in the traction circuit. This is a significant improvement over the earlier circuits, which provided only half of the drive power in such cases.

The three-phase AC drive system with induction traction motors and GTO inverters is a proven technology and represents the power circuit of choice for high-power locomotives. Units belonging to the first generation of rail tractive vehicles with this technology (still with their original oil-cooled converters) are now approaching the two-million kilometre mark. More recent development work on these drives has focused on optimising the module technology and cooling system.

Table 2: Main data of the class BR 101 locomotive operated by Germany Railways

Power system	15 kV/16 2/3 Hz	
Wheelset arrangement	Bo'Bo'	
Gauge	1435	mm
Weight in running order	86.6	t
Top speed	220	km/h
Power, max	6600	kW
Continuous rating (UIC)	6400	kW
Regenerative braking, max	6600	kW
Starting tractive effort, max	300	kN
Starting tractive effort, cont	250	kN
Max tractive effort at 220 km/h	108	kN
Cont tractive effort at 220 km/h	104	kN
Intermediate DC links	4	
Inverters	4	
Four-quadrant controllers	4	
Auxiliary converters	3	
Profile	Swiss standard gauge	
Length over buffers	18950	mm
Distance between bogie centres	10950	mm
Bogie wheelbase	2650	mm
Wheel diameter, new	1250	mm
Wheel diameter, worn	1170	mm
Other features	2 driver's cabs, airconditioned Machine compartment with central gangway	



The multipurpose bogie, with integrated drive system, designed for the Eco2000 family of locomotives. A short wheelbase plus special design features have resulted in outstanding running properties with this bogie.

Liquid cooling

ABB Henschel has developed a very compact three-phase module which accommodates the power semiconductors and all the snubber circuit and protection components. Liquid-cooling is used. The coolant is biologically degradable ester; this exhibits a high electric strength, excellent long-term stability and good arc quenching capability, and allows a high operating temperature. Ester can also be recycled. The module has been designed with a very high power density, its compactness and relatively low weight making it suitable for a wide range of applications. Only minimal work is required to connect it to the converter cubicle.

MICAS® S, an advanced control system that has been integrated in the Eco2000 design, has markedly reduced the amount of wiring that is necessary. The system replaces complex configurations that use individual control wires by simple, hierarchically

organised data bus links, a feature which also enhances the user0friendliness of the control. The system consists mainly of a higher-order, central locomotive controller. The central controller is responsible for:

- processing of commands and data, etc, entered in the driver's cab;
- locomotive protection;
- coupling to the dual-traction and reversing control;
- coupling to the vehicle bus;
- coupling to vehicle-specific parts of the internal vehicle bus, eg, in the driver's cab and at the main circuit breaker;
- diagnostics and disturbance display.

The drive controls have the following tasks:

- control of the four-quadrant controller;
- control of the inverter;
- coupling to the vehicle bus;
- link-up to the internal vehicle bus for access to the peripheral signals from the bogie;
- disturbance display diagnostics.

Although it considerably widens the scope of the control functions, MICAS S also reduces the electronics hardware markedly. This translates into fewer components and connections. Moreover, all the control functions are implemented in the software; there are no conventional hardware links. One important result is greatly enhanced (ie, failure rates are reduced).

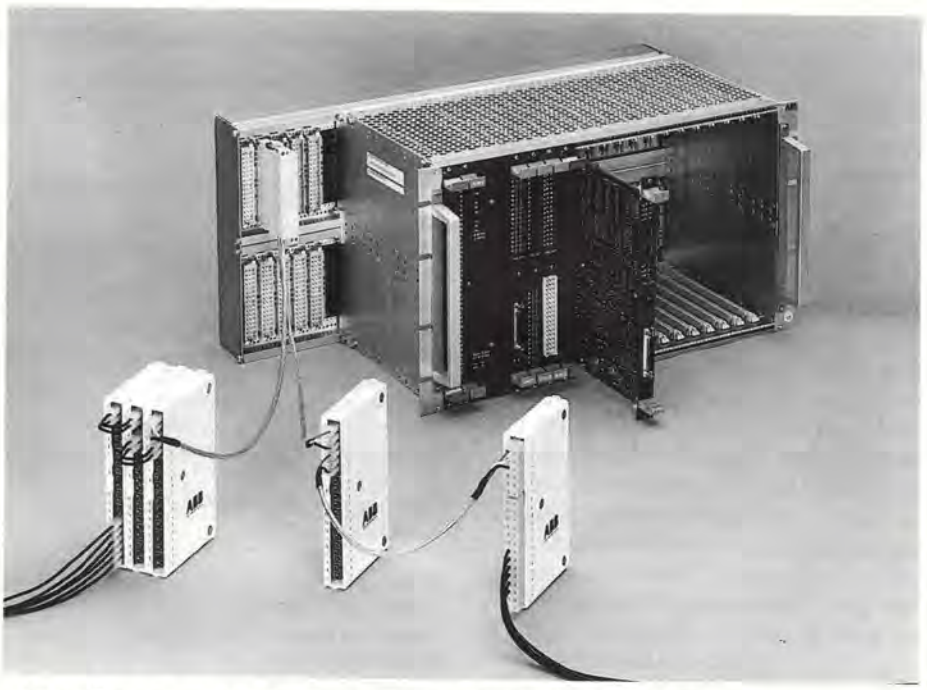
On the drive side, the fast-response DSR controller provides direct, self-regulation of the induction motors. DSR is a proven method combining excellent control response with comparatively simple signal processing. DSR supports efficient, dedicated wheelset control in an ideal way, particularly when the vehicle is running at the adhesion limit.

The computer-based diagnostics system, DAVID, developed by ABB Henschel for the German ICE power car, is used in a modified form in the Eco2000. The system provides the train driver with messages and information in plain text on his cab display. To facilitate maintenance in the workshop, the data are stored and can be read out on a portable personal computer. Computer-based evaluation of data is also a feature of this system.

Auxiliary converters

The Eco2000 design concept also provides for modifications to the auxiliaries to take account of the supply systems in the case of DC power supplies, controllers are used to reduce the voltage to a low level. One or more inverters, depending on the requirements of the auxiliaries, provide power at the lower voltage to a three-phase AC circuit.

In the case of vehicles operated off AC systems — eg, the class 101 in use with DBAG — power is supplied via converters from a special transformer winding. The auxiliary power is then supplied by the three-phase AC circuit.



MICAS® S distributed traction control system for the Eco2000 family of locomotives.

The BR 101 also features redundancy, making sure that there are practically no operational restrictions as a result of failure of an auxiliary converter.

The Eco2000 also employs advanced technology for the conventional equipment. The vacuum circuit-breaker was specially developed for traction applications and takes up considerably less space than the airblast breakers used in the past.

The main transformer lies on its side beneath the carbody and is also cooled with ecologically sound ester.

The rugged three-phase AC traction motors are without housings, forming together with the drive unit the IGA integrated drive system described earlier. Its compactness and low weight allows bogies of a simpler design to be built, since the traction motor can be suspended in the carbody. This also reduces track wear.

Auxiliaries, such as coolers, pumps and fans, are driven by simple three-phase AC motors to minimise maintenance.

The Eco2000 is the first design concept to unite ABB's know-how and experience in locomotive engineering worldwide in a single system. The basic technology and a range of subsystems have proved their worth in extensive trial runs in test locomotives (120 004 and 120 005) as well as in normal revenue service. Locomotive 120 005, equipped with modern GTO converters and MICAS S control equipment, has run as many as 25 000 km a month in daily DBAG commercial service since the beginning of 1992. Its sister locomotive, the 120 004, also successfully tested the biologically degradable ester as coolant. This replaces about 400 litres of conventional converter coolant and additional 2 tonnes of transformer oil.

Well proven technology

The basic technology used in Eco2000 has also proved itself in hundreds of ABB locomotives all over the world. The latest examples are the Eurotunnel locomotives running shuttle services under the English Channel, plus the successful Swiss family of locomotives known collectively as 'Lok 2000'.

The Eco2000 locomotive concept has a promising future, as first orders confirm: Italian Railways has placed an order for 20 Eco2000 multipurpose units, delivery of which will begin in 1996. These will feature multiple-system equipment for cross-border traffic. German Railways has ordered a total of 145 units for high-speed passenger services. With their 6.4 MW drives, these multipurpose, environmentally kind locomotives will accelerate the trains to speeds of up to 220 km/h. Greece's Hellenic Railways Organisation (OSE) has also ordered 15 diesel-electric units rated at 2000 kW from the Eco2000 locomotive family. ❑

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Scandinavian electric car rally

THE first rally strictly for electric vehicles and hybrid vehicles was run between Gothenburg and Oslo at the beginning of August. It followed a seminar on the latest developments in the field of electric vehicles, presented by researchers from all over the world, on 31 July.

Presentations for the Scandinavian Electric Car Rally (SERC) '95 included an account of the hybrid electric vehicle project at California State University; a survey of the technical and political status of electric vehicles in Germany by the Institut für Elektronik in Berlin; a paper on the present activities in electric vehicles in Switzerland came from the Swiss Federal Office of Energy; and an expert panel discussion on the theme of economy, market and electric vehicles. In the short space of one day a comprehensive coverage of a very broad topic was achieved by a highly authoratitive range of speakers.

The rally began the following day. It was organised by the energy utilities Göteborg Energi AB and Oslo Energi AB, and assisted by the Swedish and Norwegian Automobile federations. It major aim was to stimulate the development of environmentally friendly vehicles. The competition was open to electric car manufacturers, conventional automobile manufacturers, and research projects, as well as larger companies which use electric vehicles.

Amongst the 28 team entrants competing were Ford, Toyota, Volvo, Renault, Volkswagen, Norwegian Pivco, Swedish Solon and Danish Kewet. Five daily legs took competitors through Lysekil, Halden and Moss, with several different special stages, such as hill climb, racing, drag racing and regularity tests.

The rally comprised three awards. The SECR Golden award for the car with the fastest time over the special stages; the SECR Energy Saver award, for the car with the lowest energy consumption; and the Scandinavian Electric Car of the Year award, for the car with the highest potential for real market introduction. The cars were divided into different classes, with strictly electrical powered cars and hybrids, as well as classes for delivery vehicles. The total length of the rally was 550 kilometres, with the longest leg at 180 km. The special stages totalled 70 km.

The first SECR Golden Award was taken by Swedish rally driver Thomas Rådström, with co driver Benny Mellander, driving a RAV4 EV for rally entrants Toyota Motor Europe/Toyota Team Sweden. Toyota was the fastest production car and the fastest car over all. Second in this class was the Norwegian driver Birger Gundersen in a Ford Ecostar, with his team mate the former World Rally Champion, Stig Blomqvist from Sweden, in a similar car in third place.

In the prototype class, the fastest car was a City Bee Rally, driven by Svend Ole Örken and Jan Reimers from Norway. Their time was good enough to given them an overall fourth place in the rally. Second in this class was a French team in a Renault Clio. Third was another City Bee.

The SECR Energy Saver award, for the car with the lowest energy consumption, went to the small El Cat, a transport vehicle entered by Göteborg Energi.

Spectators seemed impressed by both the acceleration and speed of the electric vehicles. It was a rally in the true spirit of the sport. The next rally is planned for 1997, and we await the technological developments with bated breath. ❑

The Ford Ecostar, second fastest in its class. Two of these models were entered by Mobil Ford Motorsport.

Queen's building

— an undergraduate laboratory

*by Dr Philip Few, FInstE FIMechE and Martin Smith, BEng MSc**

This is the last in a series of three articles on the development of the Queen's Building at De Montfort University (*'The New engineering building as a test faculty for energy studies', Energy World,* October 1993; and *'CHP at De Montfort University', Energy World,* October 1994), which recently won the Green Building of the Year Award.

DE MONTFORT University's widely acclaimed Queen's building, which provides accommodation for the School of Engineering and Manufacture, has recently won the Green Building of the Year Award for its many innovative energy conscious features. At its inception it was intended that the building itself would serve as a learning tool and research facility for students and researchers to use as a full-scale experiment. Much research has already been carried out using the building, and undergraduate project work has been recently completed.

In this article we examine the use of the building as an aid to the teaching of heat transfer theory to second year undergraduate engineering students, by using examples of project work undertaken, showing how the building energy management system (BEMS) was used to help students develop, adapt and apply heat transfer theory, as well as giving them experience of a BEMS installation.

The aims of the project were to develop and apply heat transfer theory in a real situation, to supplement conventional lectures and laboratory work; to give the student some practical experience of a BEMS, which are becoming commonplace and are an intrinsic part of plant and maintenance engineering; to provide calibration of information for future research and teaching work using the BEMS — this meant that the student had a real goal to achieve, not simply academic requirements to fulfil.

Three areas of interest made the Queen's Building and its BEMS a particularly good subject for study. The first is: heat transfer through the floor, analysed using temperature sensors buried in each part of the floor construction and in the soil. The second: heat transfer through the exterior wall, analysed by using a number of temperature sensors placed through the wall construction. The third is ventilation heat transfer in the auditorium, measured using air temperature sensors and air flow meters placed in the natural ventilated auditorium.

The students were encouraged to develop basic transfer theory and apply it to the Queen's Building.

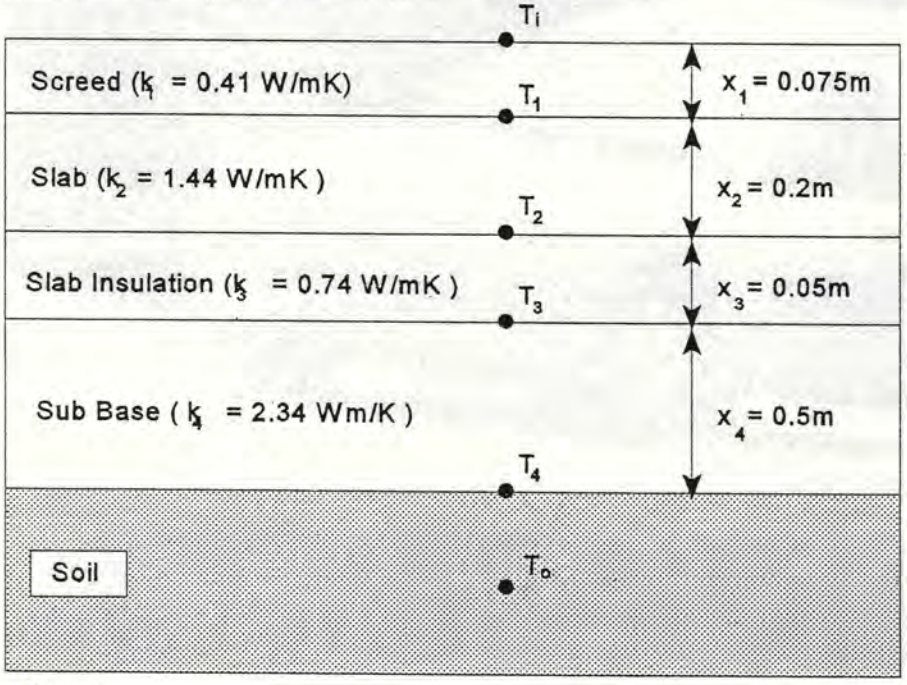


Figure 1

Heat transfer through the floor

The students were required to calculate the overall heat transfer through the floor of the building and then determine the temperatures through each part of the floor's construction, corresponding to the BEMS reading. Figure 1 shows the floor construction and the required temperatures. By assuming a steady state condition, the analysis of the floor construction provided an example for the student to apply Fourier heat transfer theory. By considering the floor construction as a compound solid and considering the thermal resistance and thickness of the component materials, the students were able to first arrive at the overall heat transfer, and then by using simple nodal analysis were able to calculate floor interior temperatures.

With reference to figure 1, the overall heat transfer may be determined from:

$$Q=\left(\frac{k_1}{x_1}+\frac{k_2}{x_2}+\frac{k_3}{x_3}+\frac{k_4}{x_4}\right).(T_i - T_o)$$

Heat transfer through the exterior wall

The exercise to determine the heat transfer through the walls of the building and subsequent calculation of interior temperature (for BEMS comparison), was similar to that for the floor. Again the student had to derive a simple nodal analysis. However, in this case the students had to consider radiative and convective heat transfer from the wall's surfaces. The students were guided to use the

**School of Engineering and Manufacture, De Montfort University*

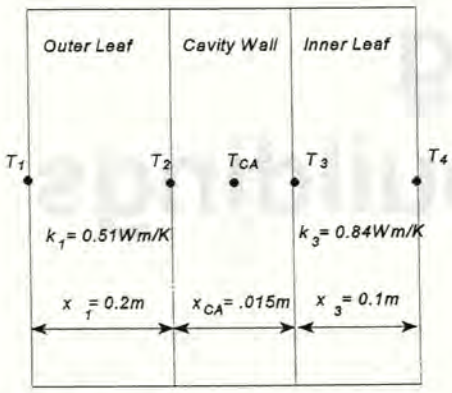


Figure 2

standard CIBSE assumptions for combined radiative and convective heat transfer to simplify analysis to an appropriate level. The analysis of heat transfer through the cavity wall (see figure 2), gave an experience of the calculations and use of U values. An overall U value for the wall was first calculated from:

$$Q_{wall}=U_{wall}(T_1-T_4)$$

where

$$\frac{1}{U_{wall}}=\frac{1}{h_i}+\frac{x_1}{k_1}+\frac{x_2}{k_2}+\frac{x_3}{k_3}+\frac{1}{h_o}$$

Once again, with the overall heat transfer rate and component U values calculated, the students could carry out simple nodal analysis, assuming no thermal capacitance, in the form of:

$$T_{(n)}=T_{(n-1)}-\frac{Q_{wall}}{U_{(n)}}$$

Ventilation heat transfer

The analysis was limited to an individual area with one air intake and two outlets and presented the students with a simple but effective demonstration of the use of the steady flow energy equation. However, this area did provide greater technical challenge for practical work.

The students considered the cross sectional area (A) of the air outlet to the passive ventilation stack (see figure 3), the velocity of the air travelling through it (Co), the density of the air (p), the exterior air temperature (T_o) and the interior air temperature (T_i). Hence the heat loss (Q_o), per unit time, through the ventilation stack could easily be calculated from:

$$Q = m\,Cp\,.\,(T_i - T_o)$$

where mass (m) is $m = C_o\,.A\,.p$

and CP is the specific heat capacity at constant pressure for the average temperature, ie: $(T_i + T_o) / 2$

Practical work

An important part of the student's practical work was to develop testing procedure, so that measurements could be carried out and also to obtain the building characteristics. The students were encouraged to devise their own programme as much as possible and to manage their own practical work, with guidance only given when necessary or sought.

As the results of the work were intended for future use and to be independent from the BEMS, the students were required to calibrate all the measuring instruments which were used to provide data for later analysis. The calibration exercise supported similar laboratory work which the students have previously carried out.

The following measurements were taken:

Floor — internal surface & ground temperatures.

Wall — interior and exterior surface temperatures.

Auditorium ventilation — internal and external air temperatures and air velocity in ventilation ducts. Measurements were taken while the BEMS was logging simultaneously the same measurements and wall and floor component temperatures.

Student experience

The students had to organise their testing programme around the building's occupation, so the testing could be carried out in empty rooms. They also had to gather site plans and specifications, requiring liaison with site service staff and architects. Even health and safety issues had to be addressed in some instances.

Basic heat transfer knowledge was reinforced, as class room theory was applied to real situations. This will compliment the more detailed heat transfer theory later in the undergraduate programme.

The students will appreciate how to apply theory to suit a particular situation, by using the most appropriate form of analysis. The importance of making appropriate assumptions was evident, not only to simplify over-complex analysis but to demonstrate how assumptions can have major effects on the analysis.

Although the students were guided to make assumptions about steady state conditions, radiative and convective heat transfer, the results of the analysis gave students the insight into more complex heat transfer theory and again showed them the importance of making appropriate assumptions.

From a practical standpoint, the students learned valuable lessons on BEMS calibration and commissioning. One of the most commonly cited problems of BEMS is transducer replacement, and the students appreciated the importance of this at first hand.

The institutional aspects of the project work taught the students the problems of assimilating large amounts of information from different sources. Furthermore, working as a team compiling a relatively large report gave the students some preparation for industrial placements and final year projects.

Student's work highlighted a number of initial commissioning problems with what is otherwise a good BEMS installation. Steps are now being taken to recalibrate instrumentation and rectify problem areas.

A final year project is planned to carry out more detailed work on the heat transfer characteristics of the floor. This will include the installation of a second set of temperature transducers and analysis will take account of thermal capacitance. A BEMS terminal will soon be installed to be dedicated for teaching and research purposes. This terminal will be used to formally teach undergraduates the operation of BEMS and will be used for three ongoing postgraduate research projects.

The paper has demonstrated the use of the building and BEMS as a practical exercise for undergraduate engineering students, supplementing formally taught heat transfer theory. Students learned how to adapt theory to suit real problems and gained experience in the use and installation of a BEMS. A well designed and calibrated BEMS system is a very powerful research and teaching tool allowing students to use a building as a full scale experiment. ❑

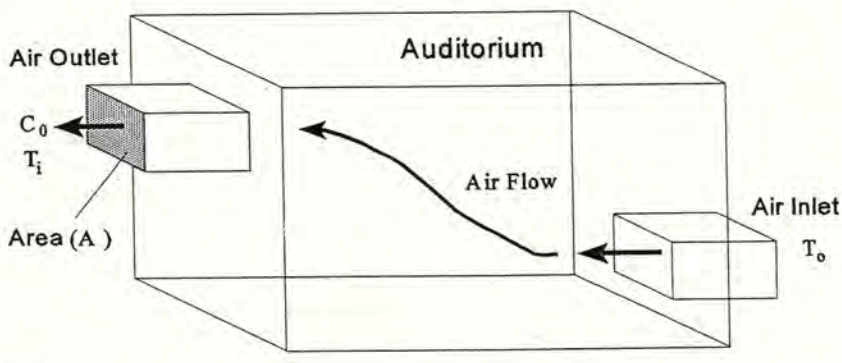


Figure 3

Promoting greener buildings

AN 'Office Toolkit' designed to help the UK achieve its environmental targets, was launched in the summer by Robert Atkins MP.

Developed by the Building Research Establishment (BRE) and PA Consulting Group, the Toolkit was sponsored and piloted by eight major organisations: Anglian Water, the BBC, Honeywell, IBM, Nat West Bank, the Prudential, the Royal Mail and P&O. The Department of the Environment helped to fund its development through the Partners in Technology programme.

The UK's 200 000 plus offices are responsible for around one eighth of the UK's energy consumption, including use of transport by staff, according to BRE. The Toolkit provides checklists against which users can rate their environmental performance in 17 different areas. And it gives advice on how improvements can be made, for example, through use of more efficient heating, lighting and ventilation systems.

BRE claims that companies can cut their energy bills by up to 20% merely by implementing a 'switch off' campaign. At its most basic level, this involves getting staff to switch off PCs and lights when they are not being used.

Refinements are also possible, such as buying lighting systems which turn themselves off when there is no movement in a room. In addition, PA recommends that companies buy only Energy Star approved PCs, which power down when they have been idle for a while.

Leaving PCs on is surprisingly expensive. In fact PCs can add more to the office electricity bill than lighting or heating, according to research carried out for the project. The average PC consumes 800 kWh per year, and pumps out heat. It takes half as much energy again for the office air-conditioning system to get rid of it! Taking that into account, each PC costs around £54 a year to run, whereas lighting costs around £45 per person.

PA Consulting Group says consumption costs for the average office worker are £4000 per person. Following the guidelines in the Toolkit, these can easily be reduced by 5% per annum. This translates into a saving of £200 per person per year, representing a saving of £40 000 off the bottom line for an office with 200 staff.

PA Consulting Group and BRE came up with the idea for the Toolkit because they felt there were a lot of simple steps offices could take to improve their environmental performance, but very little in the way of practical advice.

There are formalised environmental management schemes (such as ISO 14000, BS 7750 and the European Union's EMAS) for those who want external accreditation. And there are business books containing useful information, yet little guidance on how to prioritise different environmental campaigns.

The Office Toolkit fills this gap in the market. Initially priced at £99 for an introductory period, all its sections have review forms, to help companies assess their current environmental performance and set objectives. It enables companies to begin improving their environmental impact with great risk or expense, and can be a stepping stone towards BS 7750.In the longer term, environmentally-friendly policies will tend to influence the choice and quantity of office space required. For example, if practices such as home working and 'hot desking' are encouraged, less office space will be needed. And smaller offices require less lighting, heating and air-conditioning.

Companies which adopt 'hot desking' do not give staff their own desks. Instead when staff need to be in the office, they book a desk (complete with PC and phone) and collect their things from a locker. Hot-desking is not suitable for all types of job, but has become quite popular in consultancy and sales where staff spend a lot of time out of the office at customer sites.

Ideally offices should be located in a place which minimises commuting for the majority of staff.. Any company planning to relocate should consider the environmental credentials of the offices on its shortlist. To make this easier, the Building Research Establishment has created a rating system called BREEAM (Building Research Establishment Environmental Assessment method). Any office, not just new ones, can be given a BREEAM rating. Buildings with energy-efficient air-conditioning systems, or those naturally ventilated, will get better ratings than those with inefficient systems.

The BREEAM system rewards developers who take the environment seriously, by giving them a form of external appraisal which can help them to market their buildings.

Another important part of running n environmentally friendly office is to persuade contractors, such as cleaners, gardeners, and even stationery suppliers, to use less harmful substances. Bleaches used in kitchens and laboratories are damaging to the environment; highlighter pens also contain toxic substances.

The steering group behind the Office Toolkit advises companies to consider the following questions:

What is the visual impact of their building on staff and visitors? Is it a pleasant and safe place to work?

Is any waste generated by the company disposed of / recycled in a responsible manner?

Do delivery vehicles and staff come and go with the minimum amount of disturbance to neighbours?

The estimates of cost savings, and some of the case study examples in the Toolkit, are based on the experiences of the eight major companies which sponsored and tested the Toolkit themselves.

The Toolkit uses eco-points to grade the environmental impact of different activities. This means than an office manager, facilities manager or environment manager can see at a glance which actions will have the biggest payback in environmental terms.

Although there is much debate over how many eco points should be awarded to a particular activity (such as running a car), this points system is gaining acceptance among large European companies. Consultancies such as PA Consulting Group use them extensively.

According to the chairmen of the steering group, the best-practice office would look like this:

- everything would be switched off when not in use;
- electronic mail and computer-based fax would have replaced paper. (The average office worker uses 20 000 sheets of paper, worth £60 per year.) Presentations would be electronic. Portable PCs can be used for small presentations. Slides can be displayed directly from a PC onto a large monitor;
- print cartridges from laser printers would be recycled;
- only Energy Star compliant PCs would be bought and the ES option would be enabled. All too often people don't use it because they want to display snazzy screen savers (moving graphics) that fill the screen when a PC is idle;
- the company would set targets for reducing business travel and commuting and change its company car policy. ❑

Clean fossil fuel power generation

*by John Hunter CEng FIMechE FInstE AMIPI**

The world is demanding cleaner and more efficient power generation to satisfy rising demand for electricity at lower cost. The following article puts the case for new clean coal, or oil, combined cycle power generation systems currently being developed worldwide, but not fast enough to benefit UK consumers and British manufacturing industry.

WE HEAR a lot about nuclear power and renewables energy, such as wind, wave and solar as the panacea to meet future and current statutory requirements for a clean environment. On the other hand very little is known by the public of the advanced strides being made in the development of clean coal or oil generation systems. The impetus for these developments is the fact that worldwide, coal accounts for a total of 70% of the energy consumed worldwide; while oil follows as the second most popular fuel.

In view of the predominance of these fuels in the world market for energy supply and the long-term availability which this implies I cannot perceive coal or oil ever being replaced by renewable energy or nuclear power, however, hard proponents of these industries tell us how efficient and cheap they are. The fact is they are not!

Taking wind power as an example, a typical wind generator probably has a maximum rating of around 2MW(e) of electrical output. It has to be installed on a suitable wind flowing site. If more than one unit is required as in multiple units, each has to be installed at a reasonable distance from each other. To reason is to optimise the aerodynamic flow of wind through the wind generator, and to minimise noise pollution. Bearing in mind the low output, as expressed by the low power density per square metre of installed ground space, this compares unfavourably with the large power densities pertaining in typical power stations, such as Longannet in Scotland where the capacity output is 2400MW(e) in a very compact site. What does all this mean? It simply means that if wind power generators were to replace large fossil fuel power stations such as Longannet (or even smaller 400MW(e) stations) then large numbers of wind generators would be required occupying large tracts of ground, perhaps the area of a town. This would be very expensive, giving high costs of power generation in pence/kW, bearing in mind that backup may be required to augment supply when the wind is in repose.

I suggest renewable energy, such as wind power, has a part to play in energy supply, but from the above analysis only in a marginal way, eg, in country districts where other supplies are difficult and noise pollution is not a factor.

Turning to nuclear power generation, I have great difficulty in getting a clear picture on what the true costs are. On the one hand we were told that when the government tried to privatise the industry a few years ago, the City said the generation costs per kW were too expensive, due to high running costs, and decommissioning costs once its useful life had expired. Now we are told that miraculously costs are going down. Apparently dry storage of waste disposal at power stations may be adopted in lieu of sending it to Sellafield for processing in the new THORPE plant.

A further proposal is to dispose of non-contaminated material from an expired station by conventional stripping down means. However, the remaining contaminated core reactor will not be removed from the site, but will simply remain in situ, and may be covered over by earth burden, forming a nice little hill. To my mind, and everyone of a mind for safety to the public, this proposal makes me feel a little apprehensive. A final proposal is to arbitrarily extend the life of existing reactors to 35 years, thus reducing the depreciation and running costs, and hence the generation cost/kW.

Of course, all this manoeuvring of costs could be associated with the government review of the nuclear industry. I believe there is only one fair way of comparing generation costs for nuclear power or any other power generation system, and that is to compare like with like: taking each component of running and depreciation cost for the same rating of plant in MW(e) and over a practicable life period, not favouring one system against another.

Thermodynamically nuclear power plants are very inefficient, as are conventional fossil fuel power stations. The reason is the low efficiency of the steam cycle and the steam turbine. The essential features of a coal-fired steam cycle power unit are as follows. High pressure steam is generated in a boiler which then flows to a steam turbine, connected to an electrical generator. There is a high proportion of waste heat not useable for generating electricity and this accounts for the low overall generating efficiency of 36-37%.

Such low efficiencies were tolerated pre-war, because coal was cheap, and there was no thought given to reducing noxious emissions, such as nitrogen and sulphur oxides emitted from the station chimney.

From 1945 onwards, fossil fuel research throughout the world and principally in the UK and the USA has concentrated on engineering a generation system which would produce electricity at greater efficiency and in a clean manner absent of, or greatly reduced, NO_x and SO_x emissions. Many systems have been researched, but here we will only deal with the latest system developed by British Coal over the last few years. This will be followed by one or two observations on the author's own patented system.

The system developed by British Coal is known as the Topping Cycle system. The objective of the system is to substantially increase the generation efficiency and it is expected to achieve an efficiency of 45% if money can be found to build a demonstration plant.

It achieves its high efficiency by having a jet type gasifier operating at a low temperature of 900-1000°C mainly to prevent fusion of the coal ash particles and at the same time limit the production of nitrogen oxides in the gasification process. The gasifier is injected with limestone in a fixed proportion to the coal sulphur content to absorb the sulphur during gasification; hence reducing the sulphur oxides. The fuel gas flows from the gasifier to a cyclone unit to abstract coarse ash/carbon particles and thence to a gas cool-

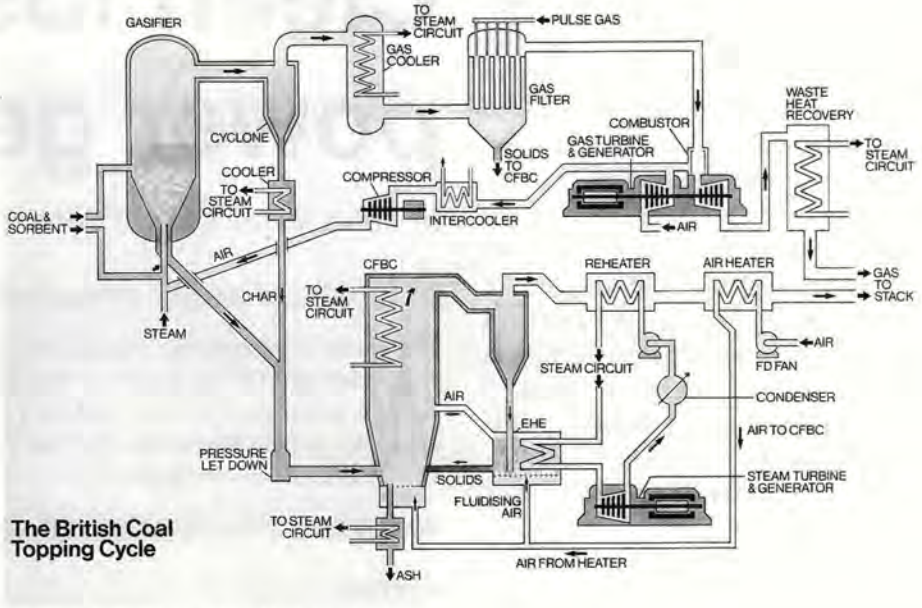
**Consulting engineer*

er. Here volatised alkali metal compounds condense onto the remaining particles and are subsequently trapped by a filer unit downstream of the gas cooler. The flow then enters a combustor unit for burning off of the fuel gas; compressor air entering the combustor at a rate for combustion and cooling the combustion gases to a temperature prior to entering a gas turbine from which electrical power is generated. Further electrical power is generated in a steam turbine. The steam for this turbine is generated in a depressurised circulating fluidised bed boiler designed to burn off ungasified carbon flowing from the base of the pressurised gasifier. Steam heat is abstracted from a steam circuit connected to the gas turbine exhaust duct, reheater and gas cooler.

The principle advantages of the Topping Cycle are the substantial increase in efficiency as compared with the conventional steam cycle efficiency. This amounts to between eight and nine percent and would result in fuel savings of 18 to 20%. This would also result in the same percentage reductions in CO_2 emissions from the stack, and substantial reductions in NO_x and SO_x emissions well below any future statutory requirements likely to be announced by the EU or national governments. A further advantage is that the construction cost per kW will be less than conventional steam cycle plant, and substantially less than nuclear plant. Bearing in mind that over the life of such a plant, coal prices will remain relatively stable, with gas prices diverging away from coal because of its relative scarcity over the long term.

The author's system is known as the rotary gasification-combustion system. It gasifies micro-sized coal (eg, 180 micron) or oil, and it has a rotating distributor with a 2" fluidised bed injected with similar sized limestone. The bed is cooled and operates at 1000°C. The bed is held on the distributor in annular shape by the opposing centrifugal and inward drag air force acting on the bed. The gasification rate is very high and changes rapidly with modulation of the distributor speed and it operates over a large turndown. The reason for these advantageous features is the small size of the coal particles, and the large surface area which they present for reaction with the inflowing pressurised oxidant.

A separate study has shown that the expected carbon conversion will be 0.90 thus eliminating the need for a separate char burner as is required in the Topping Cycle system. The rotary gasifier because of its design features is very compact. The pressure loss through the gasifier is low, making it ideal for power plant applications. The overall capital cost for combined cycle applications will be lower than the Topping Cycle system since it eliminates the circulating fluidised bed part of the Topping system and the auxiliary plant associated with it. The fuel gas generated per kg of input of coal is much higher than the Topping gasifier which uses industrial sized coal. Design calculations for a 100MW(e) combined cycle application showed a 51% efficiency, which would give fuel savings of 28-30% over a conventional steam cycle plant downstream of the gasifier and the gas turbine, including the GT exhaust boiler. The system is patented.



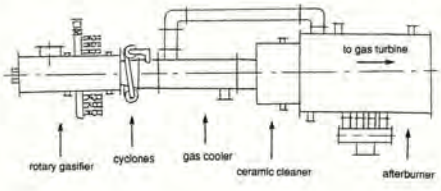
The British Coal Topping Cycle

One configuration of the Topping Cycle.

The indications are that the system could compete successfully with the gas-fired combined cycle systems presently being installed in the UK. It would allow coal and oil to compete with gas, and give a more competitive future policy, based on competitiveness rather than the tendency towards a monopolistic market of high price electricity.

If the Topping Cycle and the author's system are developed with the aid of government assistance, it could generate an export manufacturing potential fairly rapidly. It is likely the demand for electricity will increase, and with it the demand for fossil fuels. It is important, therefore, that whichever fuel is used and the plant chosen that they perform over their life period with high efficiency and low emissions. The plants described in this article are important in this respect and should, therefore, be developed with all haste. A further impetus should be that it is likely that within the next few decades electric cars will be developed, and these will require more power generation. The signs are already here, with the marketing of electric people movers in the UK and prototype electric cars by the automobile industry, for example in California. If this takes off UK manufacturing may be ill-equipped to meet the demand if development work is not started right now.

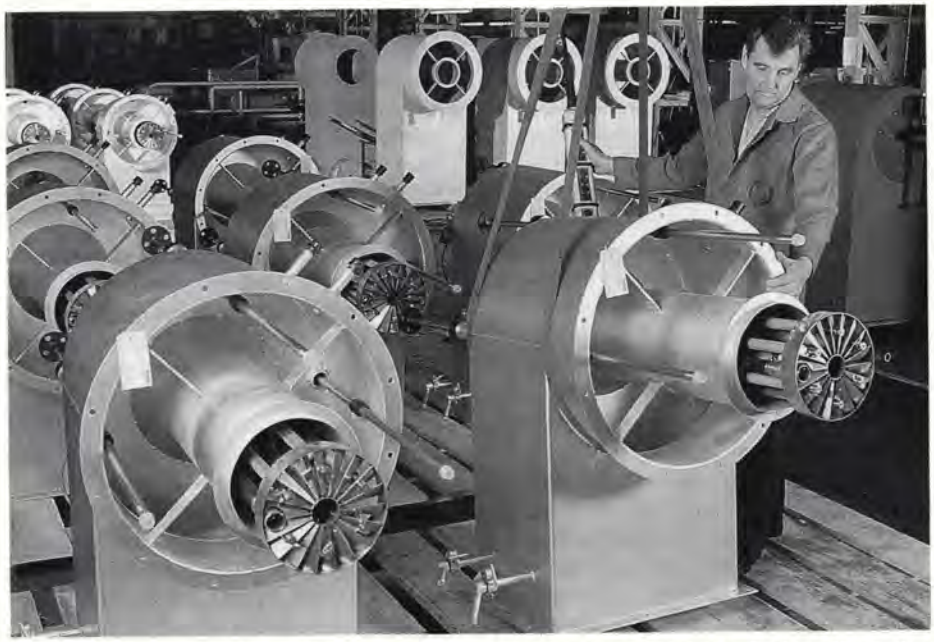
In the present industrial climate in the UK development funding is practically impossible to obtain. The electricity generators have opted out of development work on new systems. They maintain it is the responsibility of the manufacturing industry to fund development, but investment is at a low ebb. Unless, therefore, a source of funding is found quickly, gas will monopolise the power generation market and British industry will lose out, the consumer condemned to electricity prices which will be very high, and will rise at a more rapid rate than if the plant proposed here were developed. ❑



The Hunter gasification combustion system.

From strength to strength

SIX months ago Hamworthy Combustion Engineering became an independent operating company within the Powell Duffryn engineering group. *Energy World* takes a closer look at the company which is now one of the largest combustion equipment companies in the world, and certainly the largest in Europe.



To say that Hamworthy Combustion Engineering (HCE) has 'seen a few changes recently' would be a classic British understatement.

The company was formerly the Combustion Division of Hamworthy Engineering Ltd, and has been designing, manufacturing and installing combustion equipment for over 30 years. In 1991 and 1992, Hamworthy acquired Peabody Engineering Ltd and Peabody Engineering Corporation in the USA and a year later (in 1993) they acquired Airoil Flaregas.

These acquisitions greatly increased the company's product portfolio and took them into a number of new markets — Airoil Flaregas was one of the leading suppliers to the refining, petrochemical, marine and utility industries; whilst Peabody added further breadth in oil and coal firing.

In April 1995 these three companies were all integrated into one organisation — Hamworthy Combustion Engineering — which has its head office and manufacturing facility at Poole in Dorset, with an additional UK satellite office at Maidstone, Kent.

A world-class company

As a result of these takeovers, HCE now has eight subsidiary companies — six of which are based in Europe, one in the USA and one in South Africa. It also has two joint venture companies — AUSCC in the USA and Airoil Flaregas (India) Pvt Ltd — together with a well-established network of agents throughout the world. This extremely strong presence in overseas markets — together with an extensive product range — makes HCE a truly world-class company. It has an annual turnover of £60 million, and employs 750 people.

Exports are, of course, a central feature of the company's plans for future development and in the first six months it has increased its export sales by around 15%. And the order book for the next six months looks just as good, if not better. There are tremendous opportunities for the company to expand, not just in Europe and the USA, but also in many developing countries, such as Poland, the Czech Republic and the Far East.

On-going product development

Despite having a product range that is the equal of anything on offer in the world, HCE is always aware of the need for continual product development and improvement. Towards the end of 1994 it invested in a £1 million Advanced Technology Centre at its Poole site. The new test rig (on the month's front cover) is understood to be the largest and most comprehensive facility of its type in the world and will ensure that HCE remains at the forefront of burner technology.

The test rig allows the simulation of burner installations up to 100MW, and as diverse as TEC and flare applications. The test furnaces play a core role in the development of new burner technology and customising of burners for specific customer requirements. It also allows the simulation of any blend of liquid or gaseous fuel — a facility which is particularly valuable when considering the combustion of waste fuels.

HCE will be introducing a number of new products within the next few months including a new series of *ultra-low NO_x burners* which will be available in gas, oil or dual fuel form. A number of features in the design of this new 'SL Series', which can be used on inputs between 1900kW and 6900kW, will ensure that the burners save energy and fuel, and keep noise levels to a minimum.

A new series of flame monitors will also be launched early in the New Year which will, of course, be CE marked and will incorporate Peabody's 'flicker flame' monitoring to aid discrimination between different flames. They will be suitable for use in most burner applications, and a modified version will be produced for use in hazardous areas.

The next six months

Needless to say, the next six months look just as hectic at HCE. Development of the export market will be a major priority for the company, and it will be recruiting a number of new staff at all levels in order to further strengthen its team. Research and development of new products will continue, and we can expect to see an impressive set of financial results at the end of the first year's trading. ❑

Institute hosts second conference

THE Institute of Energy's first international conference on Combustion and Emissions Control was held in Cardiff in September 1993. A second conference on the subject will take place at the Commonwealth Conference and Events Centre in London on 3-5 December, and promises to be every bit as authoritative as the first.

Keynote presentations will include addresses by HMIP, University of Stuttgart, Cranfield University, Imperial College, and the Combined Heat and Power Association, to name but a few, and will be followed by open forum poster sessions.

There will be a total of seven conference sessions, all addressing different aspects of the topic. These are: emissions control, energy from waste and biofuels; modelling for industry; plant performance' advanced power generation; industrial burners & furnaces; and industrial combustion engines. The technical implications and solutions needed to meet the ever more stringent requirements of combustion and emissions control have led to the rapid adoption of new developments and research. The conference aims to provide an international forum to discuss state-of-the-art technology and experience, as well as to explore innovative research.

The conference is aimed at industry — both process users and manufacturers , research workers, pollution control personnel, academics, plant operators and contractors, process engineers, energy equipment manufacturers, fuel suppliers, consultants, energy managers and analysts, and all those involved in research and development in the combustion and emissions fields.

The diversity and volume of work on the subject has provided opportunities to run the open forum poster sessions, offering a platform for authors to present and invite discussion on research they are presenting undertaking. The first viewing session will take place at the pre-conference buffet reception, to be held on the evening of Sunday, 3 December.

The venue, situated on Kensington High Street, provides an exhibition hall and art gallery above the auditorium, as well as the adjacent Commonwealth Galleries, with three spectacular circular floors: the setting for the conference dinner on Monday, 4 December, when PowerGen's Roger Jump will be the after dinner speaker.

The conference is co sponsored by the World Coal Institute, The Combustion Institute, IMechE, IChemE, IPlantE, IoP, National Society for Clean Air, British Flame Research Committee, The Combustion Engineering Association and Associazione Termotechnica Italiana.

1995 Christopher Hinton lecture

JOHN COLLIER FEng FRS (*Fellow*), chairman of Nuclear Electric, gave the Royal Academy of Engineering's 1995 Christopher Hinton Lecture on 3 October.

Entitled *Sizewell B: from concept to completion,* the lecture told the story of the UK's only pressurised water reactor (PWR). The plant reached full commercial load in June 1995, seven years after the first permanent concrete was poured. Although ambitious in comparison with similar plants elsewhere in the world, the work was executed close to programme and within the budget confirmed by Nuclear Electric at its formation in 1990. Sizewell B was the first major project in the UK on which a comprehensive quality assurance programme was applied through all aspects of the project, including design and engineering.

A diaphragm wall 50 metres deep, one of the largest ever constructed, was built around the site to keep out water while foundations were laid. 750-metres-long cooling water culverts were constructed offsite at Teeside, floated down 240 miles of the North Sea and sunk into trenches in the sea bed offshore at Sizewell. This new procedure avoided the need for difficult tunnelling in gravel beds.

"To my mind, a high-tech project can only be successful if it has a sound engineering basis," said Mr Collier, "We must learn from past experience." Major developments to the original light water reactor design dealt with both internal and external hazards and seismic hazards. "The quality of the Sizewell B design, particularly with regard to safety was demonstrated when the design was examined against the lessons learnt from the Chernobyl accident, which took place in 1986," said Mr Collier. "The design stood up well to the test. No modifications were necessary as a direct result of the Chernobyl accident."

Performance by the CEGB on large projects had been very variable prior to the 1980s and the CEGB itself undertook the leadership of the Sizewell B project. The PWR project group managed the overall work, from compiling the safety case to managing the construction site with a peak labour force of 5000, under the direction of Brian George. "This was the first time that all of these functions had been combined for a major nuclear power station project in the UK," said Mr Collier. "The concentration of skills, cohesion of effort, and elimination of traditionally difficult interfaces, proved to be of major importance to the success of the project."

The Christopher Hinton is the Academy's premier annual lecture, and is named after the late Lord Hinton of Bankside, first president of the Royal Academy.

Watt seminars

THE Institute of Energy, as one of the founder members of the Watt Committee on Energy in 1976, has maintained its close links with the committee over the years.

A recent initiative, described in issue no 9, Summer 1995, of *Watt News*, should be of particular interest to Institute members. This concerns plans for a series of regional, one-day seminars on dissemination of energy technologies and related matters, including market conditions and environmental pressures, energy modelling and forecasting. These seminars should prove a valuable supplement to branch activities, including the Institute's plans for continuing professional development (CPD).

The first seminar will be held at the HSE Laboratory, Broad Lane, Sheffield on 1 November, and will be a forecasting forum, covering clean coal technology, combined heat and power and urban light rail systems. Longer term energy forecasting is fraught with difficulty: energy professionals, industrial decision makers, governments and regional authorities and all kinds of official bodies must approach such matters responsibly.

Registration forms can be obtained from: The Conference Manager, The Watt Committee on Energy, Burlington House, Piccadilly, London W1V 0LQ. Tel: 0171 434 3988; fax: 0171 434 3989.

Plans for 1996 include further seminars in Cheltenham and Liverpool, and two European locations.

New members

Student

Hammond McPherson Kanjere, South Bank University
Christopher Charles Kendrick, Cranfield University
Carl Keogh, Leeds University
Yakub Kheratkar, Leeds University
Anthony Richard Kidman, Middlesex University
Michelle Kingham, Middlesex University
John Lawler, Newcastle University
Sally Ann Leek, Coventry University
Stuart Graeme Lowden, Napier University Edinburgh
Enrique Antonio Pastor Martinee, Leeds University
Emmanual Chukwudumebi M'Banugo, University of Westminster
Paul McAdam, Leeds University
Martin Peter McGawley, Leeds University
Ian Richard McLaverty, University of Glamorgan
Barry Maxwell, Newcastle University

Branch events

October

North Eastern

Tuesday, 24 October, 6 pm

Joint meeting with the IChemE: 'The work of the CRE Group Ltd', Mertz Court, University of Newcastle upon Tyne. Tea & biscuits in the Buttery. Contact: Mr A W Potts, tel: 01670 712861

S Wales & W of England

24 October, from 7 pm

'Precessing gas burners and their application to industrial rotary kilns' The new Gyrotherm low NO_x burner has demonstrated a 40% NO_x reduction over conventional turbulent diffusion flame burners and higher fuel efficiency. SWEB HQ, Almondsbury, Bristol (provisional). Contact: M Biffin, tel: 01443 482231.

Northern Ireland

25-26 October

Energy Show, held at the Europa Hotel, Belfast. Contact Dr Patrick Waterfield, tel: 01232 3664090

Friday, 27 October

Energy Advice Shop, Belfast. Contact: Dr Patrick Waterfield, tel: 01232 364090.

East Midlands

Date to be confirmed

International Combustion Ltd, Derby. Lecture on Low NO_x burners and a visit to the test rig. Contact: Mr M Allen, tel: 0115 9815879.

November 1995

North Eastern

Date to be confirmed

Dinner Dance. Contact Mr A W Potts, 01670 712861.

East Midlands

Date to be confirmed

Prestige lecture, organised by the IChemE. Contact: Mr M Allen, tel: 0115 9815879.

Midlands

Thursday, 2 November, from 6.30 pm

'Trials and tribulations of an offshore gas company' by Mr M J Williams, director & general manager, Gas Energy (CI) Ltd. Snr Common Room, Aston University, Birmingham. Light buffet from 6.30 pm, lecture starts at 7 pm. Contact: Mr D E A Evans, tel: 01384 374329.

Scotland

Tuesday, 7 November

'Modern papermaking & energy' Mr Jack Lord, engineering manager, Caledonian Paper. Contact Mr Hannah, tel: 01389 765177, ext 348.

Midland

Friday, 10 November

Annual dinner and dance, The Belfry Hotel, Sutton Coldfield. Contact Mr D E A Evans, tel: 01384 374329.

S Wales & W of England

Tuesday, 14 November, from 6.30 pm

'The certainty of uncertainty, or assessment of the impact of cheap gas and combustions emissions legislation on heavy fuel oil use' by Mike Drew. At University College Cardiff, Seminar Room 2, Trevithick Building. Contact: M Biffin, tel: 01443 482231.

Yorkshire

22 November, from 6.30 pm

'Energy and the environment' by Dr William Wilkinson CBE, chairman of British Nuclear Industry Forum. At Leeds University, Rupert Beckett Lecture Theatre. Contact: Mr Mallalieu, tel: 0113 2768888.

S Wales & W of England

Tuesday, 28 November, from 7 pm

Social event: Ghost Evening. Llancaich Fawr, Nelson Mid Glamorgan. £7.50 per ticket, friends and relatives welcome. Contact: Mr Biffin, tel: 01443 482231.

December 1995

Headquarters

3-5 December, two-day event

Second International Conference on COMBUSTION & EMISSIONS CONTROL, Commonwealth Institute, London, W8. Contact: IChemE, tel: 01788 578214.

NEMEX '95

5-6 December, Metropole Hotel, Birmingham. Contact: Louise Evans, tel: 0171 580 7124.

Midlands

Thursday, 7 December, from 6.30 pm

'The Didcot combined cycle power generation scheme' by Mr N Orchard, station manager, Didcot Power Station. Snr Common Room, Aston Birmingham University. Light buffet at 6.30 pm, lecture commences at 7 pm. Contact: Mr D E A Evans, tel: 01384 374329.

January 1996

Northern Ireland

6 January

Visit to NIGEN, Kilroot Power Station. Contact: Dr Patrick Waterfield, tel: 01232 364090.

Midland

Thursday, 11 January, from 6.30 pm

'Buying electricity in the contract market' by Mr M Warrander, Utilities Coordination Executive, Allied Domecq Ltd, Snr Common Room, Aston University, Birmingham. Light buffet from 6.30 pm, lecture starting at 7 pm. Contact: Mr D E A Evans, tel: 01384 374329.

S Wales & W of England

23-30 January

'Sainsbury's Energy Manager', Mr I Williams, senior manager, Sainsbury's. Contact Mr Biffin, tel: 01443 480480.

February 1996

Northern Ireland

Date to be confirmed

PV in buildings dissemination seminar. Contact Dr Patrick Waterfield, tel: 01232 364090.

Midland

Thursday, 1 February, from 6.30 pm

'The relationship between global warming and energy usage' by Mr J Wright, Birmingham Centre for Climate & Atmospheric Research. Snr Common Room, Aston University, Birmingham. Light buffet from 6.30 pm, lecture starting at 7 pm. Contact: Mr D E A Evans, tel: 01384 374329.

Scotland

6 February, from 6.30 pm

'Young Engineers Evening' Napier University, Merchison Campus, 10 Colinton Road, Edinburgh. Contact: Mr Hannah, tel: 01389 765177, ext 348.

Yorkshire

Wednesday, 21 February, from 2.00 pm

'Hazards of Offshore Rig Operation' by Mr J King, held at Leeds University. Contact Mr Mallalieu, tel: 0113 2768888.

S Wales & W of England

21 February, from 11 am

Visit to Spirax, Cheltenham. Reserve places by contacting Mr Biffin, tel: 01443 482231 at University of Glamorgan.

A fascinating story

'Never Trust An Expert: nuclear power, Government and the Tragedy of the Invergordon Aluminium Smelter' by R E Utiger CBE Published by the Business History Unit of the London School of Economics, July 1995, 71 pp, £5.00.

THIS intriguing title underlies a most fascinating story of the 'rise and fall' of one large industrial plant, set over roughly three decades of the second half of this century. The author, Ronnie Utiger, was himself an expert in the technical and commercial arena surrounding the aluminium industry. He served as chairman of his company, British Aluminium, from 1979 to 1982, following his years as managing director from 1968.

The tragedy of the Invergordon Smelter demonstrates so vividly just how badly those parts of British Industry in the state sector were managed and financed after 1945. The interaction between fully commercial concerns, the Government and the nationalised industry was abysmal at best.

The reader of this short account can only conclude that the prosperity and progress in industrial undertakings controlled by the state are doomed to failure. Important technical and commercial decisions are taken for purely political reasons. The book shows the nuclear power industry of the 1960s and '70s in a very poor light. The stark differences between the operation of our AGRs when under the control of the CEGB, SSEB and the NSHEB are brought into sharp focus against the more successful performances since the nuclear industry's vesting in 1990.

Central to the theme is the contest between three major aluminium giants — Rio Tinto Zinc (RTZ), British Aluminium (BA) and Alcan Aluminium — running alongside a major new power technology, nuclear power, whose future in the late 1950s and early 1960s looked so bright. The author highlights the main problem, which was how to devise a scheme which would enable an aluminium smelter to obtain the lowest possible price for very large amounts of electricity. The AGRs, which were coming on stream in the late 1960s, were thought to be the most likely low-cost supplier.

The CEGB, SSEB and NSHEB had a statutory duty not to give 'undue preference' to any particular consumer, a barrier which the Government attempted to circumvent. The solution lay in having the large aluminium companies making a capital contribution equal to that proportion of the AGRs output necessary for smelter demand.

The power contract drawn up between BA, SSEB and the NSHEB is examined, with all the difficulties experienced with the construction and operation of the Invergordon smelter from its inception to its closure.

Chapter 14 describes the nightmare scenario faced by the BA management due to nuclear power's price escalation. The figures quoted seem incredulous. A price rise of 113% in 1975/76, when Hunterston B first began to deliver power. A year later the price rose by 198%, and the following year, by 387%.

These are sensational figures by any standard. It would spoil the author's story if I were to reveal any more. However, it must be recorded that the fundamental difficulty at the heart of the matter was the intransigence of the Government of the day in its dealings with the state-controlled nationalised electricity generators. BA were skilled in not only their ability to run their industry, but had considerable business and commercial acumen, clearly lacking in the civil service and nationalised bodies of the day.

By 1980 the situation had so deteriorated and become so alarming, the price of electricity having risen to an unacceptably high level. It was at this point the author reveals how further demands were made on BA. They were now expected to meet the cost of a serious sea water accident at Hunterson. Escalating capital costs, not previously set out in the power contract, totalled £27.8 million.

The situation for BA was intolerable. Without the disputed items, the power price would have been 0.77p/kWh, with them the figure was 1.26p/kWh. Closure of the smelter became inevitable, coming at the end of 1981. It was a shattering blow, with 30% of the BA's assets disappearing, not to mention the effect on the local community.

It is very difficult to know just how such an enormous technical/economic misjudgment could have been made. Ronnie Utiger believed that perhaps the enthusiasm for the new technology — AGR — overcame a sense of realism. Could this have occurred in a privatised economy? The answer is 'no'. The penalties which accompany any misrepresentation of a public floatation prospectus would have prevented it.

Mr Utiger does make a reference to the Anglesey smelter. AT RTZ's location, the CEGB are said to have supported the power contract to a far greater degree, despite its being based on the disastrous performance of the AGR at Dungeness B. Again, to set up this power contract, a situation was created whereby undue preference was given for power consumption. If one examines the CEBG Accounts for the year 1972 to the late 1980s, the evidence shows the area boards paying about 400—500% more per unit than the Anglesey smelter.

This incredible story is told by one at the sharp end. It should interest readers both inside and outside the power and aluminium industries. The one regret is that the book is too short. The publishers record the distressing fact that Ronnie Utiger only just completed his work before succumbing to cancer. He lived long enough to receive a pre-publication copy before his death, on 27 July 1995.

Eur Ing F John L Bindon

Everything from soup to nuts

'Coal Blending for Power Stations' Published by IEA Coal Research, London, 1995, £150.00 (member countries), £450.00 (non-member countries).

PUBLICATION of this comprehensive report could hardly have been more timely. In Britain, the market for power station coal is going through an upheaval unparalleled this century; and around the world,, socio-economic pressures arising from environmental concerns and the steady erosion of coal's markets by energy competitors has wonderfully concentrated the minds of power station scientists and engineers on getting the best results from the myriad blends now possible.

As the report emphasises, blending has become increasingly common as utilities attempt to save costs. meet SO_2 emission regulations and improve combustion behaviour. Many countries have been successfully blending for many years, but over the next decade the practice is expected to grow rapidly. Some countries dependent solely on imports have a powerful incentive to blend; they can extend the range of acceptable coals to increase their supply options. For other countries, such as the UK, blending indigenous coals with imported supplies is a relatively new experience, notwithstanding the practice of blending coals from a number of different collieries, which became highly developed when both industries were nationalised.

Feedstocks from Australia, Canada, China Columbia, Indonesia, Poland, South Africa, and the US, are now commonly traded in Europe, and the countries of the former USSR have not been slow to recognise the potential for aiding their dollar-hungry economies. An expanding array of coals, often at highly competitive prices, faces the blenders with unfamiliar problems. Burning unfamiliar coals in power stations accustomed to handling only local products has inevitably led to new operating problems.

The purpose of the IEA report is to aid the evaluation, and prediction of behaviour, of unfamiliar coals in conventional pf power stations. Attempting to use blends without fully understanding their behaviour risks jeopardising not only plant performance, but

safety, and since the behaviour of blends is profoundly affected by boiler design and operating conditions, the evaluation of blends is highly plant-specific.

Not the least impressive part of this valuable report is its bibliography. Probably the first time such an exhaustive list of references on the topic has been drawn together in one volume. It covers the whole gamut of research that can have any bearing on such an esoteric subject — everything, as Groucho Marx once famously remarked, from soup to nuts.

Peter Heap

Uncharted territory

'Responding to Global Warming' by Peter Read. Published by Zed Books Ltd, London & New Jersey, 1994, 304 pp (inc index)

'An Assessment of Renewable Energy for the UK' by ETSU, edited by E Bevan. Published by HMSO, London, 1994, 308 pp, £30.00.

'Renewable Energy Technologies: a review of the status and costs of selected technologies' by Kulsum Ahmed.

World Bank Technical Paper 240 Energy Series. Published by International Bank for Reconstruction & Development, Washington DC, USA, 1994, 169 pp.

TWO of these books cover aspects of renewable energies, while the third reviews the global warming situation, and then proposes a strategy for world containment, obviously involving renewable and sustainable energy. It is therefore useful to review the renewables volumes in the light of the more ambitious scope of Peter Read's work. His book must therefore provide the starting point for this review.

Mr Read's aim is indeed ambitious. He not only faces up to the technical aspects of the subject, much of which is familiar territory, but also tackles economic models and arguments and the international and political implications. Because he is able to provide such a comprehensive coverage this book must be regarded as an important one, that should lead to wide debate and discussion. I found his arguments powerful and convincing and in the long term, it is difficult to see what other solutions are possible. His proposals do, in fact, provide a way of sustaining the present 'rich' nations' life style, while providing for progress in the less developed third world and, in contrast to many programmes, gives an optimistic view of the long term future.

To an engineer the economics section presents difficulties, not least because of the author's wide use of acronyms. The style also gets in the way of easy reading and assimilation of the main thread. But the overall reward is worth the effort.

Peter Read specialises in energy economics as Massey University, New Zealand, and was trained as an engineer at Cambridge, and economics at the LSE. This educational background provides a firm basis for his book. He has also carried out a study based on his ideas, and using eucalyptus forestry for New Zealand conditions, with tables tracing the consequences of various policy options from 1990 to 2020.

The overall picture is easily outlined. First the level of CO_2 in our atmosphere is at 0.036% and rising; considerably higher than it has ever been over the past 180 000 years. From the records there is a consistent link of CO_2 levels (which did not reach 0.03% until this century) and world temperature. The current increase is taking place at a very rapid pace. We do not know the likely effect of this (there are no historic parallels) and, particularly if there are instabilities or major non-linearities involved, it is possible that the mathematical models will not be able to tell us. We really are in uncharted territory.

The various natural absorbing mechanisms remove about a quarter of the carbon dioxide emitted. Clearly to keep the level at the present high level requires a reduction of 75% in present emissions. This is beyond any present policies and probably impractical even with major efficiency programmes and widespread use of renewables.

The author introduces the concept of net releases, balancing emission of CO_2 with its absorption by deliberately planting fast growing vegetation. He believes that if this is associated with a switch from the major fossil fuels to their equivalents based on biomass, the reduction in net emissions can be achieved. The technologies of use are vegetable matter, alcohol in vehicles (or vegetable oils), gasification for gas turbines or solid fuels for combustion equipment are developed and available, although R&D could improve them. The growing of fuel crops would absorb the emissions from the new biomass and the older fossil fuel equipment. Based on carbon fixation from quick growing trees (the selection of which does require major R&D programmes in many countries) which can be regularly cropped, Mr Read arrives at a world scale of dedicated forest development which requires a large, but not impossible, area of land.

To justify such a programme financially requires a move away from the cost benefit analysis, which discounts long-term future benefit, to adopt what is called the 'regret' approach. To get the policies promoted and financed the author recommends the 'tradable carbon absorption duty' rather than direct taxation of emitters. The poorer countries, particularly in the tropics, would benefit because they are the ideal places for fast growing CO_2 absorbing forests, and this would provide an expanding role for them in the world economy.

There is much more to the subject than can be summarised here, or even covered in a book, but some policy like this must be put in hand to secure the future of our planet. I think energy engineers and, of course, policy makers in industry, government and worldwide should be made aware of what needs to be done. All other political issues pale into insignificance compared to this one.

The other two books are important, but more limited in scope. The ETSU publication is beautifully presented, comprehensive and a bargain. While it does not enter into detailed mathematical analyses, the technical sections are well written and provide a useful; reference source. Although the emphasis is on British work all technologies are set in a world context.

It is interesting to note that development and coppicing using willow and poplar are at the large-scale demonstration stage in Britain, and that ETSU believe that the 'set aside' policy of the EU provides opportunities for rapid expansion. Even in Britain there is probably enough land to absorb a third of CO_2 emissions.

The World Bank is, of course, a major contributor to energy schemes, and therefore its publications are important. This review is basically an evaluation of studies from many sources into the economics, in the conventional sense of cost per unit installed capacity or unit generated, of selected technologies — biomass, solar thermal and photovoltaics. These are comprehensive lists of references and summaries of the conclusions from these diverse sources. Not surprisingly the answers, too, cover a wide range and the report is not helped by using different units (money in particular, but also energy). The conclusions support the viability of biomass for making alcohol-based fuels, and in CHP schemes, although the figures are site dependent. The World Bank confirms the maturity of application technologies both for ethanol and CHP, although they feel that land use with other technologies may be more cost effective.

Peter Read's arguments on *net* CO_2 would appear to add to the benefits of biomass for land use. There would be scope in desert areas for solar technologies, which would not be suitable for biomass.

Norman Worley

Not as cheap as wind

IT IS disappointing to see that John Bindon feels the need to knock wind energy (*Energy World,* September 1995, Readers' Letters). Recent events in the nuclear power industry suggest that people in glass houses cannot afford to throw stones.

The really crucial question is: what is the electricity generation cost? and new wind farms bid under 4p/kWh earlier this year. That is well below anything that new nuclear could match in its recent review, and it makes nuclear whinging sound like sour grapes (to mix a few metaphors).

Electricity Pool prices have risen to 80p/kWh or more because nuclear plant cannot guarantee continuity of supply for industrialists any more than other sources can. When it comes to crucial questions, 80p seems a pretty crucial amount to pay for a unit of electricity. And don't adopt a superior attitude to small unit sizes, either. They give wind farms an advantage that our nuclear monoliths can only envy. Wind turbines can easily achieve plant availabilities of 98%, considerably higher than most other plant on the system (which is lucky to average 88%) and far, far higher than nuclear (which is lucky to reach 80%).

When I was at the Hinkley C nuclear power station public enquiry, I found that many of the protesters there were local people. Public acceptable of nuclear energy is regrettably much lower than it is for wind energy, despite the huge sums spent on advertising and image building. On wind farms, 10% of local people object to them once they are built. Opinion polls show that 70% are positively in favour.

I myself am not against nuclear energy. I do not want to see existing reactors shut down, and I am happy to see new nuclear built wherever it is economic. Indeed, I am on record as saying ('Electricity from nuclear energy: an economic or environmental problem?' *Energy World,* April 1994) that nuclear capacity worldwide may well increase by as much as 50% in the next ten years or so, mainly in countries such as Korea, Taiwan and Japan, but not, I think, in the USA or the UK. Wind energy became cheaper than nuclear energy in the UK over nine years ago and it still is. That is why I prefer wind to nuclear.

The general public share that preference for wind over nuclear quite strongly, although they may not appreciate the complex economic and technical arguments and can frequently misunderstand them. Nevertheless, many countries (particularly the USA) find that public acceptance is a crucial factor. Wind shows up quite well on acceptability, nuclear does not. John Bindon evidently represents a minority view. That does not mean he has a problem — and that problem will not be solved by knocking the competition.

Some might say figures for renewable energy which I have used are exaggerated. They are not, although DTI hardly need me to defend them against individual partisan views. I am glad he will be sticking to clean nuclear power. It does not look as if there will be much built in the UK over the next 10 or 20 years but there will certainly be plenty of closing down and cleaning up to keep the nuclear industry busy.

By contrast, wind farms are going up pretty rapidly — which, by the way, demonstrates a couple more advantages of wind over nuclear power: short construction times and no IDC (Interest During Construction). So good luck with nuclear energy, for all our sakes. I refuse to knock it. All energy sources have their problems and nuclear is a perfectly good option to consider. It just turns out to be not as cheap as wind.

That is why I prefer to stay in the wind energy field. It is growing fast and both the UK and EU are committed to supporting wind power.

Prof D T Swift-Hook *(Fellow)*

DEGREE DAYS: AUGUST 1995

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 (01531 821350)

 Note: the figures given here have been calculated to correspond as closely as possible with those published by government sources. However, because of differences in observing stations, close agreement cannot always be guaranteed.

Aerodynamic wheel wins top engineering student prize

A 17-YEAR-old student from Sheffield became the Young Engineer for Britain 1995 in September, beating 1200 other entrants. Stephen Mosley from Eckington School won the prestigious trophy, £1000, and £1500 for his school, with his invention Aerowheel — an aerodynamic bicycle wheel.

The 1995 Young Engineer Club of the Year title was awarded to Cowes High School, Isle of Wight, receiving the coveted trophy, £1000 and the European Engineering Experience, sponsored by Lloyd's Register.

They were among 180 finalists, aged 11 to 19, competing in the national final of the Young Engineers for Britain competition — the leading event of its type in Europe — organised by the Engineering Council, in association with the Standing Conference of School's Science and Technology's Young Engineers clubs, and held at the Guildhall in London. They had been selected at 13 regional events and had competed for prizes totalling £20 000.

This was the first year Young Engineers for Britain has been combined with the Young Engineers Club of the Year national awards. Presentation was by Richard Page MP, Under Secretary of State for Small Business, Industry and Energy.

The two principal sponsors of the competition are Lloyd's Register, the world's premier ship classification society and a leading off-shore and technical inspection and advisory service; and GEC, a world leader in electronics and electrical engineering. Other sponsors include: British Aerospace, BICC Group, ICI, The National Grid Company, Ove Arup, Shell UK Exploration and Production, Rolls Royce, Adwest Group, Courtaulds, IBM, Tarmac Construction, TI Group, Unilever and Thames Water.

National overall winner of the Engineering Council's 1995 Young Engineers for Britain competition, Stephen Mosley, aged 17, with his Aerowheel, an aerodynamic anti-cross wind front bicycle wheel.

The WISE award, and the £800 from the Engineering Council for the best project by a girl or team of girls, was awarded to Jennifer Thompson and Fiona Little for their project Helping Hand — a device for the arthritic allowing an aerosol can to be operated with the whole hand

Among the winners of specialist awards were Thomas Alleynes High School, Staffordshire, awarded the Rhopoint Prize for the club demonstrating the widest range of engineering skills; Blyth Ridley High School, Northumberland, who took the Philips Research Laboratories Prize for the club demonstrating the highest level of teamwork. And the Era Technology Prize for the club with the most innovative electromechanical project went to Bancroft's School, Essex.

Pictured left are Jennifer Thompson and Fiona Little, aged 13, from Blantyre School in Glasgow, winners of the first place Class A, Boots Company Prize, BP prize and the Women Into Science and Engineering (WISE) prize. Right are the winners of the Class C Group prize, Christopher Hamar and Paul Charlesworth, with Deadleg — a device to maintain correction of deformities of the knee, ankle and foot.

October 1995

Brasil Power 1995
Conference, 25-27 October, Sao Paulo, Brasil. Details from Ms Muriéle Gadaut, Conference Manager, AIC Conferences, Chile. Tel: (56 2) 246 8100; fax: (56 2) 246 8109.

Prakash '95
2nd international exhibition on lighting technology, 29 October - 3 November, New Delhi. Details from India Trade Promotion Organisation, Pragati Bhawan, Pragati Maidan, New Delhi-110 001, India. Fax: 91 11 3318142, 3317896.

A single European energy market
Two-day conference, 30-31 October, Brussels. Details from Steve Campbell, IBC Financial Focus, 57-61 Mortimer Street, London W1N 8JX. Tel: 0171 637 4383; fax: 0171 323 4298.

COSHH (residential)
Course, 31 October - 1 November, Sheffield. Details from Maria Baldham, The Division of Adult Continuing Education, The University of Sheffield, 196-198 West Street, Sheffield S1 4ET. Tel: 0114 2825391; fax: 0114 276853.

November 1995

Energy forecasting & the dissemination of energy technologies
Forecasting Forum, 1 November, Sheffield. Details from The Conference Manager, The Watt Committee on Energy, Burlington House, Piccadilly, London W1V 0LQ. Tel: 0171 434 3988; fax: 0171 434 3989.

Oil and gas India
Exhibition, 1-4 November, New Delhi. Details from Simon Madden, International Project Director, Oil & Gas Division, International Trade & Exhibition Overseas Ltd, Byron House, 112a Shirland Road, London W9 2EQ. Tel: 0171 286 9720; fax: 0171 286 0177.

Chilled ceilings & beams for low-energy air conditioning
Course, 2 November, London. Details from Mid Career College, 01223 880016.

Energy, environment and technological innovations
International congress, 6-11 November, Caracas, Venezuela. Details from Dr Giuseppe Imbesi, Dipartimento di Architettura e Urbanistica per l'Ingegneria, Facolta di Ingegneria, Universita di Roma "La Sapienza", Via Eudossiana 18, Roma 00184, Italia. Tel: + 39 6 44585665; fax: + 39 6 44585186.

Zimbex '95 (incorporating Zimine)
International trade exhibition, 7-10 November, Harare, Zimbabwe. Details from Rosy Wilkie, Zimbabwe Desk, DTI, tel: 0171 215 50018; fax: 0171 215 4965.

Business development opportunities for the UK gas industry
Seminar, 8 November, Wishaw, Warks. Details from SBGI, 36 Holly Walk, Leamington Spa, Warwickshire CV23 4LY.

Eastern European advances in ultrasonics & acoustics
Seminar & tour, 8 November, Teddington, Middlesex. Details from Teresa Pateman, UATG, University of Southampton, 13/14 University Crescent, Southampton SO17 1BJ. Tel: 01703 593545; fax: 01703 592738.

Explosion prediction & mitigation: congested volumes & complex geometries
Course, 13-15 November, Leeds. Details from Miss Julie Charlton, Dept of Fuel & Energy, University of Leeds, Leeds LS2 9JT. Tel: 0113 233 2494; fax: 0113 233 2511.

Water & waste water treatment: towards cleaner, leaner operation
3rd international conference, 13-15 November, Harrogate, Yorks. Details from BHR Group Ltd, Mrs Catherine Cox, Conference Organiser, Cranfield, Bedford MK43 0AJ. Tel: 01234 750422; fax: 01234 750074.

The maintenance of mobile plant: engines, gear drives and hydraulics
A day of presentations & discussions, 15 November, London. Details from Maria Clarke, The Institution of Mechanical Engineers, 1 Birdcage Walk, London SW1H 9JJ. Tel: 0171 9973 1291; fax: 0171 973 0182.

Expro '95
2nd international exhibition & conference, 15-16 November, London. Details from Themedia Ltd, P O Box 2, Chipping Norton, Oxon OX7 5QX. Tel: 01608 684700; fax: 01608 684796.

FISA-95 Symposium / EU research on severe accidents
Conference, 20-22 November, Luxembourg. Details from Mrs L Eisen, European Commission DGIX, Conference Service, Building JMO B2/76, Plateau de Kirchberg, L-2920 Luxembourg. Tel: +352 4301 33164; fax: +352 4301 34851.

Emergency planning & management
Conference, 21-22 November, London. Details from Uloma Otuonye, IMechE, 1 Birdcage Walk, London SW1H 9JJ. Tel: 0171 973 1249.

Railtex '95
International exhibition, 21-23 November, London. Details from Sue Frye, The Institution of Civil Engineers, 1 Great George Street, London SW1P 3AA. Tel: 0171 839 9801; fax: 0171 233 1743.

Gasification: an alternative to natural gas
Conference, 22-23 November, London. Details from Tracy Lepkowska, Conferences & Courses Department, IChemE, 165-189 Railway Terrace, Rugby CV21 3HQ. Tel: 01788 578214; fax: 01788 560833.

SOPEC '95
Exhibition, 25-28 November, Saudi Arabia. Details from Adla Moukarzel, International Trade & Exhibitions, Byron House, 112A Shirland Road, London W9 2EQ. Tel: 0171 286 9720; fax: 0171 286 0177.

Power generation in the former Soviet Union
1st international conference, 28-29 November, Vienna, Austria. Details from Anita Bath or Svetlana Lukes, Business Seminars International Ltd, tel: 0171 490 3774; fax: 0171 490 2362.

Commodity derivatives: an effective risk management tool
Conference, 28 - 29 November, London. Details from IIR Ltd, 6th Floor, 29 Bressenden Place, London SW1E 5DR. Tel: 0171 915 5055; fax: 0171 915 5056.

MARICHEM 95
Conference, 28-30 November, Cologne. Details from MARICHEM 95 Secretariat, Glen House, 200/208 Tottenham Court Road, London W1P 9LA. Tel: 0171 436 9774; fax: 0171 436 5694.

Probablistic safety assessments in the nuclear industry
4th international conference, 29-30 November, London. Details from Sarah Ashmore, IBC Technical Services, tel: 0171 637 4383; fax: 0171 631 3214.

December 1995

The mechanics & operations of oil trading
Four-day residential training course, 1-4 December, Denham, Bucks, UK. Details from Petroleum Economist, Export House, 25/31 Ironmonger Row, London EC1V 3PN. Tel: 0171 251 3501; fax: 0171 253 1224.

The changing politics of international energy investment
Conference, 4-5 December, London. Details from: Julia Thomas, RIIA, Chatham House, 10 St James's Square, London SW1Y 4LE. Tel: 0171 957 5700, ext 298; fax: 0171 321 2045/957 5710.

NEMEX '95
Conference & exhibition, 5-6 December, Birmingham. Details from ESTA, P O Box 16, Stroud, Glos GL6 9YB. Tel: 01453 886776; fax: 01453 885226.

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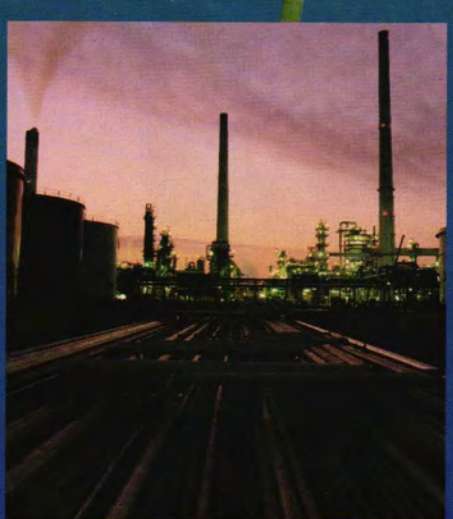

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