ENERGY WORLD

The magazine of The Institute of Energy

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transport and
Coalbed methane

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COVER

British Gas Exploration and Production's North Morecambe platform: the new field, in which £600 million has been invested, is capable of providing up to 4% of the UK's daily gas needs.

Environmental sense is commercial sense

ENVIRONMENTAL issues affect your business in many ways. The UK Government's report on sustainable development shows just one example of how the environment creates pressure for business:

'The Government, working with the EC, must establish the right conditions for adherence to and investment in good environmental practice by business. Industry can promote voluntary schemes; consumers can demand more sustainable products. There is scope for the use of market-based instruments as well as regulation." (*UK Government Strategy for Sustainable Development*, February 1994)

The response by many progressive and successful companies to environmental pressures has been to implement a company-wide environment policy. Companies with environment policies are equipped with the information, policies and management skills necessary to respond to any increased pressure.

Companies without environmental policies find themselves reacting in response to each new pressure, such as changes in legislation or demands from customers, in isolation. Such reaction leads to inconsistent response, management confusion and duplicated effort. A strategic environment policy ensures consistency, thorough understanding at all management levels and increased efficiency as the company gains experience from implementing the environment policy.

The Environment Council aims to help different interest groups work together to inspire action and changes that improve the environment through a range of programmes and initiatives. In 1988 The Environment Council identified a growing need for independent encouragement for business to recognise that 'environmental sense is commercial sense'. With that aim the business and environment programme was started. Supporters of the programme now number over 700 companies and receive in addition to the programme handbook, monthly mailings covering a variety of environmental management issues, telephone support, and access to the programme's lively seminars.

The work of the programme splits roughly into six modules covered by the handbook: design and technology; facilities management; finance; human resources; law; and PR and marketing. These reflect the nature of environment issues throughout all the operations and activities of a company.

Whilst it may be be relatively easy for a company to commit to improving their environmental performance, turning policy or commitment into action is where many difficulties lie. Our work with many of the leading companies in the UK has shown that communicating environmental aims to staff is often the hardest but most crucial aspect of an effective environment policy.

If practices such as energy conservation are to be effectively implemented it is crucial that all employees are aware of its importance. This can only be done through communication and motivation of all employees.

A new scheme, Conservers at Work, was launched earlier this year by The Environment Council aimed at all employees in an organisation. The scheme informs staff of the principles behind environmental management and how their actions at work affect the environment but also how these can be changed to reduce the individual and company impact.

Many workplace practices can be swapped with little trouble for other, more efficient ways of working that also save money. Simply switching off your computer for a few hours when you are not using it helps a lot more than just saving energy. One PC left on all day can cause the production of nearly a tonne of carbon dioxide a year.

Conservers receive an introductory book, *The Conserver's Companion: A Guide to the Art of Being Green at Work*, and a bi-monthly newsletter, *Second Nature* together with a smart recycled plastic binder to keep it in.

For further information on The Environment Council's activities, including the Business and Environment Programme and Conservers at Work scheme, please contact Suzannah Lansdell on 071 8824 8411, or write to: The Environment Council, 21 Elizabeth Street, London SW1W 9RP.

Suzannah Lansdell
The Environment Council

Bedrock study

PRELIMINARY studies to determine the suitability of Finland's bedrock for the disposal of spent nuclear fuel, have been initiated by Finnish utility Imatran Voima (IVO).

The group anticipate that shipments of spent nuclear fuel from the Loviisa nuclear plant to Russia will end in 1996, and this is most likely to be disposed of in Finland's bedrock. The studies will determine a suitable site.

A special train transporting spent nuclear fuel arrived in Loviisa from Russia in October. It carried 26 tonnes of waste removed from the Loviisa 1 and 2 reactors in 1989. This will go to the Majak nuclear reprocessing plant, located in the southern Ural region of Russia. Similar shipments from Loviisa have taken place since 1981.

The Majak reprocessing plant in Chelyabinsk-65 has acquired a total of 253 tonnes of spent fuel from Finland. In 1995 and 1996 a further 57 tonnes will leave by train from Finland to Russia. But the recent drafting of new Finnish legislation will prohibit such shipments after 1996.

IVO argues that ending the shipments to Russia will have a negative environmental and economic impact on the Chelyabinsk region. The company pays hard currency for these consignments, and fewer capital resources will undermine the Majak reprocessing plant's ability to deal with nuclear waste from the weapons industry developed by Russia during the Cold War.

Operation of the Loviisa plant will not be affected, however. The station's interim storage facilities have a capacity for five years of spent fuel, although the this would require enlargement by the turn of the century. However, the expansion option was ruled out when a wet-storage pool was built: enlarging a wet-storage pool would require further permits.

If Finnish law prohibits spent fuel consignments to Russia, IVO has the option to build final storage depots in Finland's bedrock.

Positive outlook for Eskom

SOUTH African electricity utility, Eskom, has been assigned ratings assessor Standard and Poor's 'BB' long-term implied senior foreign currency rating.

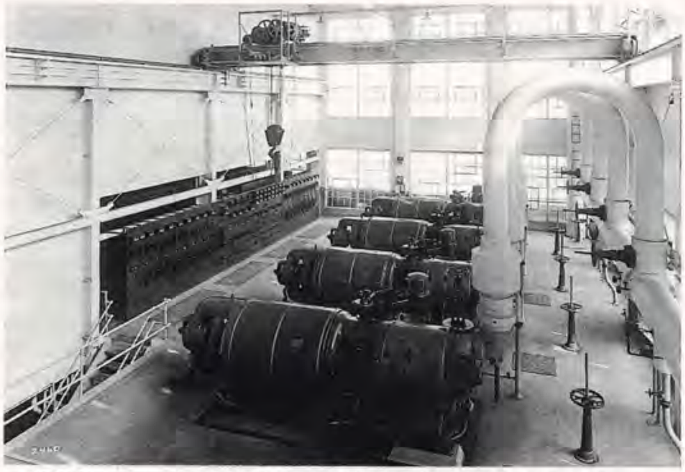
This reflects Eskom's position as South Africa's primary generator and transmitter of electricity, and its strategic importance in supporting long-term economic growth. The rating also acknowledges the implicit government support offered to Eskom through the regulatory environment, low tariff rates, good plant and management operations and limited short-term capital requirements.

Risks reflected in the ratings include a certain reliance upon large customers in the cyclical mining and basic metals sectors, an ambitious, but none the less essential electrification programme, a significant debt burden and high public expectations.

In terms of GWh sales (143 000 in 1993), Eskom is the world's fifth largest utility, and fourth largest when measured by generating capacity (37 636 MW). The company generates over 97% of South Africa's electricity — primarily from coal-fired plant, with exceptionally low variable costs.

The company is also responsible for all high-voltage transmission, and supplies electricity directly to large municipal, industrial and mining customers, representing 45%, 26% and 22% of total sales respectively. Eskom is responsible for 56% of all retail electricity in South Africa, the remaining portion is carried out by some 300 municipal distributors.

The company's low share of consumption domestic (around 15%) reflects the energy-intensive nature of the country's industry, and the fact that only 38% of households are connected to the grid. Eskom is committed to electrifying 300 000 households annually until 1999. Standard and Poor describe this programme as 'ambitious yet affordable'.



THE US company GE's advanced STAG 107FA combined-cycle system could soon be producing power adjacent to a 1920 vintage GE steam turbine, at the Crockett Cogeneration facility near C&H Sugar's refinery in Crockett, California.

The steam turbine is the last of four original GE units shown above, installed in the early 1920s to deliver power to the refinery. Two of these units were removed in 1956, and a third has since been taken out of service. The remaining 1.5 MW steam turbine is used for back-up power generation, operating about 500 hours each year.

Energy from waste market restricted by environmental lobby

THE EUROPEAN market for waste-to-energy plants has grown slower than anticipated in the early 1990s, due to Europe-wide delays and rejections for planning permission for new facilities.

Environmental lobby groups have been blamed by the industry for opposing the construction of new incineration plants without providing suitable waste management alternatives, according to a new report by international market research publisher, Frost & Sullivan.

As a result, revenues in the European market are likely to be restricted to the upgrading or replacement of existing plants to meet the latest EC flue gas emission standard by 1996.

According to the report, the market is expected to pick up after 1996, and could be worth over US$1.33 billion by the year 2000.

Mass burn technology currently accounts for over 87% of all waste to energy plant sales. This technology is well accepted and presents the least-risk approach to the industry in the immediate future. The legislative pressure to replace or upgrade mass burn facilities will continue to drive demand until the end of 1994, but their revenue share will decline throughout the decade to 56% by 2000.

Refuse derived fuel (RDF) plants emerged in 1992 with a 3.1% share of the total market. This sector is expected to hold a 16% market share in 2000, when it will be the second largest, behind mass burn technology.

The market for fluidised bed plants is expected to take longer to become established in Europe. Scandinavia is taking the initiative with this technology, but the report predicts its dispersal throughout Europe and an 8.5% revenue share by 2000.

Full-scale anaerobic plants are currently being tested in many European countries, and this technology will be the fastest growing, worth around US$159.6 million by 2000.

Modular waste to energy plants hold the smallest revenue share, with their popularity confined to smaller communities.

In a review of the market by country, the report identifies Germany as the leader, with a revenue share almost twice that of its nearest competitor.

Our 'love affair with the car' must end

THREE reports published last month endorse what the environmental lobby has been saying for some time: nothing short of a revolution in our attitudes to transport will reduce the threat to the environment and our health posed by road traffic.

Transport and the Environment is the eighteenth report by the Royal Commission on Environmental Pollution, and sets out over 100 recommendations on ways of reducing transport's impact on the environment, including a massive increase in the price of petrol at the pumps to discourage the private motorist, and greater spending on public transport

Almost simultaneously the House of Commons Select Committee on transport reported great concern for the links between high pollution levels in London, and increases over the last decade in the incidence of asthma, particularly in children.

An independent consultants report added to environmentalists' concern about the Government's road building programme. The study on the East Midland main rail line, which runs close to the M1 and A1 between London and Sheffield, concluded that motorists are clearly reluctant to switch from using their cars to public transport. 72% of those questioned said their journey would have been possible by train, but only 13% had considered using public transport as an alternative to their cars.

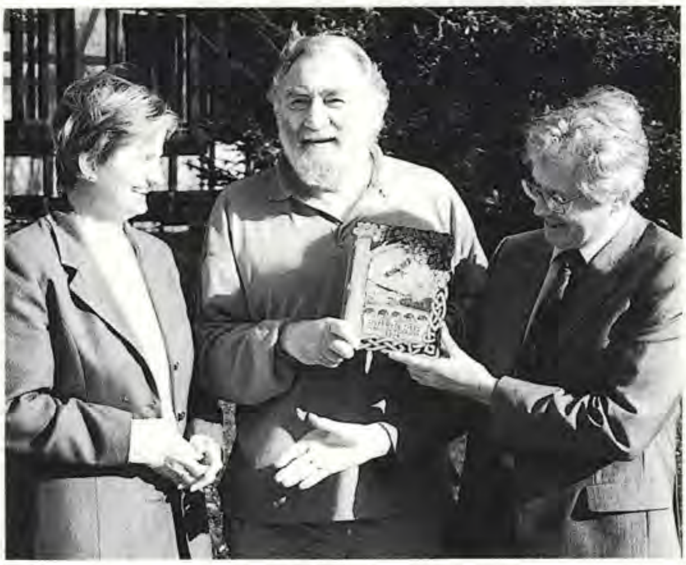
● *See pp18-19 for a report on the Institute of Energy's response to the transport sector of the Government's Technology Foresight programme.*

Charges up since privatisation

A RECENT publication by the Centre for the Study of Regulated Industries claims that typical electricity bills for domestic customers on standard tariffs have risen by 10%, but allowing for inflation there is an overall decrease of 2%.

The report cites as a contributing factor the 28% increase in distribution charges levied by the regional electricity companies since 1990/91 — a 14% increase after inflation is taken into account. The price increase to consumers has been kept to a lower level by the passing on of reduced generation costs by the major generators.

The UK Electricity Industry: Electricity Charges 1994/5, price £15 from Publications Section, CRI, 3 Robert Street, London WC2N 6BH.



Several tons of carbon dioxide emissions will be saved each year by the Dolbrodmaeth Inn's energy efficiency improvements. Graham Williams, on the right of the picture, owns and runs the hotel with his wife. He received the Green Tourism Award at the Centre for Alternative Technology in Machynlleth, Powys, in October, from David Bellamy. Pictured left is Patti Partridge of Felin Crewi Watermill, a close runner up in the award scheme.

The award was created by the Green Guide to the Dyfi Valley, and sponsored by the Snowdonia National Park to encourage good environmental practice. The criteria used in assessing the award include use of paper, water, food, transport and of course, energy, as well as the entrants' relationship to the local community and conservation.

OFGAS consults

GAS industry regulator, OFGAS has published a consultation document discussing key aspects of the separation of British Gas' transportation and storage business (TransCo). The aim of the separation is to create a structure offering the same terms for its services to all companies.

British Gas chief executive, Cedric Brown described the document as "a tough, but realistic package" and warned: "the enormity of the task should not be underestimated."

● *Copies of the consultation document 'Separation of British Gas' Transportation and Storage Business from its Trading Business' are available from the OFGAS Library, 130 Wilton Road, London SW1V 1LQ. Tel: 071 828 0898.*

Boost for clean coal R&D

A REPORT on the future of coal R&D was published by the DTI at the end of October.

Energy paper 63 *Clean Coal Technologies Strategy for the Coal R&D Programme* sets out the objectives established following the publication of the Coal White Paper in March 1993. In addition, the report outlines work currently in progress in partnership with industry and academia, and looks to the future, outlining the Government's policy for the next few years.

The stated aims of this policy are to encourage development of internationally competitive industries; to increase the potential for use of UK coals for industrial and power generation; and to reduce the emissions of pollutants from coal use.

Since the publication of the White Paper more than 70 clean coal projects have been initiated, with a total value of around £67 million, provided in part by the DTI. Technology minister, Ian Taylor, welcomed the support received from the EC and the IEA. For every £1 invested by the Government, an additional £4 had come from external sources.

The main focus of the programme over the coming years will be completing the advanced power generation R&D in collaboration with the industry-led Clean Coal Power Group, established last September.

BC preferred bidders announced

The DTI announced the preferred bidders for the regional coal companies in mid October.

RJB Mining plc is the preferred bidder for Central North, Central South and North East regional coal companies, as well as Thorne and Ellington care and maintenance collieries; Celtic Energy Ltd for South Wales; Mining (Scotland) Ltd for Scotland; Coal Investments plc for Annesley Bentinck Colliery, and the Tower Employee Buyout Team for Tower Colliery, the last remaining deep shaft colliery in Wales. The overwhelming majority of surviving UK pits are in the Central North and Central South regions, with Longannet the only remaining colliery in Scotland.

Of British Coal's seven care and maintenance collieries, two, both in South Yorkshire — Goldthorpe and Kiveton are to be sealed after efforts to find private operators was unsuccessful. Kiveton was the last BC pit to cut coal using trepanner shearers in a seam less than a metre thick.

Peabody low NOx burners for Vauxhall Motors

PEABODY ENGINEERING Ltd have supplied low Nox oil/gas (LNOG) burners to meet the specific requirements of the hot water boilers at the Luton plant of Vauxhall Motors Ltd. Vauxhall decided to re-burner their boilers to achieve immediate reductions in NOx and particulate emissions. The emissions from the Peabody burners, as with the new Vauxhall Omega, are lower than future legislative requirements demonstrating Vauxhall's commitment to caring for the environment.

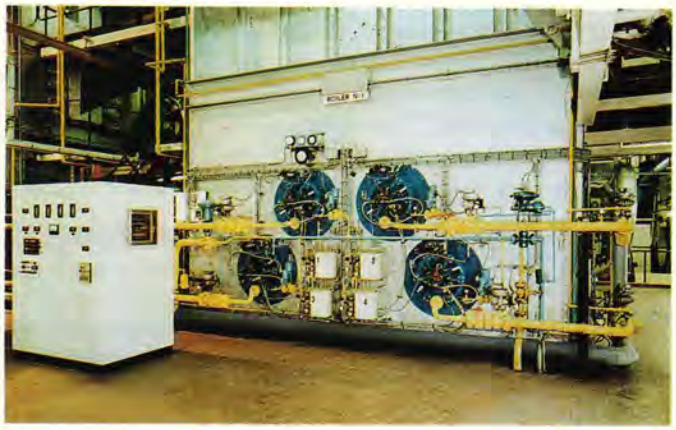
Peabody burners represent the best available technology and can be customised to suit demanding site constraints. The boiler furnace depth was extremely short with respect to the thermal loading, and the air supply windbox was very shallow. Both these factors serve to inhibit emission reductions. As the burners were designed to fit into the space vacated by the old equipment the need for costly boiler and windbox modifications was removed and site disruption during the transformation was kept to a minimum.

The contract was executed on a turnkey basis and burners were installed that now operate reliably and comfortably within the contract requirements. NOx emissions are well below 200mg/Nm^3 on natural gas, and 440mg/Nm^3 on oil. The oil has higher than average ashaltene content and 0.4% N. The Peabody LNOG burner achieves low NOx levels by staged combustion without resorting to external flue gas recirculation. This enabled the retrofitting of burners of the same thermal output, and of the same physical size whilst not requiring any additional ducting or fans.

Retention of dual fuel firing capability was important for security of fuel supplies and economic reasons. However low NOx from combustion of both fuels and low particulate emissions from oil firing were essential. The Peabody LNNAR turbulent chamber staged oil atomiser combines fuel staging for NOx reduction with small oil droplet sizes, high burn out, and consequent low dust burdens. For gas firing, Peabody arrange gas lances rotationally and axially, and select dissimilar nozzles from an available wide selection to create fuel staging. As in all cases the best combination for the specific application was selected.

Staging combustion to reduce NOx inevitably tends to increase the length of flame. For the Vauxhall installation the best compromise between NOx reduction and flame length compatible with the small furnace had to be engineered.

Following the success of the first contract further orders to reburner the other boilers on the site have been placed by Vauxhall with Peabody for completion during 1994.



One of the boilers re-burnered by Peabody Engineering Ltd for Vauxhall Motors in Luton.

International UK-based company acquires US software division

LOGICA, the leading consultancy, software and systems integration company has acquired the software division of Synercom Technology Inc.

Synercom provides work management information system (WMIS) software. This slots in nicely with Logica's worldwide expertise in consultancy, project management and systems for gas, electricity and water utilities. In the last year alone Logica has worked with more than 40 utilities.

Because of privatisation, UK utilities have undergone profound restructuring over the past eight years. This, and the increasing need to keep costs to a minimum whilst improving customer service, has created business challenges which companies like Logica are helping to meet. All utilities have major capital intensive assets which need to be maintained, developed and controlled. The Synercom work management product enables utilities to maximise their return on asset investment and also enables them to effect organisational change where appropriate.

Logica has also acquired Synercom's INFORMAP family of GIS products on which some of the world's largest asset management systems are based, including the British Gas digital records system. Logica will continue to support these major programmes.

These two products add to the range already offered by Logica, for example, Chevron (UK) Ltd has been a Logica client for over three years, and uses their products to monitor staff movements offshore, provide information on production and manage the maintenance of offshore platforms.

MAPS — Logica's personnel tracking and movement validation product — has given Chevron a significant increase in the efficiency of planning and tracking helicopter flights. It provides a key component in meeting the safety requirements specified for North Sea operations, following the Piper Alpha disaster.

The introduction of a further program: CIPARS (a dedicated version of PRODIS, an integrated production allocation and accounting product) allows Chevron to ensure hydrocarbon production is allocated accurately, and that reporting requirements are met with the greatest possible efficiency.

PM3 has been developed jointly by Kvaerner AM Ltd and Logica. Also used by Chevron, it is an integrated logistics and maintenance system, specifically designed for the offshore oil and gas industry. It enables Chevron to optimise its use of resources, with the result of increased production efficiency.

On the downstream side of the oil and gas industry, Logica's NEXUS product supports the competitive trading of gas by independent shippers. NEXUS helps to demonstrate the comprehensive nature of Logica's software products, as it is aimed specifically at the emerging competitive market in gas, sitting alongside Logica's work in helping to develop similar solutions for the electricity market.

Internationalisation affects the energy utilities more and more: it is an increasingly global business. Logica's recent purchase of Synercom's software division will enable the company to offer this work management solution to an international customer base and extend their presence in the UK market.

Among the company's utilities clients in the UK are HydroElectric, Yorkshire Electricity, British Gas and Northern Electric. Internationally, their customers include Illinois Power, Entergy, Texas Utilities, Gasunie, Shell and BP.

Monitoring — equipment and methods

*by Joe Kay, BSc PhD CEng FInstE**

ALTHOUGH the main subject of this article is boilers, much of what will be said can be applied to incinerators or other processes involving emissions to air.

Large boilers and furnaces (large combustion plant, or LCPs) were the first types of plant to be regulated by Her Majesty's Inspectorate of Pollution (HMIP, HMIPI in Scotland) under the terms of the Environmental Protection Act 1990 (EPA). The LCP regulation set the pattern for other processes, and for the part B regulation of smaller, less complex processes by local authorities. Hence, a discussion of the application of the regulations for LCPs will cover most of the demands of regulation for other processes. The latter will, in many cases, be rather simpler than LCP regulation.

The division between regulation and regulating authority is confusing. Larger, more complex plant is the responsibility of HMIP, whilst smaller, simpler plant is regulated by the local authority. The former operate Integrated Pollution Control, including discharges to land and water, whilst the latter (for the purposes of the EPA) are concerned only with emissions to air.

A further division is made between 'new' plant, for which stringent instantaneous emission levels are dictated by the EC Large Combustion Plant directive, and 'existing' plant for which no specific limits are set by the EC. For 'existing' plant, the EC directs that UK's total annual emissions of certain pollutants be reduced over a specific time period. This has been incorporated by the Department of the Environment into a National Plan. The plan is being implemented by HMIP in its registration conditions for existing plant.

LCP registration (or authorisation) is, I understand, largely completed. The experience of that exercise has set the pattern for subsequent registrations in other areas. Some of the peculiarities of the registration process and the framing of the conditions are traceable back to the LCP registration process. In particular, there are often two sets of limits for particular substances, one relating to

**Fuels/combustion/energy consultant*

Dr Kay provides us with a detailed, practical guide to the equipment required and methods employed to monitor boilerplant in line with the Large Combustion Plant Directive.

'instantaneous' or short-term emissions concentrations, and the other to the total annual release of the substance. In the initial exercise, these two were sometimes contradictory, but experience is bringing more rationality into the process.

Substances to be monitored

The Chief Inspector's guidance note (IPR 1/1) lists some prescribed substances, with the implication that they need to be monitored and controlled. The list is a bit catch-all, and its application will depend on HMIP in its authorisation conditions. The list is, at least in theory, superfluous, since there is an overriding duty to monitor and control the emission of *any* substance which could be construed as causing harm. That could include almost anything! In addition, it is not widely enough recognised that HMIP expect the plant operator to know, report and act.

In practice, in a reasonable world, the substances to be monitored will be SO_2, NO_x, particulates and smoke. For some operations the list will include HCI and mercury. For normalisation purposes, O_2 and temperature will need to be measured.

There is an overall responsibility to utilise good practice in the operation of the plant, and this could be interpreted as a need to monitor SO_3 and CO as well as the above. The authorisation will probably not include specific limits for these last two, although an aside in IPR 1/1 suggests for CO that 'good practice will generally result in a concentration below 200 ppm v/v'.

The above applies to boilers. Incinerators would be expected to have similar monitoring requirements, with perhaps the addition of organics (and partial oxidation products) and dioxins, depending on the type of plant.

General considerations

Old attitudes to emissions monitoring and abatement were a bit casual in some enterprises. Production was all important, and flues and chimneys, like drains, were where material was discarded and ceased to be the responsibility of the plant. All this has changed since the passing of the Environmental Protection Act. Instead of being a low priority, and the first victim of shortage of cash or of maintenance effort, the emissions end of the process has become a high priority area. People, not excluding senior management, could finish up in gaol, and the operation of the plant curtailed or even stopped. Whilst not suggesting that this will be the norm, it does indicate that the

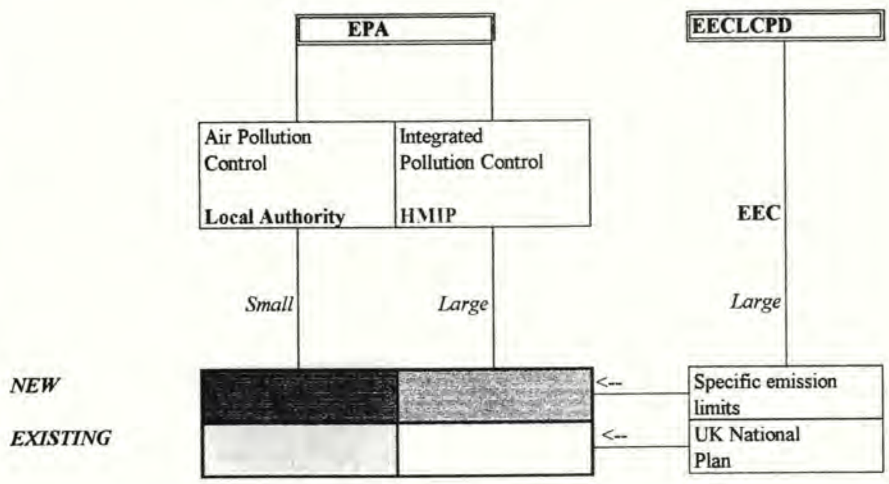


Figure 1: legislative and regulatory relationships.

environment is a serious issue, and has to have time and money spent on it, even when there are other pressing demands.

Safe access to monitoring points is important. The usual safety features should be included, and adequate lighting should be provided. If particulate measurements are to be made, then quite a large access platform will be necessary. BS3405 (para 6.4) gives some guidance to requirements. The platform should have an area of at least 2.5 m^2, and preferably more.

It is impossible to be prescriptive about monitoring methods. It would be wrong to suggest that there is an 'off-the-shelf' answer, however much instrument makers would have you believe it. Each plant will have its own set of circumstances and its own philosophy, and decisions about monitoring techniques will depend as much on these as on first-cost considerations. The whole monitoring requirement, for all emissions, must be studied, including the need for reporting in a suitable form for HMIP or the local authority, for public information, for process records and for plant operational use.

There is an understandable prejudice in favour of infrequent snapshot emissions measurements instead of the apparently expensive installation of continuous monitoring equipment. Careful arithmetic will often reveal that the manpower requirements of snapshot measurements in fact exceed the continuous monitoring costs. Any enterprise that can assume a zero marginal cost for piling a bit more work on to existing technician resources is overmanned.

If instruments are to be installed for continuous monitoring, the following requirements should be adhered to as far as possible. The instruments:

- should be easy to calibrate and set zero;
- should be tough and able to withstand the less-than ideal conditions to be found in some boiler houses;
- should be compact, if, as is usual, there are severe space limitations;
- should be easy to maintain, and make little demand on instrument artificer time;
- should be inexpensive;
- and should be capable of meeting with HMIP or local authority approval.

Monitoring — general techniques
(for fixed monitors)

- wet chemical methods, gas chromatography etc. These are usually time consuming, messy, expensive and demanding of high-level technical skills. For monitoring purposes, they are to be avoided if at all possible;
- spectrophotometric methods. Infra red (IR) methods can be used, in principle, for the measurement of CO NO SO_2, volatile organic compounds (VOCs), and sometimes CO_2. Ultra violet (UV) and visible light methods can be used for SO_2 (absorption), SO_2 (fluorescence), NOx (chemiluminescence);
- electrochemical methods. Ambient temperature electrochemical cells could be used, in principle, for measurements on cleaned and cooled flue gases. They are not generally available as monitors, but are invaluable for portable instruments (qv). High temperature electrochemical methods are available for O_2 (the well known Zirconia probe) and for NO and SO_2

Sample treatment

Monitors can be situated **outside duct** using an extracted gas sample. This would be useful for wet chemical and gas chromatography methods, for ambient temperature electrochemical methods and for the UV and visible spectrophotometric methods. Alternatively, situated **cross-duct,** for some of the IR spectrophotometric methods; or **in-duct** for the high-temperature electrochemical probes.

Extraction methods are not favoured. Extractive methods have found favour with some of the US power utilities, and with some of the CEGB successors. The cost and complexity of such systems are not as great a deterrent to the operators of very large boilers as they are to the industrial operator. An ESI power station boiler might be 2000MWth, whereas most industrial boilers are less than 50MWth.

All extractive systems demand that the flue gas sample be representative, which, due to the effects of air leakage, and of particulate stratification, is not always an easy demand to satisfy. The sample should be filtered to remove smoke and particulates. The wet acid gases must then, if the instrument has a heated cell and is suitable for hot measurement, be kept hot enough to avoid condensation. Otherwise, the sample must be cooled and dried, and the cooling train must possess an acid condensate removal system. The result is a system that has a high first cost, intense maintenance and high space demands, all of which features are unattractive.

Cross-duct and in-duct instruments do not need gas conditioning and are the instruments of choice. Cross-duct optical instruments sometimes suffer from dirt contamination of the glasses, demanding manual cleaning, if purge systems are inadequate. The in-duct zirconia O_2 probe has proved cheap and reliable, and similar probes for other gases would be ideal. There is a similar probe for measurement of NO and SO_2, but the SO_2 probe is reported to suffer from HCI attack in coal-fired systems. The probe is still quite new, and cannot be said to be well established yet.

Monitoring instruments are usually fixed. Portable instruments, however, have several uses. These are investigation work, and optimisation of individual boilers; and survey work prior to installing fixed monitors. Many authorisations will require that only the common flue, or stack, be monitored continuously. It is difficult to pin down the source of problems on multi-boiler installations unless portable instruments are available.

Sometimes the authorisation will not require continuous monitoring, but will only need snap readings at fixed intervals. In this case, properly calibrated portable instruments can often be used. Care must be taken in costing this method of monitoring. It can be expensive in manpower time and indisruption to normal operations, especially if measurements have to be made under specific boiler conditions.

Compendium instruments based on the ambient-temperature electrochemical cell have revolutionised technical investigation on boiler plant. One instrument is now capable, at reasonable cost, of measuring O_2, CO, NO, SO_2 as well as ambient and flue gas temperatures. The instrument will provide a print out of all the readings, and include the time, date and boiler number — admirable for people whose notebook recording technique automatically includes omission of something.

Criteria for choosing a portable instrument depend on the user's requirements. My own personal criteria would include the following:

- a portable instrument should be truly portable. An instrument weighing 12 kg feels more than that when it has to be carried up to a power station roof;
- the version bought should be as simple as possible. There is no point in having an RS232 interface and data storage facility if you are not going to need it, or if you are not clever enough to use it;

The author

Dr Kay was formerly ICI fuels and combustion engineer, with responsibility for fuel technology and combustion engineering for the company throughout the UK, with special responsibility for the dozen or so industrial power stations classed as LCPs.

He left University of Birmingham in 1962 with his first degree in chemistry and a PhD in chemical kinetics of NO compounds. During his time at University he gained industrial experience with L&B Rubber Co (now BTR) as a technician.

He served ICI for 28 years, until 1993, when he become an independent consultant. His time at ICI included research into plant commissioning and studies of inorganic reactions in flames.

● instruments used in boilerhouses will be knocked about, used under leaks and left in the rain. They have to be rugged;
● a good condensate pot is essential. Electrochemical cells refuse to work when wet;
● cross-sensitivity between gases can be problem. For example, CO cells are sensitive to SO_2. If chemical filters are used, it must be easy to detect when the filter is spent; the colour change must be unambiguous, and the filter inspection must be easy;
● the price must be right, and servicing readily available at modest cost. The cells have a limited life (even if not used), and it is preferable to have cells that can be replaced by the user. As a rough guide, a good compendium instrument can be had for about £2000.

Ideally a potentially suitable instrument should be borrowed for a month. Use of an actual instrument can give the user a good idea of his real requirements, and can also reveal the faults in an instrument that sounds excellent on paper.

My own experience with these instruments has been of excellent measurement of all the parameters indicated above, except for SO_2. These cells seem to be prone to producing measurements that are often unlikely. I do not propose here to discuss the reasons for this, simply to encourage caution.

Compendium instruments should not be used for measuring smoke number. It is an unnecessary complication, and doesn't work anyway. A simple smoke pump is cheap and effective.

Particulates are a special problem. The mass measurement specified by BS3405 can be carried out with the BCURA apparatus (made by Airflow Developments). The method is cumbersome, time consuming and demands specialist staff. It is recommended, if the measurement is only to be done infrequently, for instance for calibrating fixed obscuration monitors, that it should be done by bought-in specialists.

The BCURA apparatus, like the dewpoint meter, hardly qualifies as 'portable'. If the user has sufficient demand to justify buying his own kit and training his own people, it is recommended that the gas washer be discarded. There will be an increased cost for replacement fans, but it will be amply justified.

New forms of particulates measurement apparatus are now appearing on the market, and a new British Standard has appeared (BS6069 pt 4.3). I have, as yet, no experience of these, and am unable to comment on them with authority. The kits that I have looked at appear just as cumbersome as the BCURA kit, and the new British Standard seems as troublesome to use as BS3405.

No portable method for measuring HCI has been found that can be recommended yet. It has not been necessary, for boilers at least, to monitor organics, NO_2 etc, so no comment is made on the development of cells for these gases.

The use of tubes containing detector crystals is not encouraged. They can be useful indicators of the presence of specific gases, but as a quantitive measure they are fraught with difficulty. They should only be used by experienced, trained technicians, and even then can give very misleading results.

Continuous monitoring

Oxygen and temperature. Emissions must be normalised to the conditions specified by the regulatory authority. For boilers, the emissions will be standardised to mg/m^3 at 273K, 101.3kPa, dry, 3% O_2 dry. Coal-fired boilers are normalised to 6% O_2 dry.

The O_2 and temperature measurements must be made at the same place as the emission is measured. Most boilers already possess an O_2 meter close to the combustion chamber, but this will not normally be the emission measurement point, so the probe will have to be duplicated. The zirconia oxygen probe is now much cheaper than in the past, and more reliable, and is the instrument of choice. Temperature can be measured by a number of suitable methods, and is not a problem.

Sulphur oxides (SOx). Emissions of sulphur oxides should, with the agreement of the regulatory authority, be calculated. Fuel suppliers can supply analytical data for their products which include the sulphur content. It is general practice with this method to assume that all the sulphur entering the process leaves as sulphur oxides (expressed as SO_2). HMIP will sometimes agree to a deduction of 5% for sulphur retention in coal-fired boilers.

Incinerator operators have a problem in that the sulphur content of the waste that they burn is variable and not easy to analyse in a properly representative fashion. The sulphur content of most waste is, fortunately, low, and the authority should be agreeable to using an average value based on whatever analysis can reasonably be carried out. The emission will not be accurate on a day-to-day basis, but should be more accurate over the longer term.

A monitoring instrument will be necessary where flue gas desulphurisation is carried out. The instrument of choice is a rugged, reasonably priced cross-stack IR detector. Instruments needing an extracted sample should be avoided for reasons stated earlier.

Nitrogen oxides (NOx). It is not proposed to discuss the reasoning for the assertion, but N_2O can be ignored in the context of most boilers and furnaces, and it can be assumed that NO_2 will be a small, and fixed, proportion of the NOx emission. It is therefore only necessary to monitor NO continuously. The regulatory authority will permit the NO_2 emission to be calculated from the NO emission, provided that the proportion is confirmed, at intervals to be agreed. The level of NO_2 emission is generally about 5% of the NO emission. Again a cross-stack IR detector is recommended.

The in-stack hot electrochemical probe is comparable in price with the cheaper IR detectors, and looks and feels like the familiar O_2 probe. It is, though, a comparative newcomer to the field. One version of the probe will measure both NO and SO_2 with a single instrument.

Carbon monoxide (CO). The emission level for CO might well not be specifically regulated, but good practice will dictate its

Table 1: Fuel characteristics

	AR GCV (GJ/te)	AR NCV (GJ/te)	SA (m3)	SD (m3)	SW (m3)	SW/SD =r	SD/SA	SW/SA
Coal	26.00	25.09	6.30	6.12	6.70	1.09	0.97	1.06
HFO	42.11	39.72	10.60	10.02	11.23	1.12	0.95	1.06
Gasoil	45.34	42.39	11.19	10.47	11.92	1.14	0.94	1.07
N gas	53.53	48.13	12.85	11.55	14.20	1.23	0.90	1.11
Waste	12.26	11.24	2.09	2.11	2.74	1.30	1.01	1.31
H2	141.78	119.16	26.53	20.98	32.09	1.53	0.79	1.21

measurement anyway. The cheap, rugged IR detector is well established, and accurate.

Hydrogen chloride (HCl). HCl emission is unlikely to be regulated in oil or gas burning boilers. Boilers using British coal will have significant emissions, and there is no detector that can be recommended. The emission should be calculated from the fuels analysis, as for sulphur. Again the assumption should be made that all the Cl in the fuel appears as HCl in the flue gas. There should be no assumption of any retention in the boiler. Foreign coals usually have negligible chloride content.

The above advice is more difficult to apply to waste incineration, where composition is less well defined. Likely looking instruments demand an extracted sample. Extracted samples are always associated with condensate problems, and HCl, being very soluble always finishes up being largely caught by the condensate. Perhaps the easiest way out is to accept this and use an absorption train, followed by analysis of the absorbate, but this hardly constitutes continuous monitoring.

The composition of clinical waste is even harder to define. Although I claim no expertise, I would have thought that, in the absence of PVC, the chlorine content of clinical waste would be low. Reduction of PVC input at source, if possible, might persuade the regulatory authority to agree to a less rigorous HCl monitoring schedule.

Particulates and smoke are both monitored by obscuration methods. Small particles make an unduly large contribution to the obscuration, and the particulate 'measurement' therefore makes an assumption of constant particle size distribution. Experience with sampling measurements shows that there is very little correlation between the dust/grit (>1-5 micron) and the fume (<1-5 micron) emissions, indicating that particle size distribution is definitely not uniform. The measurement of obscuration as an indicator of particle content is therefore very dubious. Nonetheless, there is no other method which is remotely applicable in a practical installation.

The older smoke alarms are not suitable for particulate measurement, giving an inaccurate measure of obscuration and being susceptible to dirty windows and light fade. The best cross-duct obscuration instruments use a LED source with controlled intensity, and use a specific frequency to avoid the effects of stray light. More sophisticated instruments use a double transceiver system to compensate for misalignment and dirty windows. Even so, it pays to have a good purge system to minimise contamination.

An alternative to measuring reduction of light intensity is to use a fixed frequency source with a frequency detector. Each time a particle crosses the beam, the frequency is affected. This instrument is immune to dirty windows (within reason), and is effectively a particle counter. My experience with one of these instruments showed it to be susceptible to stray light.

The obscuration meter has to be calibrated by using a sampling method. The most usual method is that of BS3405 using the BCURA apparatus. The relationship between the non-normalised particle concentration and the obscuration is given by:

$$p = -\log(1-Ob)/fx$$

where,

p = particulate concentration in mg/m3
Ob = obscuration (decimal fraction, not %)
fx = calibration constant multiplied by path length. It is not necessary to know x: the combined factor fx can be used

Measurement of smoke intensity is defined in terms of Ringelmann number, where number 5 represents black smoke. There are not many people left who can carry out the original Ringelmann test, and it is not recommended for the tyro. A better method for this hitherto subjective test is given by BS2742 Add. 1, which gives the obscuration equivalent (at the stack top) of various Ringelmann numbers. The relationship is linear, and of the form:

$$Ob = 0.12R+0.4$$

This can be used to convert the obscuration measured by the instrument to a perceived Ringelmann number from,

$$R = 5.0 - 8.33(1 - Obi)^{xs/xi}$$

where,

R = Ringelmann number
Obi = obscuration (decimal fraction) measured by the instrument
xs/xi = ratio of stack diameter to path length of instrument

Although the relationship between obscuration and Ringelmann number is linear, it does not go through the origin. Any derived Ringelmann number below 1.0 is therefore meaningless. Note that the obscuration should be corrected for temperature if there is a significant difference between the stack exit temperature and the gas temperature at the obscuration instrument.

Flow. In order to derive a total emission from the concentration measurement, a flue gas flow is required. Several instrument manufacturers offer products. Flow of flue gases is not easy to measure, not least because it is never constant across the duct. Most boiler operators measure the fuel usage, and that can be used, with some accuracy on a minute by minute basis that is required for the computation of total emissions.

The fuel composition is required, but need not be known exactly. The data given for the liquid and gaseous fuels in Table 1 will be found accurate enough for monitoring purposes. The data for coal are on an 'as received' basis, and assume 10% moisture and 15% ash. They would more conveniently have been quoted on an ash free basis, but are easy enough to use in the given form. Data for waste are more difficult to come by, as composition varies and frequent sampling is difficult. The data in Table 1 are a best guess at a clinical waste containing 20% ash.

Normalisation of emissions

Emissions test results have to be standardised to: 273K, 101.3kPa, dry, 3% O_2 dry for liquid and gaseous fuels. Other systems are similar but with different O_2 levels, eg, coal 6%; gas turbines 15%.

Many instrument suppliers offer to produce a value for the emission that is ready normalised. it is not unknown for the equations used to be in error, and it is often difficult to reconstruct the calculation produced by the black box. It is recommended that instruments produce their raw data as ppm v/v, and that a separate intelligent box is used for the normalisation. The user then knows what algorithms have been used in his calculations, and the intelligent box can also be used for averaging, for data storage and for producing reports.

The normalisation algorithms are quoted below. The derivations of the algorithms are not shown.

Conversion to weight / volume at 273K. The measured emission concentration, Em (v/v) is multiplied by its density to convert to a weight/volume basis. Note that the v/v concentration is the same at all temperatures. The weight/volume concentration obtained by this method is in mg/m3 at 273K, 101.3kPa (since the densities in the table correspond to these conditions). Densities of some common gases are shown in Table 2.

Temperature conversion. Emissions measured in v/v concentrations and converted, as above, to w/v do not require temperature normalisation, as they have already been so normalised. Concentrations measured in terms at temperature Tm can be converted assuming ideal gas behaviour, by:

$$\frac{Es}{Em} = \frac{Tm}{273}$$

where,

Em = emission concentration as measured
Es = normalised emission concentration
Tm = temperature (absolute K) of gas at emission measurement point

Pressure normalisation: v/v concentrations converted as above to w/v concentrations do not require pressure normalisation, as it has already been done. Other w/v concentrations can be converted, assuming ideal gas behaviour by:

$$\frac{Es}{Em} = \frac{Ps}{Pm}$$

where p = pressure and the subscript and other symbols are as for temperature conversion.

The pressure at most test points will differ by only the odd inch wg from atmospheric pressure, and remembering that 1 atmos = 407"wg, the correction hardly seems worthwhile.

Oxygen and water vapour normalisation. Differences between the volumes of stoichiometric air, stoichiometric wet flue gas and stoichiometric dry flue gas are sometimes ignored when calculating excess air in everyday work. This neglect is sometimes repeated in other circumstances, such as normalisation calculations. The neglect is not justified, as quite large errors in normalisation can occur.

The water vapour content owes much more to the hydrogen content of the fuel than it does to its moisture content. It is justified to assume a fixed moisture content for coal of say 10% avoiding the need for constant manual input of a variable into the normalisation equation. The same is probably true of most waste (qv).

It is convenient to use measured values of emission (Em) and O_2 (Om) and to correct for wet measurement of either or both with a combined moisture factor. The basic normalisation equation is:

$$\frac{Es}{Em} = \frac{(20.95 - Os)}{(20.95 - Om)} * \text{'moisture factor'}$$

where,

Om = measured O_2 content (% v/v)

Os = normalised O_2 content (3% for oil/gas, 6% for coal)

The water content of the flue gas depends on the fuel consumption. The water vapour in the flue gas can affect both the measured emission concentration and the O_2 concentration. In-duct and cross-duct measurements are both 'wet' measurements. Measurements on extracted samples (which include those made using portable instruments) are 'dry'. There are therefore four cases for the normalisation. The relevant equations, combining the oxygen and water corrections are shown below. The equations are not derived in this note.

It is very inconvenient to measure the moisture content of the flue gas directly. The moisture content of the stoichiometric flue gas is a characteristic of the fuel, but is awkward to handle, as such, in calculations. Single normalisation equations, using **r**, the SW/SD ratio, are more convenient for repetitive and machine calculations. The ratio would normally be known for well-characterised fuels, such as oil and gas. Coal is more variable, but, given the lower accuracy of most measurements on coal-fired boilers, use of standard values is justified. Uncharacterised waste is problematical, and the choice lies between estimating the composition or doing regular simultaneous measurements of Od and Ow. **r** can be calculated from:

$$\mathbf{r} = \frac{Od.(20.95 - Ow)}{Ow.(20.95 - Od)}$$

Table 2: ideal gas densities at 273K, 101.3kPa

Gas	Density
SO_2	2.86
SO_3	3.57
NO	1.34
NO_2	2.05
CO	1.25
HCl	1.63
CO_2	1.96
H_2O	0.803

The four normalisation equations, using only measured values and **r**, are:

Case 1 Em dry, Od dry

$$\frac{Es}{Em} = \frac{(20.95 - Os)}{(20.95 - Od)}$$

Case 2 Em dry, Ow wet

$$\frac{Es}{Em} = \frac{(20.95 - Os)}{(20.95 - Ow)}.(1 + Ow(r-1)/20.95$$

Case 3 Em wet, Od dry

$$\frac{Es}{Em} = \frac{(20.95 - Os)}{(20.95 - Od)}.(r+Od(1-r)/20.95$$

Case 4 Em wet, Ow wet

$$\frac{Es}{Em} = \frac{(20.95 - Os)}{(20.95 - Ow)}.r$$

An assumption of a constant moisture content of 10% w/w for coal gives a maximum error of 2% in Es, at the extremes, when the real moisture content varies from 0% to 20%. That error is for Case 4. Other cases have lower errors. Given the accuracy of measurements on coal-fired boilers, the assumption of a constant fuel moisture content is justifiable.

Waste is more problematical. If emissions from waste-fired systems have to be normalised, then an assumption of a fixed moisture content would be convenient. An assumption of a constant 20% moisture in clinical waste leads to a maximum error of 6.7% in Es when moisture content is really 10% w/w, and a maximum error of -8.6% in Es when the moisture content is 30% w/w. Given other uncertainties connected with the composition of waste, the convenience of using a best-guess fixed moisture content in the normalisation equations would seem to be justified.

Values of SW, SD, r for some common fuels are shown in Table 1. Note that the values for 'waste' are an estimate for a particular example of waste, and should not be assumed typical.

Mixed firing. If more than fuel is fired, the simple values of **r** cannot be used. A weighted average value will give the wrong answer. The correct mass weighted average value of **r** can be derived from SW and SD values (Table 1) using the equation:

$$\mathbf{r}_{av} = \frac{m1.SW1+m2.SW2=m3.SW3 \ldots}{m.1SD1+m2.SD2+m3.SD3 \ldots} = \frac{\Sigma m_i.SW_i}{\Sigma m_i.SD_i}$$

Although the emissions normalisation is mass weighted, the emission limits are weighted by thermal input. The thermal input is proportional to both the mass flow and the calorific value of the fuels. The European LCPD, IPR 1/1 and PG 1/3 all specify weighting by thermal input, but none of them state whether thermal input should be gross or net for emissions limit weighting. By analogy with the sizing of boilers by thermal input, it is presented that net values should be used. The weighting equation is:

$$EL_{av} = \frac{m1.CV1.EL1+m2CV2.EL2+m3.CV3.EL3 \ldots}{m1.CV1 \quad +m2CV2 \quad +m3.CV3 \ldots} \quad \frac{\Sigma m_i.SW_i}{\Sigma m_i.CV_i}$$

Some CVs are given in Table 1.

In practice, inspectors seem to be setting fixed limits for various firing regimes, and this has the virtue of avoiding the complications of thermal input weighting.

I will not discuss reporting requirements in detail. They are a matter for arrangement with the regulatory authority. There are some general requirements, however, and the authority can be expected to insist on these being adhered to.

Monitoring records should be easily accessible to the authority. If they are held in computerised form (which will be usual) then the inspector should be able to access them without too much reliance on the operator.

Monitoring results should be made available to the public in a form which is easy to understand. By implication, a mass of monitoring results is not wanted. The results should be averaged, and such information as number and magnitude of infringements quoted.

Real-time monitoring should be available to the boilermen. In addition, though not mandatory, it is common sense to keep archives for examination by technical personnel. The expense of monitoring will be partially recouped if the information is made use of to improve the operation of the plant. ❑

Symbols

Em = emission as measured

Es = emission normalised for excess air & moisture

Os = standard O2 (% v/v, assumed always specified dry)

Od = O2 as measured (dry)

Ow = O2 as measured (wet)

SD = stoichiometric dry flue gas (per unit weight of fuel)

SW = stoichiometric wet flue gas volume

r = SW/SD ratio

Alternative liquid transport fuels

by Roger Green MSc PhD CEng MInstE FIPENZ
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ALTERNATIVE liquid fuels are often seen as being a more attractive option than gaseous fuels. This is not necessarily because of any improved combustion properties, but because the onboard vehicle storage of liquid fuels is far simpler than gaseous fuel storage. In addition the existing infrastructure is equipped to deal with large scale transportation and storage of liquid fuels.

Those currently in use or at the centre of considerable research and development may be considered under the heading of two main fuel groups, which are sub-dividable as alcohols (ethanol, methanol) and triglycerides (tallow esters, vegetable oils).

The alcohol fuels are considered promising alternative transport fuels as they offer reduced levels of exhaust pollutants and are able to be produced from renewable resources. Methanol and ethanol have a number of similar properties, and hence require similar attention when considering fuelling, combustion, storage and handling.

The stoichiometric air-fuel ratio's for both methanol (CH_3OH) and ethanol (C_2H_5OH) are considerably lower than that for petrol and diesel. This is because the alcohols are oxygenated fuels and both contain a considerable amount of oxygen. In the case of methanol the oxygen content of the fuel is 50%, on a mass basis. This means alcohols require significantly less atmospheric air for combustion, and burn with a very clean, almost invisible, flame.

Methanol and ethanol have lower calorific values of approximately half that of petrol and diesel. As a consequence, to obtain the same power output from an engine, the mass flow rate of the alcohols needs to be approximately doubled. This requires increasing the capacity of carburettor jets, injectors and fuel pumps.

Alcohols have a latent heat of vapourisation, many times greater than conventional fuels. This coupled to the fact that approximately twice as much fuel has to be burnt means that the heat required to vapourise the alcohols is far greater than conventional fuels, approximately eight times greater for methanol. It is absolutely essential, in spark ignition engines, that this heat is supplied in the vicinity of the inlet manifold and that the alcohols are vapourised prior to entry into the engine cylinder. Failure to ensure proper fuel preparation can lead to severe wear problems within the engine. However, correct control of the level of vapourisation can allow some decrease of the inlet air temperature resulting in improved volumetric efficiency and greater output torque and power. Reductions in a vehicle's gear ratio's should be made, in order to take advantage of the increase in torque, if fuel economy is to be increased.

In the last issue of *Energy World*, Roger Green and Steve Pearce examined alternative gaseous transport fuels. In this article they turn their attention to the liquid alternatives.

Both ethanol and methanol are polar fluids and are therefore more corrosive than the conventional petroleum-based fuels, methanol more so than ethanol. Metals that are affected are terne plate, magnesium, aluminum, zinc and copper. These metals should be replaced or plated, for example with nickel, for protection. The exposure of plastic and rubber components in the fuel delivery system to alcohol can also cause swelling and softening. These problems are easily overcome with correct material selection.

Due to the alcohol's fixed boiling point, the vapour pressure at low temperatures is not sufficiently high to start engines, resulting in poor cold starting performance. This can be overcome with the use of a more volatile fuel additive or employing a secondary 'cold start' fuel.

Other engine and vehicle modifications include: spark plugs with a higher heat rating; engine oil engineered to suit alcohol fuels; corrosion resistant and increased capacity fuel tank, lines modified connecting rod and crankshaft bearings.

If attention is paid to all these points, spark ignition engines can be converted, or built as dedicated engines, to operate on alcohol fuels and achieve good performance and a long operating life. Satisfactory compression ignition engine operation is however, rather more complex, and the technology is less well developed.

Spark ignition engines

The physical properties of the alcohols, such as their high octane number, improved volumetric efficiency and soot free combustion means that they are excellent alternative fuels for use in spark ignition engines. As such that have been used in specialist applications, such as motor racing, for many years. Today the alcohols are becoming a little more widely available, most commonly as a small percentage blend of approximately 15% with petrol, since they can improve engine performance and act as a petrol extender. Small amounts of alcohol in petrol require little, or no, alterations to a standard engine. Because of the cold start problem, high percentage alcohol blends are likely to be utilised rather than pure alcohol. Blends of 85% methanol in petrol, and 85% ethanol in petrol are currently receiving a lot of attention and are known as M85 and E85 respectively.

The exhaust emissions from alcohol fuelled vehicles contain lower concentrations of photochemically reactive components, except formaldehydes, than do petrol exhaust emissions. As a direct consequence, alcohol fuelled engines have the potential to reduced smog production.

There are two broad categories of alcohol fuelled vehicles being developed by major motor manufacturers. These are the dedicated alcohol vehicle operating on either pure alcohol, or a fixed percentage blend of alcohol and petrol, and the flexible fuelled vehicle, which is designed to be able to operate on alcohol, petrol or any blend of the two fuels up to a maximum of 85% alcohol.

The compression ratio of a dedicated alcohol engine can be increased to approximately 12.5:1 without encountering auto-ignition problems. The higher compression ratio takes advantage of the higher octane rating of the fuel and results in higher efficiencies and power output for the same energy input as petrol. This coupled with the ability of the alcohols to burn lean mixtures and improved volumetric efficiencies due to inlet charge evaporative cooling make the alcohols a viable alternative to petrol.

During the changeover period to alcohol fuels, when universal availability of these

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Table 1: Selected properties of liquid fuels

	petrol	diesel	methanol	ethanol	vegetable oil (typical values shown)	tallow esters
energy density MJ/litre (lower calorific value given)	31	35.7	15.9	21.6	32.5	32.7
octane number (RON)	90-100	10	105	110	n/a	n/a
cetane number	10	50-55	3	8	38-40	70
heat of vapourisation (KJ/kg)	293	192	1110	904	—	—
stoich. air fuel ratio	14.6	14.5	6.4	9.0	—	—
autoignition temp (K)	490-530	450-510	658	638	—	—
viscosity @ 20°C (cSt)	0.6	4	0.75	1.5	35 @ 40°C	4.5-5.5@40°C

Note: properties may vary according to composition and temperature

fuels cannot be assured, engines and associated fuelling and control systems are being designed for flexible dual fuel operation. To achieve this a sensor is required to determine the proportions of each fuel in the blend and set engine control parameters accordingly. This can be accomplished by measuring the change in one of the physical properties of the fuel, for example refractive index or capacitance. An electronic control unit is used to continuously monitor engine parameters that include fuel composition, exhaust gas oxygen content, engine speed, engine coolant temperature and auto-ignition. With this data, fuel injection volumes and ignition timings are continuously adjusted using pre-programmed engine data maps. Modified fuel injectors are needed to ensure precise fuel metering and good air-fuel mixture preparation.

The alcohol fuels have a high resistance to auto ignition which is reflected by their high octane rating. Consequently they have a low cetane number when compared to diesel fuel. The alcohols are therefore inherently poor fuels for compression ignition engines. The low cetane number is a measure of a long ignition delay period that occurs between the start of fuel injection and the commencement of combustion. Therefore all methods used to substitute alcohol fuels in the compression ignition engine are aimed at reducing this ignition delay period so that regular, smooth combustion occurs, avoiding such problems as pre-ignition and high rates of pressure rise that could cause engine damage.

The alcohol fuels also have a low viscosity when compared to conventional fuels. This can cause problems with fuel injection pumps, in particular rotary types, and injectors as they rely on the fuel for lubrication. This problem is usually overcome by the addition of a small percentage of compatible lubricant to the alcohol fuels.

If incomplete or partial combustion should occur, high wear rates of pistons, rings and liners may result. Exhaust smoke and particulate emissions are, however, greatly reduced.

There are a number of approaches that have been made with regards to the combustion of alcohol fuels in compression ignition engines. These fall into two main categories. The first is fuel management, in which major changes are made to the combustion characteristics of the alcohol fuel to make it more acceptable to diesel engine operation. The second is engine management, in which major changes are made to the engine so that it can accept and burn unmodified low-cetane rated alcohol fuels.

In both cases changes may have to be made to the on-board fuel storage and fuelling systems.

Cetane improvers, when added to the low-cetane alcohol fuels can reduce the ignition delay period to that comparable to diesel fuel. However it is probably impractical to convert a standard compression ignition engine to utilise ignition enhanced alcohols unless the engine is able to supply the larger volume of fuel required without major modifications.

Alcohols have limited solubility in diesel fuel so that a relatively stable emulsion must be formed to allow it to be injected into an engine before separation occurs. Separation of the fuels in the injection system can lead to misfire or total loss of combustion. Mechanical and chemical means of producing an emulsion have been tested. This method will allow about 20% to 30% substitution of diesel fuel with alcohol fuel.

A dual injection system employs a small amount of diesel fuel, injected through a pilot injector, to act as the ignition source for a far larger quantity of alcohol fuel injected via the main injector. The pilot injection controls the start up and idle conditions with the main power being provided by the alcohol. A major disadvantage of dual injection is that the system requires two completely separate fuel injection systems consisting of a tank, feed pump, injection pump and fuel injectors. The control system required to accurately deliver two separate fuel flows is also more complex, adding to the cost of a dual injection system. Diesel substitutions of up to 95% are achievable using this system.

The conversion of compression ignition engines to spark ignition operation has been demonstrated as a way to give satisfactory operation with alcohol fuels. The main advantages are that substitution levels up to 100% can be achieved with much reduced pollutant emissions. The disadvantages are the extensive engine modifications that are required, and higher maintenance costs normally associated with spark ignition engines now apply to the modified engine.

Although the alcohol fuels have poor compression ignition characteristics, they do not have lower surface ignition temperatures than any of the hydrocarbon fuels. Engines have therefore been developed that employ a hot surface or glow plug as the ignition source upon which the injected alcohol fuel spray is directed.

Fumigation is a process whereby alcohol fuel is introduced into an engine's inlet air supply, either by means of a carburettor or injection into a turbo-charger diffuser scroll. A pilot injection of diesel acts as an ignition source for the alcohol-air mixture. The combustion of such a mixture is not entirely that of diffusion burning as there is also premixed combustion of the alcohol-air mixture. The amount of alcohol that can be fumigated into an engine is limited by late injection and incomplete combustion at part load and by knocking combustion at high load. This method requires fewer modifications to the engine and is therefore relatively cheap to implement.

Exhaust gas throttling has been developed in two stroke engines by controlling the scavenging process of the engine. Such control maintains the charge temperature at an elevated level. Thermal efficiencies are equivalent to normal compression ignition operation, with significant reductions in NOx and particulate emissions.

Although the alcohols can be produced from renewable energy sources, large scale use of methanol is likely to be produced economically from non-renewable resources of natural gas or coal, with associated environmental pollution problems occurring at source. Also, even though the alcohols are very clean burning, the carbon component of the fuel still produces the greenhouse gas, CO_2. Consequently methanol is often viewed as an interim alternative fuel with hydrogen as the 'ultimate' fuel for planet earth.

Triglycerides

Vegetable oils and tallow are both members of the triglyceride family of molecules having high cetane numbers and are therefore well suited for use in compression ignition engines. They are able to be used in a raw state, but their high viscosity leads to problems in fuel pumps, filters, injectors and with the atomisation of the fuel in the combustion chamber. Deposits can be formed and this can lead to the partial blocking of the injectors.

The viscosity can be reduced by converting the oil into an ester by reacting with methanol in the presence of a catalyst. An additional benefit of this process is the production of the by-product glycerol, which has a market value that can be used to offset the processing costs. The use of esters eliminates the problem of injector fouling.

Tallow esters

Tallow is a by-product of the meat processing industry and is readily available in countries with large meat processing facilities. The energy content of the esters is slightly lower than that of diesel fuel, however, field trials have indicated that power, torque and emissions are similar to those of diesel operation. Tallow esters do have a much higher cetane number compared with diesel, which indicates a shorter ignition delay period, and an earlier start to the pressure rise in the cylinder. To allow for this injection timing must be retarded. The rate of pressure rise within the cylinder is also reduced giving a reduction in the combustion noise. The emissions of HC, CO, NOx and smoke are found to increase with a higher content of ester in a fuel blend. Tallow methyl esters are solid or partially solid at 15 to 20°C, so they cannot be used as a 100% diesel substitute unless heating coils are installed in the fuel tank. The esters are 100% soluble in diesel fuel and can therefore be used in tallow ester/diesel blends. This option seems the most attractive. Storage facilities for tallow esters are the same as for diesel fuel with anti-dioxant/dispersant additives to prevent degradation.

The major area of concern is seen to be the detrimental effect of the tallow ester on the lubricating oil, such as the depletion of the anti-dioxant and dispersant properties. An oil developed especially for use with tallow esters will need to be developed.

Vegetable oils are characterised by energy contents similar to those of diesel fuel. They are easily produced from a range of sources, eg, peanut, palm, sunflower, rapeseed and soyabean, and can be produced on marginal land with very little energy input. The oils are easily extracted mechanically, and the vegetable matter by product of the extraction process can be used as stock food. The use of vegetable oils in a raw state is therefore seen as being well suited for use in remote rural areas in developing countries, where diesel fuel supply is unreliable and expensive.

This article has reviewed alternative liquid fuels, some of which should become available as existing crude oil reserves for the manufacture of traditional hydrocarbon fuels become depleted. They also offer the opportunity to convert to fuels that produce low, or very low, levels of pollution. This review, along with the article on alternative gaseous fuels in last month's *Energy World*, has concentrated on existing engine technology in the form of the reciprocating engine. There are, however, suggestions that alternative power plant technology may make better use of these alternative fuels. Possible examples include the electric hybrid vehicle, utilising a low polluting fuel, which may prove very attractive, especially in built-up areas. Another is the rotary engine, which may prove better suited to hydrogen fuelling than the reciprocating engine. Fuel cells may establish themselves as the most energy efficient and lowest polluting of all power plants. The outcome will depend on future legislation, just as much as on technological development. ❑

DTI wood as fuel workshop

A Department of Trade and Industry workshop, entitled *Wood Fuel — the Green Debate* was held in October.

The term 'wood fuel' encompasses forestry residues and industrial wood wastes, but the DTI workshop was devoted exclusively to short rotation coppice (SRC). This consists of plantations of willow or poplar, mainly the former, from which shoots are harvested at short intervals of between two and four years. These are chipped and dried for use in a gasifier or suitably designed conventional boiler.

As a fuel SRC is still at the pre-natal stage, with little experience in growing or burning it, but in the UK a midwife is on hand — in the shape of the third tranche of the non-fossil fuel obligation (NFFO) — and there are many nascent schemes whose birth is eagerly awaited by their parents, the proposers.

The workshop was mainly devoted to crop production and its environmental impact, and economic issues were addressed. If SRC can become a viable fuel, it could be a prime contender for 'set aside' land — the fly in the ointment being our large surplus of generating capacity. NFFO support would be needed to give an initial 'kick-start' subsidy and provide a niche in the electricity market.

Wood fuel could be utilised in two quite different ways: burned in an appropriately designed conventional boiler, generating steam for electricity generation in plants of up to 20MWe; or used in simple gasifiers — already available — to provide 'in-house' CHP in the range of 200kWe - 1MWe, using internal combustion engines or small gas turbines in a similar mode to landfill gas. The attraction of the latter, especially post-NFFO, is that they compete with the RECs selling price, not the Pool or Contract for Differences price.

In the USA there is currently more than 7000MW of biomass power connected to the grid. The fuel is derived from mill and wood processing residues, and well as agriculture and forest residues.

Are wood fuels an alternative fuel of the future? The workshop consensus was that nothing would get off the ground without initial support from the NFFO, all be that support transient. As Caroline Foster of ETSU pointed out: SRC must take this opportunity to prove itself or it would not survive in the market place. A potential major player in that market, John Seed of Border Biofuels, said: "The kick-start that the renewables order can can provide will prove invaluable. In the longer term it will have served to support the development of a self-sustaining industry. It must not be viewed as a one-off opportunity to burn wood for money for the next fifteen years and then walk away." It will probably be three or four years before we start getting answers to the questions posed here.

R G Loram MInstE MIWM

R&D recommendations for transport

THE PUBLICATION last month of the Royal Commission report on transport has sparked a public debate that many recognise is long overdue. The Royal Commission recommended that the price of petrol be doubled by 2005, and the road building programme be drastically reduced and reviewed. Monies derived from these proposals could then be invested in improving public transport infrastructure.

These recommendations are largely a response to increased atmospheric pollution, particularly in towns and cities, which is causing concern, particularly to asthma sufferers. The Royal Commission points out that traffic growth at the present rate is unsustainable.

Another approach to tackling the problem of traffic pollution is, of course, to improve the efficiency and cleanliness of road vehicles. This was one of several suggestions made in the following letter, from the Honorary Secretary of the Institute to Bill Chrispin, technical secretary to the transport sector panel, which oversees the Foresight programme.

12 October 1994

Dear Mr Chrispin,

Technology Foresight programme — Transport

I am writing somewhat belatedly in reply to Dr Black's letter of 25 July, inviting an Institute of Energy input to the Transport Sector Panel's deliberations. We note that one of your principle tasks is to seek to identify future market trends, and the related science and technology which will be required to underpin UK competitiveness over the next 10 to 20 years. We had to consult quite widely in preparing this reply, and regret that this took rather longer than we anticipated.

Our perspective of the transport sector is in its specific energy requirements in terms of moving people and goods, and the environmental problems with which this has become associated. The principle issues for the future appear to lie in the need to achieve higher conversion efficiencies from the various energy sources to useful work. At optimum conditions a modern vehicle engine may well convert 30 or even 40% of the chemical energy in the fuel to work at the wheels. However, in urban driving conditions, the overall efficiency will fall to the low 'teens.

October's *Energy World* carried a transcript of a letter, the Institute of Energy's response to the Technology Foresight Programme's Energy Sector investigations. As a supplement to this contribution, and Institute also submitted a letter on recommendations for the transport sector.

We believe that the future markets for technology and equipment in the transport sector will depend upon the combined effects of the push of new technology and ideas in a free market, and a framework of intelligently drafted legislation which responds to environmental and public health concerns and sets clear targets for performance and emissions, whilst avoiding extremes which close options for technological advance. An example of what not to do is the Californian 'Zero Emitting Vehicles (ZEV)' legislation which can be met only by the electric car. This excludes a range of possibilities which promise a dramatic reduction in vehicle emissions coupled with increases in fuel efficiency. A legislative framework for the UK is needed which would provide good opportunities to exploit our undoubted scientific and engineering skills, always provided the initiative has not been taken by others.

The present UK Government position on environmental pollution by transport systems appears to be essentially reactive, and there is the strong possibility that the impetus for legislation will come from the EC. There is already the tripartite Auto/Oil industries/EC EPEFE programme which is engaged in research on the impacts of engine design and fuel quality on vehicle emissions in order to provide a better scientific basis for legislation on minimum performance specifications for future vehicles and fuels. The UK contribution is not clear, as the Ford and Vauxhall input appears to be influenced by Detroit, and Rover, presumably, will reflect the approach of its new parent, BMW. This work is pre-commercial, as is the US Partnership for a New Generation of government. The PNGV aims ultimately at the development within a decade of totally new production prototypes achieving up to three times the fuel efficiency of current models. The targets include: 80% recyclability, acceleration from 0 to 62 mph in 12 seconds, recharge or refuel range of 380 miles and a useful life of 100 000 miles. Regrettably, we have no information on the detail of these programmes and we feel it would be important for this to be obtained and studied by the Transport Sector Panel in order to identify gaps offering opportunities for UK R, R&D.

As with flue gas desulphurisation (FGD), an EC Directive on vehicle emissions would probably build upon initiatives taken by those Member States where urgent action has been perceived to be important. The UK position in this regard is not clear, but if we are not in the forefront of such action, the technological developments which this exercise is intended to identify could well be produced by others and, as with FGD, we could end up importing the technology and equipment which we might otherwise have originated and exploited ourselves.

The road transport sector contributes to two separate environmental problems. First, and most important, is urban air pollution by vehicle exhausts, viz NOx, carbon monoxide, unburned hydrocarbons — which lead to ozone — and particulates. The jury is still out on the second problem, the enhanced greenhouse effect due primarily to CO_2 emissions. Although great strides have been made in recent years in increasing efficiency and reducing emissions, the total emissions continue to rise with the increase in the number of miles driven.

Restraints upon the use of the private motor car would be extremely unpopular and, if Government is to make any real impact upon this problem, alternatives to the petrol or diesel internal combustion engine, need to be brought forward. Further development of 'lean burn' petrol engines, engines designed specifically for natural gas, diesel designs to minimise particulate emissions, and improved petrol and diesel fuels would provide a stepping stone for the medium term, and there is a case for an early look at the design of vehicles used solely in urban environments, ie, buses, taxis and delivery vans. However, the longer term solutions for both private and public road transport are likely to be drawn from a wider range of technologies.

A number of avenues are opening. The nearer term, into the early years of the 21st century, will see the electric vehicle becoming increasingly important. Its simplest form employs re-chargeable batteries to provide motive power. Present battery technology limits the range of such vehicles to short range urban use, and the US PNVG programme has a substantial effort devoted to the increase in specific energy compared to the lead-acid battery, equivalent to a range of between 300 to 400 miles. The range limitations can also be overcome by hybrid systems in which a small internal combustion engine running at optimum efficiency drives a generator for charging batteries, or other energy storage systems, such as ultracapacitors or flywheels. All these avenues are being studied under the PNVG programme. We believe that the electricity supply industry would have little difficulty in increasing capacity to meet the additional demand created by the introduction of simple battery powered electric vehicles.

For the longer term and later in the 21st century, the hydrogen-powered vehicle is likely to come into its own, although the infrastructure to support directly fuelled vehicles presents considerable obstacles. Indeed, hydrogen power would appear to be the only alternative to the battery-electric car, under the California legislation, always provided that water vapour did not rate as an emission.

An alternative to the hydrogen-powered internal combustion engine lies in the use of fuel cells as the power supply, and prototype vehicles are being tested. Recent advances in hydrogen-powered fuel cell technology, coupled with increased tolerance to traces to CO suggest that such vehicles eventually could use methanol as a primary fuel to produce fuel cell hydrogen by on-board reforming. The present infrastructure support for hydrocarbon-fuelled internal combustion engines could be readily adapted to support such vehicles. Such systems would have to be studied in-toto in order to obtain an overall picture of the emissions from and energy requirements for, say, methanol production as well as those of the vehicle. This factor also needs to be taken into account with the manufacture of hydrogen reforming of natural gas or the gasification of fossil fuels. The CO_2 emissions of these respective routes would have to enter into the equation.

Even though the developments outlined above would materially change the motor vehicle as we know it today, the rate of replacement of existing vehicles by more efficient and less polluting models will be only modest, without legislative pressures there appear to be three main time frames through which the vehicle stock will be replaced. The first is from the present until about 2010, during which current technologies for fuels, engines and materials will be upgraded. The second time frame covers a few decades beyond 2010, during which the electric vehicle and the hybrid in particular could well become a major technology. The third period in the middle to late part of the 21st century would be dominated by new technologies.

Such changes will come about from research and development being undertaken today, and a clear indication of Government thinking in terms of vehicle emissions control is needed if UK research and development is to be focused upon areas where the application of limited resources is likely to have the greatest chance of success. The international nature of the motor vehicle manufacturing and oil industries, and the way that will respond to market pressures outside the UK complicates the picture. Care will need to be taken to identify gaps in parallel programmes which offer the best chance of a pay-off for UK industry.

With these strictures in mind, the specific areas for UK R&D in the road transport sector appear to be:

- an exploration of the design parameters for achieving maximum power output and economy from lightweight petrol, diesel and natural gas-fuelled internal combustion engines;
- development of small high efficiency low emission internal combustion engines for powering lightweight generators for hybrid systems;
- development of catalyst systems which will achieve significant reduction in exhaust NOx and particulates as well as CO and unburned hydrocarbons;
- the possibilities for changes to fuels specifications to minimise emissions from the new technologies in the above;
- greater efforts to devise improved storage battery systems for electric vehicles, focusing upon increasing capacity, rate of charge and reduction in weight;
- materials for use in energy storage flywheels with particular reference to safe containment in accidents;
- the introduction of greater recyclability in materials used for vehicle construction with particular reference to production and recycling costs.

There are excellent research facilities and considerable expertise in the UK available to tackle successfully the combustion work necessary.

These remarks summarise the Institute's views on the transport sector where our expertise relates mainly to fuels for internal combustion engines. In response to your request for names of people with specialist knowledge, we would like to suggest: Mr R H Booth, Head of Renewable Energy Supply & Marketing, with Shell International Petroleum Co Ltd.

As much of this letter falls across the boundaries between the Transport and Energy Sector Panels, I am copying this letter to Nigel Hayman as a supplement to our energy contribution.

Yours sincerely,
H F Ferguson
Honorary Secretary

Coal bed methane exploration — a problem solved?

*by David Anderson**

Several hurdles have inhibited the development of coal bed methane exploitation in the UK. These have been largely addressed by the Coal Industry Act 1994 and the Petroleum (production) Act 1934. But, asks solicitor David Anderson, has the issue of access been truly resolved?

THE EXPLOITATION of coal bed methane in the UK has become an issue of increasing interest over the last few years.

While, historically, coal bed methane was regarded as a hazard to coal mining operations, resulting in the need for methane to be removed from coal mines in order to make them safe, the possibility of exploitation of coal bed methane as an energy source independent from coal mining activity has developed as a result of initiatives originally generated from the US in the 1970s.

AS a result of these developments there has been increasing interest in this country in the prospects of developing a viable industry based on the commercial exploitation of coal bed methane. This development hgas, however, hitherto been severely hampered by difficulties in determining ownership of coal bed methane and the legal mechanisms for procuring access to such methane for the purposes of its exploitation.

The debate on ownership of coal bed methane has now been conclusively determined as part of the privatisation of the coal industry with the enactment of the Coal Industry Act 1994, but, given the number of interests involved in the exploitation of coal bed methane, the issue of access remains problematical.

Even if the question of ownership is now settled, parties representing a minimum of four different interests still need to have their respective rights and obligations clearly defined and agreed before coal bed methane can be exploited.

These four potentially competing interests are as follows: the rights of ownership to the coal bed methane itself; rights of ownership to the coal in which the coal bed methane is found and into which any person seeking to exploit the coal bed methane will require access; rights of the party seeking to exploit the coal bed methane; and rights of the surface owner of the land beneath which the coal and coal bed methane are found.

While the above catagories clearly represent four separate interests it is, of course, possible for one party to have interests in more than one category.

It is worth running through each of the above four interests in turn.

Prior to the enactment of the Coal Industry Act 1994 the question of ownership of coal bed methane turned on whether such methane came within the definition of 'petroleum' for the purposes of the Petroleum Production Act 1934 ('Petroleum Act'), and was therefore the property of the Crown, or whether such methane (given its physical and chemical characteristics) should properly be regarded as part of the coal in which it was found, and was therefore the property of the coal owner.

The distinction was obviously fundamental to the orderly development of any industry based on the commercial exploitation of coal bed methane. How could this possibly develop when the crucial issue of ownership remained uncertain?

The Petroleum Act vested all petroleum in the Crown. The definition of petroleum in the Act, while it included reference to 'natural gas', was not sufficiently clear to resolve beyond doubt that coal bed methane itself came within the definition, particularly as the definition of petroleum specifically excluded coal.

This uncertainty arose due to the specific and distinct nature of coal bed methane from other natural gases and its unique association with the coal seams in which it is found. A detailed analysis of the respective arguments surrounding the uncertainty is beyond the scope of this article and, in the light of the provisions of the Coal Industry Act, now of no more than academic interest.

The fact that the issue of ownership of coal bed methane had not, prior to the enactment of the Coal Industry Act 1994, been adequately resolved was itself partly due to the fact that, even if the issue of ownership had been resolved, the question of access to the methane itself was inextricably tied up with ownership of the coal.

Under the Coal Industry Nationalisation Act 1946 interests in unworked coal and in mines of coal were vested in the National Coal Board. This remained the position until this year when the Coal Industry Act 1994 (section 7(3)) confirmed that British Coal's interests in unworked coal and coal mines shall vest 'without further assurance' in the new Coal Authority.

The Coal Authority is established pursuant to provisions in the Coal Industry Act. The Coal Authority's functions include the licensing of coal mining and the granting of exploration rights over coal. Notably, the Coal Authority will not itself have the right to work coal and there is therefore to be a very clear separation between regulation and exploitation of coal, a separation which did not previously exist when both regulation and exploitation resided with British Coal.

Prior to the vesting of British Coal's interest in coal in the Coal Authority, notwithstanding any dispute as to the ownership of coal bed methane, any party wishing to exploit coal bed methane would, necessarily, require the consent of British Coal to enter the coal seams owned by British Coal for such purposes. This question of access was entirely separate from the issue of ownership of the coal bed methane itself.

British Coal, accustomed in the past to dealing with oil companies seeking to pass through its coal seams (for the purpose of traditional oil and gas exploration) confirmed that it was willing to grant consent for coal bed methane operators to enter its coal seams but wished to regulate both the terms upon which that entry was made, and the way in which any methane extraction operation was carried out. The coal bed methane industry as a body regarded the terms sought by British Coal as unreasonable and an impasse developed between British Coal as the owner of the coal, and those seeking to develop the exploitation of coal bed methane. With the establishment of the Coal Authority, this will now be an issue to be determined between

**Partner, Nabarro Nathanson*

the Coal Authority and those seeking to exploit coal bed methane.

In the UK, since 1957, authority for draining methane has been granted through licences issued in accordance with regulations made under the Petroleum Act. These confer a right to get natural gas in the course of operations for making and keeping safe mines (whether or not disused) within a specified area. These licences are granted on the basis of drainage required essentially for safety reasons.

As far as exploitation of methane is concerned (rather than drainage for safety reasons) it is worth noting, however, that there is no separate procedure for the granting of licences for coal bed methane extraction alone. On the assumption that coal bed methane is petroleum, those interested in methane extraction have applied for on-shore oil and gas searching for traditional reserves of oil and gas.

The surface owner's consent will, of course, be needed for any project to be set up on or across his land. The surface owner's consent will also be needed where a coal bed methane well located on a third party's land enters his land below the surface as is often the case with directional drilling. Where appropriate, necessary negotiations will always therefore need to be concluded with the surface owner.

While petroleum licence holders have assumed that their licences will cover exploitation of coal bed methane, the issue of access has led to sufficient difficulty for those licence holders in exploiting coal bed methane that the question of ownership of the coal bed methane itself has never needed to be categorically resolved, as ownership of coal bed methane and the right to exploit it were of no value without clear rights of access.

The Coal Industry Act 1994 seeks not only to resolve the issue of ownership of coal bed methane but also to put in place a framework for its future exploitation to the extent that such exploitation interacts with exploitation or potential exploitation of coal.

Notwithstanding the past uncertainty as to the ownership of coal bed methane, the Coal Industry Act is sweeping in its treatment of the ownership issue. At section 9 (1) the Act states:

It is hereby declared, without prejudice to section 10(2) of the Petroleum (Production) Act 1934 (petroleum set free in the course of mining and other lawful operations), that the interests and rights which are vested or deemed to be vested in the Corporation (British Coal) immediately before the restructuring date do not include:

a) any interest in, or any entitlement to an interest in, any oil or gas which, in its natural condition in strata, is or becomes absorbed in or adsorbed to any coal; or

b) any right, without a licence under Section 2 of that Act of 1934, to search for, bore for or get any oil or gas which is or becomes so absorbed or adsorbed.

The references to 'any oil or gas absorbed in or adsorbed to any coal' are clearly intended as reference to coal bed methane and section 9(1) therefore makes it absolutely clear that coal bed methane is not vested in British Coal.

The very fact that it was felt necessary to include a provision of this nature confirms the doubts that there has hitherto been as to ownership of coal bed methane and it is interesting to note that section 9(1) works by way of declaration. In other words it purports to declare what has always been the law although, if the law had been free from any doubt, there would, of course, have been no need to make any such declaration. The fact that the Act declares that coal bed methane was petroleum and therefore the property of the Crown were right all along. Yet while a declaration contained within an Act of Parliament is often used to clarify an area of ambiguity, it is also an established constitutional device for a 'declaration' to be used actually to change existing law. One of the earliest examples of this is found in Fox's Libel Act of 1792, where an Act purporting to be declaratory actually changed the law as it was applied by the judges within the courts in libel cases before the passing of that Act. What should be noted about a declaration is that it does not, however, purport to change the law and is therefore presumed to have retrospective effect.

While section 9(1) makes it clear that coal bed methane does not belong to British Coal, this particular subsection does not go so far as to make clear to whom coal bed methane does in fact belong. That coal bed methane is in fact the property of the Crown is, therefore, confirmed by the provisions of section 9(2):

Accordingly, nothing in any enactment or subordinate legislation relating to interests or rights in or in relation to any coal, or in relation to any oil and gas, shall be taken to have prevented any such interest or entitlement as is mentioned in subsection (1) (a) above from having become by virtue of any enactment or subordinate legislation, or from continuing to be, an interest or entitlement of the Crown.

Any doubts as to whether methane itself should come within the definition of 'oil or gas' is removed by section 9(6) which confirms that oil or gas includes 'methane or any other natural gas'.

What then of rights of access to the coal in which the coal bed methane is to be found? The Coal Industry Act also addresses this issue with a view to promoting the possibility of exploitation of coal bed methane. Section 3 of the Coal Industry Act sets out the duties of the Coal Authority with respect to its property. At subsection (5) it provides:

Subject to subsection (6) below, it shall be th duty of the Authority, in the exercise and performance of its powers and duties with respect to its land and other property, to have regard to the desirability of the exploitation, so far as that is economically viable, of coal bed methane in Great Britain.

Subsection (6) provides that in determining the terms on which the Authority should dispose of any interest in unworked coal or a coal mine to a petroleum licensee that the Authority should act in accordance with such arrangements and principles as it may, with the approval of the Secretary of State, have determined for the purposes of subsection (5).

The mechanism is therefore put in place not only to require the Coal Authority to perform its duty, bearing in mind the desirability of exploitation of coal bed methane in the UK, but also to put in place appropriate arrangements and principles in conjunction with the Secretary of State for access to coal seams.

How is it then intended that this new regime whereby the Coal Authority will grant access to coal seams will be implemented in practice?

In June 1994, the Department of Trade and Industry (DTI) issued their *Revised Coal Authority Explanatory Note* which updated their explanatory note, originally issued in January 1994. This document sets out the basis on which the DTI expects the Coal Authority to deal with the issue of access to coal seams for the purposes of fulfiling its duty pursuant to what is now section 3(6) of the Coal Industry Act. (It should be noted that as the explanatory note was published prior to the Coal Industry Act receiving Royal Assent the provisions of the note are with reference to the clauses of the Coal Industry Bill).

For the purposes of granting access to coal seams for the exploitation of coal bed methane the explanatory note envisages that the Coal Authority will divide known areas of coal deposits into two categories: those that are being, or are likely to be, used for coal mining operations; and all other coal fields areas in and off Great Britain.

It is envisaged by the explanatory note that the Coal Authority will not normally grant access to coal bed methane operations to coal in areas in category one, unless the proposals for coal bed methane operations are made in conjunction with those carrying out, or proposing to carry out, coal mining operations. In category one areas the Coal Authority is expected to consider, inter alia, the extent to which the proposed extraction methods will cause physical damage to the coal and the Coal Authority may set conditions which, to the extent practible, mitigate that damage.

In areas in category two, however, it is envisaged that the Coal Authority will normally grant access to coal bed methane operators on standard terms and with a minimum of conditions, although it is expected that the Coal Authority would reserve the right to protect mining prospects that are identified within category two areas before access to coal bed methane operations is granted. Conditions in respect of access for coal bed methane operations in areas in category two are likely to be relatively limited, for example to ensure that the Coal Authority is protected from liabilities which might arise from the exploration or extraction activities and to cover the provision of information.

Confirmation of the Government's view that coal bed methane in now fully within the petroleum exploitation regime is given in the explanatory note. It is made clear that in all areas the right of access to coal for coal bed methane operations will remain in place only for so long as the coal bed methane operator has the appropriate licence under the Petroleum Act.

The explanatory note further considers that the access to the coal will give rise to issues of interaction between the activities of the coal bed methane operator and other operations entering the coal seams. Coal bed methane operators will therefore be required to enter into an Interaction Agreement. This will facilitate arrangements under which those concerned can reach commercial decisions between themselves on the best way of tackling practical issues of interaction that arise between operations in respect of coal, which can have an interactive effect on each other.

The Coal Industry Act and the Petroleum Act have now, therefore, between them addressed the three key areas of difficulty which had previously hindered the exploitation of coal bed methane. These are: ownership of the coal bed methane itself; access to coal in which the coal bed methane is found; and rights of exploitation. The first two are addressed by the Coal Industry Act with the third, as a result of the clarification in the Coal Industry Act, now clearly being covered by licences under the Petroleum Act. The issue of the rights of the surface owner (except where the surface owner is the Coal Authority, in which case the CA's duties under the Coal Industry Act will come into play) will continue, as before, to be a matter of commercial contractual negotiation between the coal bed methane operator and the relevant surface owner(s).

The question must remain as to whether the new regime, based on the provisions of the Coal Industry Act and the DTI's expectations as to how the CA will fulfil its duties, will now enable the coal bed methane industry to clear the hurdles which had previously been in its way. Experience will determine whether, in practice, the issue of access to coal bed methane has in reality been resolved.

Vital to determining this is the expectation, as set out in the DTI's explanatory note, that the CA will not normally grant access to coal bed methane operators in areas which are being, or are likely to be, used for coal mining operations *unless* the proposals for coal bed methane operations are made *in conjunction with* those carrying out, or proposing to carry out, coal mining operations.

The question of interaction between the rights of the coal owner (or person to be licensed to exploit the coal) and the right of the coal bed methane operator is therefore specifically acknowledged but remains to be resolved, it would seem, on a case-by-case basis. The explanatory note appears to consider that of principal importance will be the extent to which the proposed extraction methods will cause physical damage to the coal such that the CA may set conditions to mitigate that damage to the extent that this is practicable. The question of damage to the coal will not, however, be the determining factor. The duties of the CA include that it should carry out its functions to secure that an economically viable coal mining industry in the UK is maintained and developed. Given that the Coal Industry Act is the mechanism by which the UK coal industry is to be privatised, one may consider that this is arguably one of the principal duties of the CA in the Coal Industry Act. Such duty will, however, need to be considered in the light of the CA's other statutory duties, including those in relation to exploitation of coal bed methane (section 3(5) referred to above) even if these duties may be regarded as subsidiary.

While the DTI's explanatory note refers to the CA considering the issue of physical damage to the coal, there is no indication as to how it should balance its potentially conflicting duties, in the light of commercial issues which will inevitably arise between the coal mining and coal bed methane operators.

To this end, the DTI has produced by way of consultation, a map delineating those areas which it considers will come within category (1) referred to above (areas which are being, or are likely to be, used for coal mining operations).

It is interesting to note that no sites are reserved on the map in category one for future deep mines, if a deep mine does not already exist in known coal deposits, no reservation is made.

Also of importance, no category one reservation has been made on the map for opencast areas. While these areas will clearly be within the category one definition, it is presumably thought that where seams are accessible for opencast mining, prospects of viable coal bed methane exploitation will be minimal due to the proximity of the coal seams to the surface. Only existing coal mines have therefore been identified on the map as having the benefit of a category one reservation as envisaged by the explanatory note.

In the application of the principles set out in with the aid of the map, consideration of the application of the principles set out in *BP Petroleum Developments Ltd v Ryder and Others (1987) 2, EGLR, 233* may still come into play. This case concerned the obtaining of an Order pursuant to the Mines (Working Facilities and Support) Act 1966 pursuant to which a petroleum licence holder may, if it is unable to negotiate rights of access with the coal owner, seek a court order permitting it to enter the coal seams. In order to obtain such an Order under the legislation, the applicant, as decided by *BP v Ryder*, had to show that the access rights are needed for the exercise of rights granted by the petroleum licence. Also that the rights are needed in order that petroleum might be properly and conveniently exploited. The applicant must show that the grant of access rights is expedient in the national interest, and that it is not reasonably practicable to obtain the right by private arrangement, because the coal owner is demanding unreasonable terms.

The merits of any such application obviously will depend on the particular circumstances and strengths of the arguments on either side and it remains to be seen how (and if) the principles set out in *BP v Ryder* will continue to be relevant and applied in the context of future coal bed methane exploitation and indeed whether coal bed methane operators will be prepared to go to such lengths to resolve any impasse with the CA and the coal operators.

While the principles set out in the explanatory note may give guidance, the conflict between the interests of the coal mining operator and the coal bed methane operator will remain. This is evidenced by the ongoing consultation process in respect of the map. Notwithstanding any anticipated principles to be put in place to enable future exploitation of coal bed methane, friction will continue to exist between the two separate interests.

While the legal position on ownership, access and exploitation may appear to be resolved, the practical application of the new statutory regime will continue to be uncertain, and it may well be that, notwithstanding the attempt to regularise and clarify the position, where there is clear interaction between coal mining and coal bed methane operators, the future development of the coal bed methane exploitation industry will necessarily continue to be dealt with in reality on a case-by-case basis. ❑

Testing ... testing

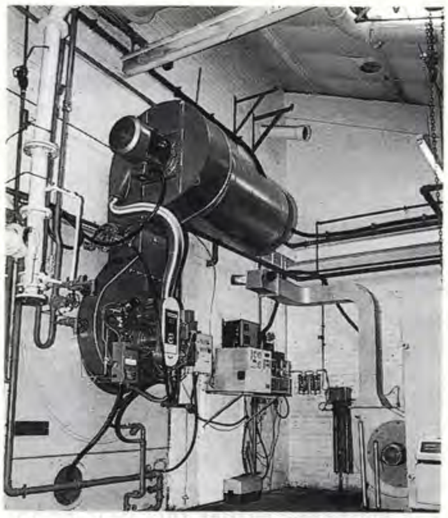
THE RECENT acquisition by the Hamworthy Group of companies of Airoil Flaregas and Peabody Engineering has added to Hamworthy's already impression combustion test facilities at their site in Poole, Dorset.

Hamworthy's enhanced Advanced Technology Centre was officially opened in October, and is believed to be the largest R&D test facility of its type in the world.

Hamworthy Combustion Engineering design and manufacture a comprehensive range of burners to fire boilers and furnaces. The firing capacity of the nine test rigs on site ranges from 0.5MW to 100MW. These rigs play a core role in the development of new burner technology, as well as retrofitting older plant to fulfil the requirements of new emissions legislation, and the customising of burners for specific requirements. A complete range of fuel and steam services are also available on this single site, including preheated combustion air; flue gas recirculation simulation, with any blend of liquid or gaseous fuels.

In the centre's control room, NOx O_2, SO_2, CO and particulate emissions are measured. Portable equipment is available for measurement of noise emissions on both the test facilities and site installations.

R&D is vital to developing environmentally friendly technologies, and to advance the understanding of low-emission burner technology, scientific support is given to projects utilising recent developments. To assist the understanding of the relationship between hardware, flame structure and the formation of pollution species within flames, extensive computational fluid dynamics (cfd) modelling studies have been undertaken by the Hamworthy Group, with the help of the local University.



Test furnace number nine uses an AW rotary cup burner. A typical application for this burner is to fire tube shell boilers in the 1.8-22MW range.

Effective atomisation of liquid fuels is essential for the control of particulate emissions. Hamworthy's technology centre has a test rig dedicated to the examination of atomiser sprays by laser phase doppler anemomentry (LDPA), facilitating research on atomisers suitable for the entire range of boilers.

Impressive performances have been achieved by many of the company's products prior to the combination of the test facilities. Burners have been developed to meet not only EC regulations, but also to comply with more stringent regulations laid down in other, individual countries.

In certain cases these burners have performed 'above specifications'. An Austrian district heating installation has achieved NOx levels of 360mg/Nm^3 and 60mg/Nm^3 with Hamworthy's rotary cup burner, duel-fuelled with fuel oil and natural gas, which is significantly below the required minimum level of NOx emissions. At the Shell Dansk oil refinery in Denmark, emissions from 'Enviromix' burners — developed by Airoil Flaregas, have reached ultra low NOx levels of 50mg/Nm^3 burning refinery gas.

Seven of the nine test rigs on the Poole site have the capacity to fire all types of fuel, with the two smallest firing gas only or gas/light oil. ❑

Test furnaces numbers one and four. Number one has an Enviromix Flat Flame 2000-140 natural draft gas burner with an output of 1MW. Furnace number four has a low NOx LNOG 3.57 dual fuel burner, with a fuel flow equivalent of 2MWth.

Energy efficiency training from the InstE

THE Institute of Energy has recently published three authoritative new energy efficiency training packages for use in professional training organisations, academic centres and in-house training companies.

'The Energy Efficiency Training Series' consists of three technical training packages, on *Energy Efficient Refrigeration*, *Energy Efficient Electric Motors & Drives* and *High and Low Temperature Heat Recovery*. The series, which was developed by ETSU on behalf of the Energy Efficiency Office, Department of the Environment, and supported by the SAVE programme was published by the Institute of Energy in association with Energy Publications.

Each package was compiled by a leading UK consultancy organisation, and provides self-contained presentation modules which can be used individually or as a whole. Detailed lecturer's notes are printed alongside slide illustrations, originals of the slides for use as overhead projection transparencies are provided, and student sheets with slide illustrations and provision for note taking are included. Each package costs £250 including postage and packing in the UK.

❑ *Energy Efficient Refrigeration* ***£250.00**
Introduction ● cooling loads ● cooling systems ● component efficiency ● tutorial examples ● operation & maintenance ● current affairs
ISBN 1-8744334-02-1

❑ *Energy Efficient Electric Motors & Drives* ***250.00**
Economics & efficiency opportunities ● motors & drives technology ● characteristics & system features ● application areas ● selection considerations ● evaluation techniques & economics
ISBN 1-874334-005

❑ *High and Low Temperature Heat Recovery* ***250.00**
Assessment of heat recovery opportunities ● principles of heat transfer ● boiler heat recovery techniques ● industrial high temperature heat recovery ● industrial low temperature heat recovery ● commercial sector heat recovery ● worked examples
ISBN 1-874334-01-3

*An 'early bird discounted price' of £199.00 each is available for purchases made by 30 December 1994. Please note that this offer applies to each pack. All prices are inclusive of postage and packing within the UK.

A similar training package *Small-scale CHP — A Teaching Programme for a Modern Technology*, developed by ETSU for the Energy Efficiency Office in conjunction with Manchester Metropolitan University, was published earlier this year by the Institute of Energy in association with Energy Publications. Details of the successful pilot study carried out at six universities and further information about the package are described in Best Practice programme, General Information Leaflet 14, which can be obtained directly from ETSU or the Institute.

❑ *Small Scale CHP — A Teaching Programme for a Modern Technology* ***£150.00***
Principles of CHP ● buildings services interface ● site appraisal ● selection of CHP system ● fuel supplies ● economics of CHP ● installation & connection with existing boilers ● exhaust systems ● contractual terms and commissioning ● plant operation
ISBN 1-874334-03-X

For further details on any of these packages, please contact Louise Evans, Institute of Energy, 18 Devonshire Street, London W1N 2AU. Tel: 071 580 7124; fax: 071 580 4420.

Three authoratitive training packages from the Institute of Energy.

South Coast technical visit

A FEW select members of the South Coast branch were privileged visitors to the central boiler house at Graylingwell Hospital in Chichester on 12 October, by prior arrangement with the Estates Management Officer.

The boiler plant consists of four shell boilers, three pass wetback pattern, manufactured by Robey of Lincoln in 1984, and two rated at 12.5K lb st h and two at 20K lb st h, F & A 212°F each fitted with a Saacke dual fuel burner with automatic changeover for either natural gas or heavy fuel.

This boiler plant (1984/85) was a major modernisation scheme, replacing five post-war Daniel Adamson twin furnace burners: oil-fired by Vosper Thornycroft pressure atomising burners.

The current operating costs (1994) are in the region of £1/2m, with the steam output in mid-October averaging 150t/day. This supplies St Richards and R W Sussex Hospitals, the central laundry and Chichester Festival Theatre in addition to the Graylingwell facility. An independent heating scheme for St Richards and Graylingwell hospitals is currently under consideration.

Institute visitors were impressed with the high standard of both maintenance and cleanliness. The boilerhouse is spacious and well-designed with full instrumentation. Steam output/FW input/fuel supply/thermal efficiency/ condensate return are monitored and recorded and the results evaluated and costed. A detailed budgetary control system is in use, the aforestated site recipients regularly charged for steam supplies.

We, the visitors, left well satisfied that our visit was both worthwhile and interesting, apart from feeling that the operational performance more than justified the original capital investment.

J N Bartlam
Chairman, South Coast branch

Looking for a venue?

THE central location of the Institute of Energy offers a pleasant and convenient venue for small meetings and functions.

We are in the West End of London, at 18 Devonshire Street, between Harley Street and Portland Place, within minutes of rail termini and London Underground connections.

Nearest underground stations are Great Portland Street and Regents Park (both within 5 minutes' walk), with Oxford Street and Warren Street only 10 minutes away.

For further information on availability and rates, please contact Derek Smith on 071 580 7124.

A timely addition

'Photovoltaic System Technology: A European Handbook' edited by M S Imamura, P Helm, and W Palz. Published by H S Stephens and Associations, Felmersham, Bedford on behalf of the Commission of the European Communities, 1992.

THIS IS a highly significant handbook. It contains comprehensive information on photovoltaic (PV) system design and operation, together with a wide range of application studies from pilot plants and other projects funded by the EC's Research and Development directorate during the period 1980-1992.

The principal aim of the handbook is to provide a practical guide for photovoltaic plant designers and operators. It covers the design, operation and monitoring of photovoltaic-powered systems with reliability and cost optimisation in mind. A particular feature is the emphasis on giving a realistic assessment of what a photovoltaic system can achieve, and its benefits. This is covered well in the appendices, which describe the design and operating performance of the pilot plants sponsored by CEC/DGXII up to 1990.

The original 16 pilot plants were installed between 1982 and 1984 and were regarded as very important, as a majority of them were stand-alone systems. These plants ranged in size up to 300kW of PV array power, with a total capacity of 1.11 MW. Many were still operating as the handbook went to press in mid-1992.

The handbook is sub-divided into four chapters, commencing with an introductory overview and background to the technology. The second chapter is also fairly brief and examines basic design considerations. For example, the principal factors affecting the design of PV systems are solar irradiance, ambient air temperature, electrical load characteristics, system configuration, and characteristics of the three major sub-systems — the array, batteries and power conditioning. Two tables give useful checklists. The third, and by far the largest, chapter provides a summary of discussion of current practices and guidelines, based on the lessons learned from previous and on-going CEC programmes. Topics covered include design and operation at the systems and sub-system levels, performance monitoring, project management, documentation and public information dissemination. The fourth chapter discusses the operating experiences and lessons learned from the 16 original pilot plants, three PV-powered houses and three new system applications. A total of 30 appendices not only describe the various projects, but also include the methodology and a fascinating appendix on PV applications in passenger cars (mainly solar powered ventilation in the summer and trickle charging in the winter). As with many CEC publications, there is no index.

The publication is illustrated with many colour photographs of applications and the overall standard of presentation is excellent. With current forecasts suggesting that the annual world market for PV modules is likely to rise to some 6 GW by the year 2010 from the present level of some 60 MW. This is a timely addition to the literature and should be in the reference libraries of all those designing or operating photovoltaic systems.

Dr Cleland McVeigh

Valuable reference text

'Power Station Instrumentation' edited by M W Jervis. Published by Butterworth Heinemann, £150.00.

IN COMMON with other process industries, power stations depend heavily on control and instrumentation for their safety, reliability and economic performance. The generating arm of the electricity supply industry provides the infrastructure for the whole community and for the nation's prosperity.

The electrical and mechanical plant of a modern power station embodies not only a vast array of instruments, but its variety is such that it has to cover the whole installation, structures, liquids and gases and electrical equipment operating over a broad band of pressures, temperatures, voltages and currents.

The primary aim of this book is to serve as a source of information providing a most comprehensive review of modern practice for all types of power station. Today, modern stations depend to a large degree on the correct functioning of automation embracing sophisticated control devices and systems.

This volume in the Industrial Instrumentation Series, adds appreciably to the depth of knowledge necessary for the instrument engineer engaged in the field. The book's contents are primarily aimed at professional engineers who need a reference work which will guide them through and the very latest technology in the specification, development and evaluation of the science. This book will serve them well.

The editor, Max Jervis, has had a life time's experience in instrumentation, covering a range of stations both large and small. He is to be congratulated on the manner in which he has brought together a number of contributions in addition to his own, all of which bring a wide and experienced background to the subject matter.

Chapters include topics such as control room instrumentation, engineering aspects, alarms and alarm systems, management systems for control and also a large section covering measurement. Computerised equipment is covered, providing detail which is applicable to genetic computer technology in sufficient depth for it to be applied to a particular design.

Despite its high price, the book is recommended, not just because of the needs of instrument engineers and control system designers for whom it was intended, but will prove a valuable reference work for all engaged in power station practice.

The style is clear and precise without over elaboration in the diagrams. Each chapter has an excellent set of references. The final chapter is written solely by the author and provides a state of the art view together with an examination of future developments.

Eur Ing F John Bindon

Recently published

'MacMillan Dictionary of the Environment' 4th edition
by Michael Allaby, published by MacMillan Press Ltd, Basingstoke, 1994, 377 pp, £13.99.

'Concern for Europe's Tomorrow'
Summary, WHO Regional Office for Europe, Copenhagen, 1994, viii + 88 pp. Available in English, French, German and Russian. ISBN 92 890 1 3 1 7 6. Sw fr 14.00 /US$ 12.60. In developing countries Sw fr 9.80. From HMSO Books, Publications Centre, 51 Nine Elms Lane, London SW8 5DR. Tel: 071 873 9090; fax: 071 873 8463.

'New Thinking for EC Energy Policy Review'
by John Mitchell, published by The Royal Institute of International Affairs, London, 1994, xiv + 50 pp, £7.50. Distributed exclusively by The Brookings Institution in Washington DC (tel: [010 1]202 797 6258).

'Energy consumption in public and commercial buildings'
IP 16/94, published by the Building Research Establishment, Watford, 1994, £3.50 + 35p p&p). Available from the BRE Bookshop, Garston, Watford WD2 7JR. Tel: 0923 664444.

'The Ivanhoe Guide to the Engineering Profession 1995'
6th edition, published in association with The Engineering Council, London, 1994, £9.95.

November 1994

Royal Society Esso Energy Award Lecture: Wave energy: a resource to be harnessed
by Prof Trevor Whittaker, 24 November, London. All are welcome to attend. Details from the IMechE, tel: 071 839 5561, ext 247.

ET '94
3rd international railway exhibition, 29 November - 1 December, Messe Basel, Switzerland. Details from Mack Brooks Exhibitions Ltd, Forum Place, Hatfield, Herts AL10 0RN. Tel: 0707 275641; fax: 0707 275544.

Nuclear Safety Progress
Two-day conference, 30 November - 1 December, London. Details from Sarah Ashmore, IBC Technical Services Ltd, tel: 071 637 4383; fax: 071 631 3214.

The UK Electricity Industry
2nd annual conference, 30 November - 1 December, London. Details from AIC Conferences, tel: 071 329 4445; fax: 071 329 4442.

December 1994

Clean coal technology
Seminar, 1 December, London. Details from Philip George, tel: 071 973 1312.

Modelling Uncertainty
Course, 1-2 December, Cambridge. Details from the Course Administrator, University of Cambridge Programme for Industry, 1 Trumpington Street, Cambridge CB2 1QA. Tel: 0223 332722; fax: 0223 301122.

A different expertise? Professionalism in Central and Eastern Europe
Conference, 1-2 December, Leeds. Details from Samantha Armitage, Dept of Continuing Professional Education, Continuing Education Building, Springfield Mount, Leeds LS2 9NG. Tel: 0532 333236; fax: 0532 333240.

An introductory guide to the JCT 80 Contract
Saturday course, 3 December, Runnymede. Details from Mid Career College, tel: 0223 880016.

Environmental management systems
Conference, 7 December, London. Details from Conference Department C4, Mid Career College, P O Box 20, Cambridge CB1 5DG. Tel: 0223 880016; fax: 0223 881604.

Procedures for dealing with gas escapes
Technical seminar, 7-8 December, Nottingham. Details from Mr K R Young, Seminar Secretary, The Institution of Gas Engineers, 21 Portland Place, London W1N 3AF. Tel: 071 636 6603; fax: 071 636 6602.

Power-Gen Americas '94
Conference & exhibition, 7-9 December, Florida. Details from Power-Gen Americas '94, 3050 Post Oak Boulevard, Suite 205, Houston, Texas 77056-6524, USA. Tel: 010 1 713 621 8833.

Dispute resolution in the international oil and gas industries
Conference, 8 December, London. Details from Caroline Little, Conference Officer, The Institute of Petroleum, 61 New Cavendish Street, London W1M 8AT. Tel: 071 467 7105/6; fax: 071 255 1472.

CHP in Europe - The market opportunities
Workshop, 9 December, Birmingham. Details from Michael Brown, CHPA, tel: 071 828 4077.

How to do an energy survey
Saturday course, 10 December, Runnymede. Details from Mid Career College, tel: 0223 88016.

DEGREE DAYS: SEPTEMBER 1994

Source: **Degree days direct**

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

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

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

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

Your invitation to

An Institute of Energy Conference

INTERNATIONALISATION

Power & Energy Services

THE BUSINESS OPPORTUNITIES FOR UK COMPANIES

Organised by The Institute of Energy ***in association with***

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

The Speakers:

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

Tim Eggar MP, Minister for Industry and Energy

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

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

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

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

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

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

Sir Alan Cockshaw, Chairman, Overseas Project Board

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

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

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

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

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

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

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

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

For further details please contact:
Judith Mackenzie
The Institute of Energy
18 Devonshire Street
London W1N 2AU
Tel: 071 580 0008, Fax: 071 580 4420

Thursday 1 December 1994

The Café Royal, 68 Regent Street, London W1.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