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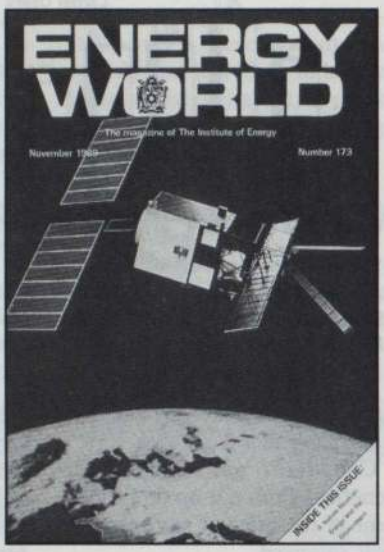
COVER STORY



Our cover photograph shows an artist's impression of the ERS-1 remote sensing satellite which is due to be launched into an Earth orbit in 1990 by the European Space Agency.

This satellite will carry a payload of sophisticated instruments capable of accurately monitoring a range of environmental criteria in the oceans, coastal zones, land masses and polar regions. The development and launching of ERS-1 is part of the European Space Agency's Earth Observation Programme which aims to maintain the integrity of the environment for future generations.

One of the instruments to be carried by the satellite is an Along Track Scanning Radiometer (ATSR) which is designed to measure sea surface temperature to an accuracy of ±0.3° Kelvin and will enable the scientific community to better understand the complex interactions between ocean, ice and atmosphere, the major driving forces of the Earth's weather and climate system.

Other instruments in the payload include an Active Microwave Instrument (AMI) to operate as a wind scatterometer, an imaging Synthetic Aperture Radar (SAR) and a high resolution radar altimeter.

British institutions and companies have been involved, through the British National Space Centre (BNSC), in every aspect of the ERS-1 programme since the late 1970s.

Cover photograph by courtesy of BNSC.

* See our series of feature articles on Energy and the Environment, beginning on page 8.

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International gas survey — findings

DESPITE a combination of price increases and the highest unit cost for gas in Europe for heavy industrial users, the average cost for gas in the United Kingdom has fallen by 7 per cent.

This reduction means that the UK has moved from the most expensive to the second most expensive country surveyed in this year's National Utility Services (NUS) international gas price survey.

The survey reveals how British gas prices have been affected following the introduction of recommendations made by the Monopolies and Mergers Commission regarding British Gas's pricing policy. The principal recommendation stated that British Gas should publish an industrial price schedule, an act now completed by the utility supplier.

The results of this new price structure show an overall average reduction in the price of gas for consumers who are charged under a firm gas supply agreement — ie those totally committed to gas as a fuel source.

Although reductions have been seen on all firm gas agreements, heavy industrial users — typically those on interruptible gas supplies — are now facing substantial price rises of up to 60 per cent. In some cases these large process users pay as much as 48 per cent more than their European counterparts.

NUS spokesman Andrew Johns, commenting on the survey results said: "Although the majority of small and medium-sized businesses have benefited from the Monopolies and Mergers Commission recommendations being implemented, little has been done to redress the problem with regard to the UK's larger manufacturing companies. These companies are currently paying more for their gas than their European counterparts, thereby making them less competitive."

Italian consumers experienced a gas price rise of more than 30 per cent, the highest average rise recorded in this year's survey.

This huge increase is a result of government intervention and an increase in the tariffs for space heating, which means consumers now pay 43 per cent more for space heating than gas used for other purposes.

Italy is a major importer of gas and, therefore, exposed to the changes in the European market where prices are closely linked to those of oil.

France becomes the most expensive country for the purchase of gas with a small rise of 0.6 per cent compared to an increase in the rate of inflation of 3.5 per cent.

French prices increased during the early part of the year, falling later when it became apparent that Gaz-De-France was not going to make a loss but break even. This followed successive years of government intervention, resulting in prices being artificially held down to control inflation.

France is a major importer of gas and the cost to Gaz-De-France is subject to price fluctuations within the international gas market as well as to intervention from the French Government, whose policy has been to subsidise consumer gas prices.

The cost of gas in West Germany has substantially risen during the year surveyed. A combination of the introduction of a gas tax and small increases in oil prices has meant that German consumers are now paying 16.5 per cent more for their gas than at this time last year. This is in stark contrast to the rate of inflation, currently increasing at 2.9 per cent.

It is anticipated that further rises are likely to occur in late 1989, following which prices should stabilise.

The survey results show the US moving from fourth to sixth place in the table. This is due to the continuing transition to a free competitive gas market, and the fact that prices seem to be reflecting a more stable oil market.

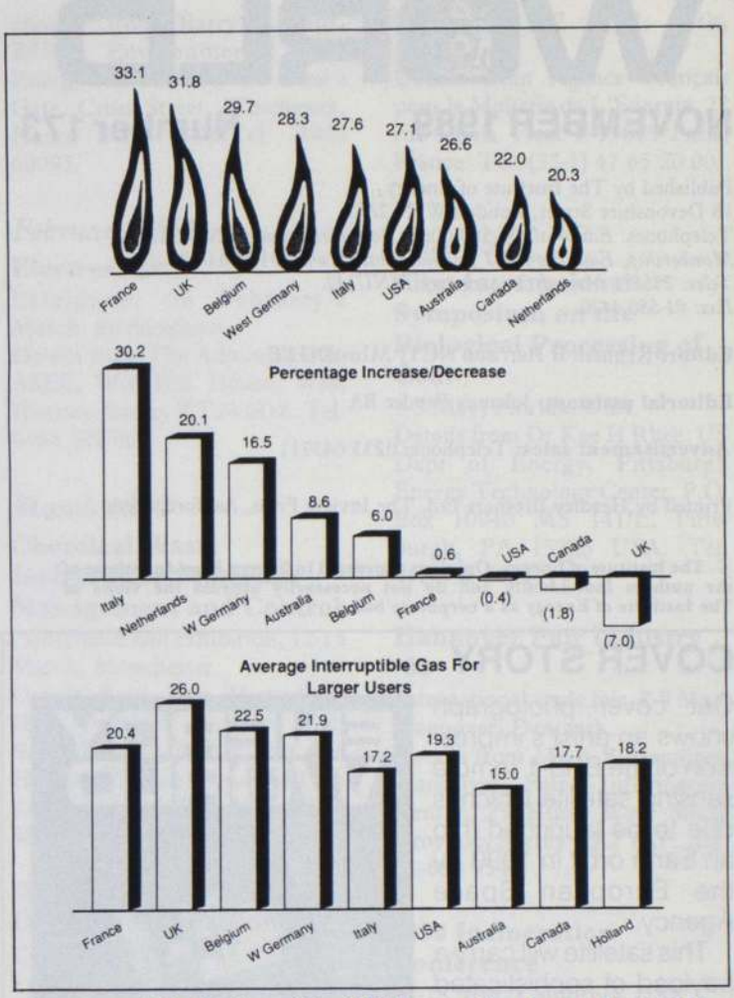
Australia has moved from fifth to seventh place in the table in spite of an increase of 8.6 per cent against an increase in the inflation rate of 7.6 per cent.

Canadian gas consumers benefited from a drop of 1.8 per cent in the price of gas over the year surveyed.

Canadian gas prices are expected to remain at their current low level until 1991 when, on the expiry of long running transport contracts, it is anticipated that gas prices will rise sharply. The current low prices are also being aided by a "softer" oil price and the introduction of competition following the deregulation of the Canadian gas industry.

Despite a 20.1 per cent increase in Dutch prices, Holland is still the cheapest gas provider of the nine countries surveyed. Inflation is currently running at only 1.1 per cent. The price of gas is adjusted according to the previous six-month oil price on the Rotterdam spot market and on the dollar rate of exchange. The Dutch consumer will face a further slight rise before the end of the year.

Belgian consumers faced an increase in prices of 6 per cent compared to a rate of inflation of 3.1 per cent. The price is expected to go up further based on the slow increase in the price of oil during the first part of the year.



Summary of the findings of the NUS international gas price survey. Prices quoted are average prices in pence per therm.

Billions to be spent on 'acid rain' controls

INTERNATIONAL coal users plan to spend £15 – £25 billion by the end of the century to control 'acid rain' pollution from power stations and large industrial plant, a new report revealed in October.

The report by IEA Coal Research — a branch of the International Energy Agency — praises coal plant operators for their willingness to adapt to 'green' issues and concludes that coal will remain the major fuel choice for power generation in the future.

The report — the latest in a series of technical publications by IEA Coal Research which deal with the environmental impacts of coal combustion — says that scrubbers and other equipment to control sulphur emissions will be fitted on nearly 200 gigawatts (electrical) of power plants and large industrial boilers to meet recently-introduced and planned pollution control laws.

Spending on clean coal-burn technologies will also increase but these are not likely to make any major impact until the year 2000, the report says.

The report's author is Dr Jan Vernon, Head of IEA Coal Research's Environment Group.

Nuclear energy: fundamental choices in prospect

THE WORLD cannot put off for very much longer making some fundamental choices about energy — and particularly about the future of nuclear power, John Wakeham, the UK Energy Secretary recently told the International Atomic Energy Agency General Conference in Vienna.

He also said that the decision to withdraw the Magnox nuclear stations from the privatisation of the electricity supply industry "has *not* demonstrated that nuclear power as a whole will remain fundamentally uneconomic in the medium to long term."

Mr Wakeham told the conference on 27 September that even on the most optimistic assumptions about improvements in energy efficiency, a major re-ordering programme for world generating capacity will be needed between now and the end of this century simply to replace the growing number of power stations now reaching the end of their useful lives — let alone to keep pace with the latest projections of the rise in future international demand.

It was also clear, that nuclear power, which is currently meeting nearly a quarter of the electricity demand within the OECD area — and considerably more in a number of countries — would be enormously difficult to replace as one of the world's leading energy resources.

Mr Wakeham said: "Of course it is still argued by some environmentalists that further improvements in energy efficiency can offer a practical alternative to the continued development of nuclear power. And I have no doubts whatever about the key relevance of energy efficiency — indeed as I have already previously said it is likely to become an increasingly important part of the answer to our energy problems.

"But it does not follow that to be strongly pro-energy efficiency is to be anti-nuclear power. Energy efficiency can never be the *total* answer, because it is not in itself an additional energy resource — although it is still sometimes presented as one. At the risk of making an obvious distinction, energy efficiency saves energy; it doesn't produce it. It can help towards restricting the expansion of energy demand, but it cannot contribute towards meeting demand itself.

"Above all, it does not obviate the need to renew a substantial proportion of the world's generating capacity, nor the need to arrive at some increasingly urgent decisions about both the nature and mix of the power stations which will serve our energy needs into the late 1990's and beyond in the light of the growing worries about environmental pollution."

China follows Sweden's lead in CWF use

SALA International, part of the Swedish-based Trelleborg Group, has recently received an order from the China National Technical Import Corporation for a major coal-slurry plant, of coal-water fuel (CWF) type, scheduled to start operating in the Beijing area in mid-1991.

It will be the first such installation in China to be based on the fluidcarbon process developed by the specialist company Fluidcarbon International, which installed a commercial plant in Malmö, Sweden, in 1984. The Swedish plant, and the technology on which it is based, have attracted great interest on the world market.

During the contract negotiations, Sala International and Fluidcarbon International acted as a consortium. However, for the carrying out of the contract, and the future marketing of the fluidcarbon technology, it was deemed advantageous to establish closer links between these two Swedish companies. Consequently, Fluidcarbon has been acquired by the Trelleborg Group, and its coal-slurry technology is now included in the mineral processing product programme of the Pumps & Process Equipment Division (Sala International) of Boliden Allis AB, a major Trelleborg Group company.

All the vital process equipment for the Chinese plant will be manufactured and delivered by Sala International, Sweden, while the pipes, ducting and other structural material will be made locally on the basis of engineering specifications from Sala.

The Chinese installation will have an annual capacity of 250,000 tons of CWF and will be a virtual copy of the Malmö plant. However, the coal will be cleaned before grinding to the required particle size range, whereas in Malmö the flotation cleaning process forms an integral part of the plant. The coal for the Chinese installation will come from the Datong deposits some 150 miles west of Beijing.

The object of introducing coal-slurry techniques into China is to reduce the overall consumption of oil and to increase the use of the country's abundant coal resources. In China, boilers in power-stations and industry consume about 30 million tons of oil annually, about 25 per cent of national production. It is much easier to modify these oil-fired boilers to use cold-water slurry as fuel rather than to convert them to burn coal in solid form.

ABB STAL receive Spanish order

ABB STAL AB of Sweden, have received an order from Cogeneracion Gequisa SA, Spain, for a 9 MW (ISO) Mars gas turbine generator set. Cogeneracion Gequisa is jointly owned by General Quimica SA, a large chemical company, and Iberduero SA, through its 100% holding in Proindesa, a major electricity utility.

The generator set will form part of a new energy-saving CHP (combined heat and power) installation at the General Quimica works near Miranda de Ebro, in northern Spain. It will be connected to a supplementary-fired, exhaust-heat recovery boiler, and will cover all the electrical requirements of the plant, with surplus power being fed into the grid. The steam generated in the boiler will be used for process purposes. The fuel will be natural gas.

ABB Energia, Spain, an ABB Group company, will supply certain electrical equipment and site services as part of the contract. The project engineering will be carried out by Powertec Espanola SA, Madrid.

New proposals for Australian mine and power station

MEEKATHARRA Minerals, which is in joint venture with BHP-Utah to exploit major lignite deposits in Northern Ireland, announced in October that new submissions for development of its Arckaringa coal field in South Australia have been put forward by the company and its Japanese partner Kumagai Gumi at the express invitation of the State Government.

The two companies' nine different proposals involve potential new private capital investment in South Australia of between $A1billion-$A2billion, using processes and techniques which lie comfortably within current pulverised fuel and circulating fluid bed technology.

Located approximately 900 km from Adelaide, the Arckaringa coal field contains 10 billion tonnes of coal representing the best quality economically recoverable coal in the state. It was discovered by Meekatharra in 1980 and, when developed, could supply a major part of South Australia's future electric power needs.

Meekatharra also reveals that Kumagai, one of Japan's largest power station builders, has now increased its equity in the Arckaringa coal field to 8 per cent and has options to raise its interest.

The proposals by the partners respond positively to invitations by the State Government in 1988 to re-submit plans first put forward in 1984.

The partners believe that all their proposals would provide cleaner, cheaper, more efficient and more reliable power than any other coal field development in South Australia.

"This is especially important," the companies state, "because the Industries Assistance Commission recently reported its concern about the very high costs of electricity in South Australia which is mostly provided by high cost Leigh Creek lignite and natural gas. Both these fuels are expected to continue to increase significantly in cost and are in limited supply."

Tackling the greenhouse effect

'TAX breaks' for energy efficiency rather than a 'carbon tax' could be the best way of tackling the greenhouse effect, a senior British Coal official stated recently.

Mr Martin Cruttenden, British Coal's director of sales, said it made 'no sense' to talk about imposing a 'carbon tax' in isolation when there were other gases — CFC's, other specialist gases and methane — which contributed to the problem.

"In the case of methane I never cease to be amazed by the substantial estimates of just how much methane gas goes missing between well head and combustion point," he said.

"The whole concept is fraught with difficulty, even before assessment is made of other non-greenhouse forms of pollution associated with energy — flooding valleys, nuclear waste disposal and ultimate decommissioning."

Mr Cruttenden told the Coal Industry Society in London that more emphasis needed to be placed on using polluting goods and energy more efficiently. This could mean encouraging research into more efficient electricity generation, such as British Coal's 'Topping Cycle' programme; installing flue gas desulphurisation and low NO_x burners in more conventional plant; and promoting the use of combined heat and power plants for industry.

Severn Barrage report published

THE GENERAL report on the Severn Barrage Project was published in October by HM Stationery Office, as Energy Paper 57, on behalf of the Department of Energy, the CEGB and the Severn Tidal Power Group.

The report summarises the findings and conclusions of a £4¼ million development project study funded equally by the three parties and managed by the STPG. The work has been carried out in close collaboration with generic tidal power studies funded by the Department of Energy and costing a further £1.5 million.

Within the study, the engineering of the project has been carefully re-examined and revised cost estimates prepared. The report confirms the conclusion of the earlier studies by the Severn Barrage Committee (1981) and the STPG (1986) that an electricity generating barrage on an alignment seaward of Cardiff to Weston-super-Mare is feasible with current technology. Furthermore the cost of electricity generated remains substantially unchanged in real terms (3.65p/kWh at 5 per cent discount rate) from that determined in the 1986 study. A very substantial effort has been made to improve the knowledge of the ecology of the estuary and the effect of the barrage upon it and to study the impact on the regional economy. No insuperable ecological problems are foreseen though the report stresses that a great deal more work will be necessary before a full environmental assessment may be made.

This general report will be followed by a 5 volume detailed report by STPG to be published shortly by the Department of Energy. Copies of this detailed report may be obtained in due course from ETSU at £20 per volume (£100 set).

Study of new coal import facilities

NATIONAL POWER is to investigate the possible development of two new deep water port facilities in South Wales and the North of England to handle imported coal.

The new facilities, if developed, could each be capable of taking up to five million tonnes of coal annually.

Consultants will be appointed by National Power to carry out design studies at Milford Haven, in Dyfed, and on the Tees in Cleveland.

"Development of these two facilities would enable National Power to import coal at much lower cost than by the current method of transhipping via the Continent," said Mr Malcolm Rainbow, National Power's head of fossil and fuel supply designate.

"The new ports would also be able to supply power stations which are not well placed to receive coal supplies from import facilities currently in use."

The two study sites were selected for further investigation following a review by National Power of the existing and proposed import facilities. Both are capable of receiving large bulk carriers holding over 120,000 tonnes of coal.

As well as serving National Power's generating stations at Aberthaw, Uskmouth and Didcot, the Milford Haven facility would have the potential to supply imported coal to stations in the South Midlands.

The Tees facility would provide access to the larger power stations operated by National Power in the Aire and Trent Valleys.

Mr Rainbow said that the studies being carried out would examine design, optimal tonnages, throughput and costs.

New gas competitor

JAMES McKINNON, the director general of gas supply, welcomed the arrival of Quadrant Gas on the gas supply scene in October.

"I am sure that industrial gas users will be as delighted as I am by this development, marking as it does a significant commitment by two major oil companies to the emergence of a competitive gas-to-gas market," he said.

"The report on gas from the Monopolies and Mergers Commission which was published just a year ago led to the emergence from British Gas of an industrial price schedule on which further improvements were made only last week.

"The removal of the mystery surrounding the company's prices has enabled potential competitors to make a better assessment of the risks associated with entering the gas supply market.

"Clearly, Quadrant Gas thinks the risks are worth taking and I believe that where they have led others will follow," Mr McKinnon said.

Skill shortage in offshore sector

THE OFFSHORE oil and gas sector must urgently review the problem of skill shortages in the industry if it is to meet the challenge of the 1990s, said Peter Morrison, Minister of State for Energy, in October.

Speaking after chairing a meeting of the Offshore Industry Liaison Committee in London, Mr Morrison said:

"There is no doubt that a highly skilled offshore supply workforce is essential for the industry to continue to fully realise the opportunities that the UK continental shelf will offer during the 1990s and beyond. It is a need that is doubly vital as offshore exploration, development and production becomes even more advanced.

"The offshore sector, together with many other industries in the UK, is beginning to feel the effect of a shortage of skilled workers; a shortage that is likely to become more acute in the coming years as industries compete for fewer graduates and specialist personnel."

Green power challenge

LABOUR Energy spokesman Kevin Barron MP called upon the Government in October to 'end the doubt and uncertainty' surrounding the Government's commitment to the 'green power' of combined heat and power.

Combined heat and power (or co-generation) systems not only generate electricity highly efficiently, but also use the heat created in the process. Through this, overall efficiency can be raised from the normal 30 per cent or so of conventional power plant, to around 80 per cent. This leads to dramatic reductions in UK greenhouse gas emissions, up to 30 per cent in some cases.

Spelling out what he believes needs to be done to boost the impact of CHP in the UK, Mr Barron commented: "Ten years ago, the current government published a report commissioned by the last Labour Energy Minister setting out the exciting prospects for the development of large scale CHP schemes in Britain. Since then, the government's lacklustre support for new approaches to energy production has meant that not one large scale CHP power station has actually been developed."

According to Mr Barron, industry and local authorities have been much quicker off the mark with a number of industrial co-generation and small scale CHP schemes being put to work for the benefit of consumers.

Gas rethink on price schedules

BRITISH Gas has agreed to make major modifications to its recently-published price schedule following discussions with the industry's watchdog body, the Office of Gas Supply.

Announcing the agreement, Mr James McKinnon, the director general of gas supply, said the original price schedule published in May had brought a stream of complaints to his office from existing customers.

"I had a duty to follow up those concerns with British Gas on behalf of the complainants. I held extensive discussions with the company to establish the most appropriate way of resolving the anomalies that were inherent in the published schedule," he said.

"I am pleased that British Gas has responded positively to the seven-point plan I put to it in July and I hope the resulting changes will go a long way to satisfying the many aggrieved gas users. British Gas has had regard to the aspirations of its customers and I believe this to have been a very promising feature of the discussions on the changes.

Mr McKinnon added: "The recognition of energy management companies along with the other changes to be made to the schedules by British Gas could also benefit those involved in affinity trading groups."

Interruptibles threshold lowered

THE THRESHOLD for supplies of interruptible gas is to be lowered, initially from 250,000 to 200,000 therms. This was the position agreed by the Office of Gas Supply and British Gas, following a consultation exercise undertaken by OFGAS.

The exercise started at the end of July when OFGAS sought the views of industrial customers on a paper considering the arguments for lowering or abolishing the minimum threshold of 250,000 therms above which interruptible supplies of gas are available. The question was outstanding from last Autumn's report on gas by the Monopolies and Mergers Commission.

Britain could face energy shortage in five years' time

BRITAIN could well face an energy shortage in five years time as a result of the confusion and delay surrounding the privatisation of the electricity supply industry, according to the new president of the Energy Industries Club, Dr Robert Hawley.

Dr Hawley, who is also managing director (operations) of Northern Engineering Industries plc, and a director of Rolls-Royce plc told a meeting of the club in October that there was an urgent need for clear decisions on several aspects of privatisation.

So far there had only been confusion between the new power companies, the independent producers of electricity and the distribution companies, with the only winners the men from the City, the PR men and advertisers.

This situation was occurring at the same time as the move towards a single European market, increasing concern over the degradation of the environment and a re-structuring of the equipment supply industry following the various mergers, take-overs and joint ventures which have taken place.

Dr Hawley concluded: "I am deeply concerned that in the dust-storm of privatisation the potential shortfall in capacity is not being recognised.

"I know that when called upon UK-based and UK-managed companies will rise to the challenge. However from the point of view of the man in the street, the confusion in the UK is leading to delays in the ordering and building of new plant, no matter what size or in whose hands, and unless we see some clear direction in the immediate future we could well be facing an energy shortage in five years, with all that that entails for our economy."

Hinkley C inquiry reopens to hear new cost estimates

THE HINKLEY Point C public inquiry reopened at the beginning of November to consider fresh evidence submitted by the CEGB.

The evidence contained new estimates of the capital cost of Sizewell B that indicated that this could increase by about 10 per cent on the previous estimates.

However, the CEGB has told the inquiry that despite the increases in Sizewell B's capital cost, it sees no reason to adjust its central estimate for the similar PWR nuclear power station, Hinkley Point C. The latter is estimated to cost £1,550 million at 1987 prices.

According to the CEGB, the extra cost in the new estimates for Sizewell B is due principally to design modifications arising from the fact that the project is a "first of a kind".

In response to the CEGB's statement, the Council for the Protection of Rural England (CPRE) submitted a new memorandum, suggesting that the real final cost of Hinkley C may be up to £500 million in excess of the CEGB's original figure of £1,470 million.

Oil terminal project on schedule

THE £40 MILLION Hamble Oil Terminal modification project is on schedule for completion by the end of 1989.

Foster Wheeler Energy Limited (FWEL), the Reading based international engineering contractor and consultant, was awarded the engineering and procurement contract for the project in February 1988 by the joint venture participants in the Wytch Farm Development.

The terminal, which was originally built in 1924, is being modified to accommodate the 60,000 barrels per day (BPD) from the Wytch Farm Oilfield. A 56-mile, 16 inch pipeline from Purbeck has already been laid, part of it across Southampton Water. Modifications are currently being made to the terminal's 530-metre long jetty and jetty head to accommodate a 30 inch export pipeline and allow the docking of larger tankers of up to 100,000 dwt. Four new 22,000 tonnes crude oil storage tanks will hold the equivalent of 10 days' supply from the oilfield.

Long-term deals for coal supplies

LONG-TERM contracts with price guarantees for coal supplies to the new generating companies, and a move into small-scale pithead power plant were the cornerstones of British Coal's determination to build on the dramatic improvement in the industry's efficiency, Malcolm Edwards, the corporation's commercial director said in October.

Addressing the UK Electricity European Study Conference in London, Mr Edwards, referred to the need to establish coal supply contracts with National Power and PowerGen, the successor companies to the CEGB. He said long-term contracts were essential in the United States because coal mines need large capital investment, first to create and then to be maintained in efficient production.

British Coal are planning to go further and take advantage of the Government's wish to see additional generation by building small power stations at the pithead — with partners in the private sector. A revolution in coal burning technology makes this possible, and small environmentally friendly power stations can now generate as efficiently as the biggest. Developing the topping cycle technology — potentially the best advanced coal generation technology in the world — would make it first choice for the next generation of small clean and efficient coal power stations.

Reviewing offshore safety

FURTHER measures towards improving safety on offshore installations were outlined in discussion documents published by the Department of Energy in October.

The documents are intended to lead to formal safety assessments of offshore installations and to improved requirements for protection against fire and explosion.

Welcoming the discussion papers, Peter Morrison, Minister of State for Energy, said: "Industry-wide formal safety assessment procedures will help operators identify risks and take any necessary action in the design of plant as well as in improving working practices."

Welsh Energy Managers' Conference and Exhibition

THERE is still a long way to go in improving energy effectiveness, claimed the President Professor Brian Brinkworth in opening the Welsh Energy Managers' Conference and Exhibition at Swansea on 25 October. More than £40 billion a year was spent in purchasing energy supply in Britain. A former Energy Secretary, Peter Walker, now Secretary of State for Wales, had pressed the case that this sum could be reduced by £7 billion. That had not yet been achieved, but the prospect continued to be realistic.

But saving money, or even saving fuel, were not the only objectives of energy management, he said. The real aim was to ensure that wherever energy was used, it was used with good cost-effectiveness. This might be "more-from-the-same", as well as "the-same-from-less".

Dr Elliot Finer, Director-General of the Energy Efficiency Office, had been prevented from attending the conference by a back injury, but sent a message which was read out by the President. Dr Finer wrote that energy managers had never been more important, and that their efforts were greatly appreciated at the EEO. In addition to the economic benefits of their work, there were environmental benefits which were being increasingly recognised. Energy efficiency was an important way in which firms and organisations could be environmentally friendly.

Energy management was a developing technique; managers needed to be up-to-date with the latest technology, with modern management techniques and with methods of securing motivation. They had to be professionals, with the status which that implied. Dr Finer urged them to continue improving their capability through conferences, seminars, courses and other activities, which the regional EEOs were keen to support.

The President added that the objectives of energy managers were very much aligned with those of the Institute, which were to promote the effective use of energy of all forms, with due regard to the prudent use of resources and the protection of the environment. Energy managers were among the membership of the Institute, and much had been done to support the emerging national organisation which had been operating from the address of the Institute's HQ in London. It was expected that the National Energy Efficiency Association would be formally launched shortly, and this would be fully endorsed by the Institute.

The registrants, numbering about 150, went on to hear presentations by other energy managers, consultants and energy efficiency specialists on technical matters such as monitoring and targeting, waste heat recovery, electricity saving and building energy controls and on organisational matters such as developments in the energy manager movement, extended services in the field being introduced by British Coal and the 'Best Practice' scheme of the EEO. A substantial exhibition of energy-efficient services and products accompanied the conference, which was sponsored by the Energy Efficiency Office and British Coal.

Applied Energy Research: conference report

THE 1989 Applied Energy Research Conference was held at University College, Swansea from 5-7 September.

Organised by The Institute of Energy, the meeting was held in the Taliesin Arts Theatre Complex, located on the main Singleton Park campus.

The Taliesin building also housed an integrated exhibition with contributions from W S Atkins Energy, British Coal, British Gas, British Steel, the Welsh Office of Regional Efficiency, IOP Publishing Ltd, JEL/Thorn Security, South Wales Electricity, Swansea Bay Energy Action and University College, Swansea.

The five principal themes of the meeting were:

1, Optimisation of thermal energy transfer,
2, Renewable energy update,
3, Generation and utilisation of electricity,
4, Energy management, and
5, Thermal energy processes.

The social and technical programme included a visit to the CEGB (National Power) Carmarthen Bay Wind Turbine site, as well as a civic reception by the Lord Mayor, accompanied by a Welsh choir and a conference dinner in Margam Abbey Orangery.

Full details of the papers presented, published in an attractive hardback volume, may be obtained from the publishers: IOP Publishing Ltd, Techno House, Redcliffe Way, Bristol BS1 6NX. Tel: 0272 297481.

P J Padley, FInstE

Ottawa engineer receives medal

George K Lee (Fellow) has received an Engineering Medal for Research and Development, at a presentation in Toronto, Canada, organised by the Association of Professional Engineers of Ontario.

With over 150 publications and reports on coal and fossil related fuels to his name, Mr Lee has made a major contribution to ensuring that the coal Canada burns in the coming century will be as clean as human technology allows.

A new 300 MW coal-fired power plant planned for Cape Breton, Nova Scotia, is based on one of Lee's designs, and aims to remove 90 per cent of sulphur emissions. A plant of this type using high sulphur coal would emit no more sulphur than a conventional plant using low sulphur coal.

As laboratory manager at CANMET's Energy, Mines and Resources Combustion and Carbonisation Research Laboratory, Mr Lee has pioneered several important coal technologies. He helped set up a bubbling fluidised bed boiler demonstration, showing the possibility of burning high sulphur coal cleanly.

Mr Lee also personally managed an industrial scale demonstration of a limestone injection and staged combustion process in New Brunswick. This technology, which reduces both sulphur and nitrogen oxide emissions, is expected to be widely used for burning medium sulphur coal. Not only do such technologies reduce pollution such as acid rain, they also burn coal more efficiently. He commented:

"The old units at Gatetown (New Brunswick) were running at about 78 per cent efficiency. We got that up to 81 per cent efficiency with acid rain controls.

Mr Lee received a masters degree in engineering from Queen's University, Canada. He is a director of the International Combustion Institute, the Canadian Gas Research Institute, and the Canadian Institute of Energy. He is a member of the Association for Professional Engineers of Ontario, as well as being a Fellow of The Institute of Energy.

Call for papers

THE "call for papers" for COMADEM 90 International congress, which is being co-sponsored by The Institute of Energy, has been issued.

Intending authors should submit an abstract of their proposed paper, not in excess of 250 words, to the conference organisers at Brunel University by 31 December. The abstracts will be reviewed by a panel of professional experts, and their decisions notified to individual authors in January.

The aim of the congress is to provide a forum for professional engineers, scientists, technologists, managers and educationalists to exchange views, and focus attention on the latest advances in the discipline of condition monitoring and diagnostic engineering management (COMADEM).

If you would like more information about COMADEM 90, please contact Dr Raj B K N Rao, Director, COMADEM Centre, Faculty of Engineering & Computer Technology, Birmingham Polytechnic, Perry Barr, Birmingham B42 2SU. Tel: 021-331 5440.

New director

ENERGY management specialists Associated Heat Services (AHS) have recently appointed Ray Parsons (Associate Member) as their major projects director.

Mr Parsons joined AHS as an operations engineer in 1978.

Previously AHS's general manager in Nottingham, Mr Parsons will now be responsible for the development of major projects, AHS's Technical Services Division, the National Projects Office as well as Health and Safety throughout the company.

New members

Fellow

Peter Douglas Dunn, University of Reading

Paul Eric Lander, Sir Frederick Snow & Partners *(transfer)*

Brian Norton, University of Ulster, N Ireland

Member

Malcolm John Brown, St Martins Property Corp, London

Paul Andrew Gredley, BOC Limited, W Yorks

Jonathan Adrian Harley, NIFES Limited, Notts *(transfer)*

Stephen Jones, British Nuclear Fuels, Cumbria

Robert Craig McLean, University of Strathclyde

Howard David Metcalf, DMS Energy Ltd, Notts *(transfer)*

Maurice P Rabach

Ogwang, African Highlands Produce, Kenya *(transfer)*

Philip George Pike, W S Atkins Energy Ltd, Bristol

Dennis Richard Rachwal, British Gas, Midlands Research Station

John Philip Smart, Intl Flame Research Foundation, The Netherlands

Safouh Mohamad Soufi, SECO-EAST, Saudi Arabia *(transfer)*

Mohammad Zolghadr, Mount Allison University, Canada

Associate Member

Andrew Peter Broadbent, Stockpack Ltd, Stockport

John Antony Samuels, Trafford Borough Council

Associate

Faris Sahib, Southhall College of Technology

Barry Collings, Securicor Ltd, Milton Keynes

Graduate

Mark Atkinson, *(transfer)*

Donald William French, NEC Semiconductors (UK) Ltd, Livingston

Gillian Hands, White Young Prentice & Royle, W Yorks

Richard Michael Hansen, Whallace Whittle & Partners, London

Stuart John Kennion, Metallurgical Engineers Ltd, London

Darryl Wyn Lewis, British Steel, Port Talbot, Wales

Group Affiliate

Energy Technology Support Unit, Didcot, Oxon

Midlands Electricity Board, Halesowen, W Midlands

Michelin Tyre, Stoke-on-Trent

IEE President's inaugural address

GREATER use of electricity to meet the country's energy needs will result in both better control of the environment and a more efficient use of fuel. This was the message given by Dr Jim Smith CBE in his inaugural address as President of the Institution of Electrical Engineers in October.

Dr Smith, who is chairman of Eastern Electricity, was speaking to an audience of over 400 senior professional engineers and industrialists.

"We have not yet faced up to the energy policy decisions which other countries have met head on" he warned. Only 15 per cent of the energy used in the UK is in the form of electricity. However, the depletion of fossil fuel reserves, environmental damage through the emission of carbon dioxide and other gases, the destruction of the world's forests and the threat of future energy shortages all suggest the need for a greater use of electricity derived from non-fossil sources.

Dr Smith went on to stress the additional economic benefits of conversion to electricity.

"There is evidence on the energy scene that the increased use of electrotechnology within a society can improve the efficiency of overall energy usage. It can be argued therefore, that the rational use of energy requires a transfer to a greater use of energy in the form of electricity".

Dr Smith ended his Presidential address with a look to the effects of the privatisation of the electricity supply industry.

"It is to be hoped that the new public electricity supply companies will take on the mantle of leading the drive for energy efficiency through the electric route". Success in this aim, he concluded, could result in a renaissance in the British power engineering industry and a corresponding benefit to the economy.

New consultant

JOHN POOLEY (Member), formerly of NIFES Consulting Group and Arthur Young Management Consultants, has set up his own consultancy practice in Hartlebury, Worcestershire.

Mr Pooley, who has been actively involved in the development and promotion of management techniques in energy cost control, will be specialising in energy management techniques, computers applied to energy management and training in energy management and computers.

Green talk

IAN FLINDALL, energy spokesman for the Green Party, initiated a lively discussion at the October meeting of the London and Home Counties branch.

In his talk he outlined the Green's policy on energy. Energy efficiency foregrounded his argument, with particular emphasis on a decrease of energy use for transportation purposes.

Whilst calling for the maximum efficiency in the use of gas, the Greens also call for the complete phasing out of nuclear power.

Mr Flindall saw the reduction of NOx and SOx emissions from coal-fired power stations as vital to combat the environmental threat of acid rain.

The use of oil was seen as important in the short term only, owing to what Mr Flindall saw as the long term availability problem.

Finally he called for the developed countries to set an example to the third world, whose increasing energy needs pose serious problems for the coming century.

The next meeting of the London and Home Counties branch is on 28 November, and will be addressed by Malcolm Keay, deputy director general of OFGAS, the Office of Gas Supply, on the subject of 'Gas industry regulation'.

Obituary

Len Webb

LEN WEBB died on 24 June this year, aged 60. He had been a Member of The Institute of Energy for 23 years.

Len joined the CEGB in 1952 as a junior chemist at Blackburn Meadows Power Station, following his National Service.

His career progressed rapidly, with moves to Mexborough, Lincoln, Brimsdown and Belvedere, where he was appointed station chemist in 1964.

In 1966 he became station chemist at Ratcliffe, and continued in that role until 1987. During this time Len brought his talents and energy to bear on the numerous challenges that the commissioning and operation of new plant requires, and was an essential part of the team that made Ratcliffe the most successful station the Board possessed. All the staff who worked for and with Len, held him in the highest regard, both for his technical abilities, and unfailing good humour.

This esteem was much in evidence at his funeral, when colleagues, current and retired, from all parts of the organisation joined with his family and many friends to pay their last respects.

For the past two years, Len has been seconded to CEGB HQ commercial department (overseas) preparing and producing technical literature for BEI to sell CEGB services overseas, based at Fairham House.

Len's enthusiasm was not confined to technical matters. He was an accomplished musician, playing both the piano, and his great favourite, the organ. He was closely associated with Kendrick Partington at St Peter's in Nottingham for many years, both as a student of the organ and as a baritone in the church choir and the St Peter's Singers. He was also a member of the Nottinghamshire Choral Trust.

In 1988 he was elected President of the Nottingham and District Society or Organists, during which time he was instrumental in persuading the CEGB to sponsor remedial work on the Albert Hall Binns Organ.

Despite his failing strength, he remained optimistic, and was always courteous to visitors, being more interested in their news, than in discussing his own problems.

The energy agenda for the 90s

*by Prof Ian Fells FEng, FInstE**

In the following article, Ian Fells reviews the plethora of reports, the technical presentations, and some of the supporting activity at the recent congress of the World Energy Conference, held in Montreal, leading him and other experts to the conclusion that the event highlighted the importance of the political process in ensuring a growing energy supply whilst, at the same time, protecting the environment.

THE 14th Congress of the World Energy Conference opened on 17 September in Montreal with a flurry of dancing, singing, vox pop videos on huge screens and a laser beam that burnt its way through a pink ribbon suspended between two posts on stage.

The 5000 delegates from 93 countries sat in the great hall of the Palais des Congress to listen to speeches, most of which seemed to be in French, which set the agenda for the conference. It was no surprise to anyone that the theme of the conference "Energy for Tomorrow" soon became dominated by environmental concerns.

The Prime Minister of Canada, Brian Mulroney, pointed out in his opening address that most people accepted that "the polluter pays" but "we will not really have changed our attitudes until we all realise that the polluter is us". He went on to say "nowhere is that truer than in Canada where our energy consumption per capita is double that of Western Europe and Japan . . ."; he could have gone on to say, a hundred times more than some of the developing countries.

This imbalance between energy consumption and consequently life style between "the haves" and "the have nots" became one of the main themes of the conference, as it was three years ago in Cannes, and three years before that in India. But whereas the Cannes Congress had been preoccupied with the instability of the oil price and the likely effect of the Chernobyl accident on the already ailing nuclear programme, this Congress, as well as dealing with a wealth of important technical matters, found itself grappling, perhaps to its surprise, with institutional arrangements, and shifting political opinions and their effect on energy policy.

In a welcome and necessary innovation the energy ministers of South Korea, USA and Britain addressed the congress in optimistic, market-led terms but it was unclear whether the political will was really there to effect the changes they advocated. Changes that should lead to a more equitable distribution of resources and a cleaner global environment. Another innovation was the introduction of a youth section into the World Energy Conference. What surprised and depressed the senior delegates was the belief of the majority of the young people from Canada and elsewhere that solar energy could provide for most of our future energy needs.

The title of the first keynote lecture was "Energy and Society". It was given by Lord Marshall, Chairman-elect of National Power who pointed out that "in the energy sector our progress or lack of progress in the future will depend upon our success in solving institutional not technological problems. . . . (they) will be political, or financial, or motivational or one of public understanding, but I believe . . . we can no longer expect a scientific invention or a technological achievement to produce a miracle and show the next way forward".

Turning to environmental concerns he listed the four most important topics: acid rain, the ozone hole, the greenhouse effect and nuclear radioactivity. To get a measure of their importance he examined man-made production against natural production. If man's production is only a small fraction of what God produces there is little cause for concern but if they are similar there is reason to worry as we might be upsetting the balance of nature. By a series of ingenious arguments he constructed the information given in Table 1.

His enthusiasm for nuclear comparisons may have caused him to overstate his case a little but there is plenty of 'slack' in his figures so the argument is unlikely to be upset.

Nuclear energy

Lord Marshall commended a nuclear programme to the congress reminding them that the problems facing nuclear power are institutional and primarily problems of understanding and public acceptance.

A Round Table, "Energy Policies and the Public", was devoted to questions of public understanding but the perennial arguments were rehearsed without startlingly new ideas so one can be forgiven for treating Deputy Energy Minister Moore of the US with some sceptism when he propounded a new positive nuclear power programme in the US. Nevertheless the 16 per cent of world electricity which is nuclear-generated reduces CO_2 pollution of the atmosphere by some 2 billion tonnes per year and in France where nuclear electricity generation has increased by 80 per cent over a decade acid sulphur dioxide emissions have fallen by 50 per cent.

There was, however, a general optimism that nuclear power has to an extent rehabilitated itself since Chernobyl although paradoxically the Russian delegate Antoly Beschinski called for a slowing down in both nuclear and coal burning technology over the next 20 years in order to give time to develop inherently safe reactors and clean coal technologies. There was certainly a general feeling that coal is now seen as environmentally suspect and that will hinder its future development.

The universal panacea seems to be natural gas which generates only 57 per cent of the CO_2 produced by the combustion of coal per unit of heat and can be burnt in combined cycle gas turbine/steam turbine systems generated electricity with an efficiency of 50 per cent. The US expects to double its use of natural gas for electricity generation by the year 2000.

Sweden with the daunting task of phasing out nuclear power by 2010, the result of holding a referendum to settle the matter, will turn to natural gas rather than coal with its environmental penalties. With hydropower also proscribed by the environmental fishing lobby and 60 per cent of Swedish electricity generated by nuclear power it will be a very close run thing to phase out nuclear.

Russia also talks of increased use of natural gas for electricity generation and the "about to be privatised" UK electricity generators are talking of gas-fired systems, provided suitable contracts can be arranged. Although natural gas reserves look healthy a concerted expansion of gas-fired power generation world-wide could soon lead to shortages and increased prices.

Table 1: Comparison of man-made sources against natural sources of pollution

	Pollution by	
	Man	**God**
Acid Rain	approx 10 units	1 unit
Ozone hole CFC	infinity	1 unit
Greenhouse CO_2	0.25 units	1 unit
Buried nuclear waste		
"nuclear reactivity"	scale 1 unit	80 million units
"Risk to man"	scale 1 unit	80 billion units

**Professor of Energy Conversion, University of Newcastle upon Tyne*

Price factor

The constrained but continuing instability of the oil price was seen as universally bad, inhibiting research and development in new and, particularly, renewable energy sources. It also directly affects the price of gas and coal; fortunately nuclear power provides a stabilising influence.

Some delegates, including the Energy Minister of South Korea, Mr Sun Lee, proposed a more managed oil price emphasising that the present uncertainties are the fault of the supply side where a free market does not operate. A long-term equilibrium oil price is required and comparison can be made with the money market where stability is encouraged by exchange rate mechanisms. Any such intervention was discouraged by UK Secretary of State, John Wakeham, who nailed his colours to the mast of market forces, despite the fact that artificially induced distortions in the energy market continue to proliferate.

Renewable energy

The role that renewable energy resources can play was looked at critically and realistically. In particular, solar energy was seen as unlikely to be a major source of economic and environmentally benign energy for several decades.

Many developing countries will continue to utilise biomass, more specifically wood and biogas, to support their developing economies for a long time into the future although fuel wood is now in desperately short supply in some countries. The situation in these countries is exacerbated by rapid increases in the birth rate; this is a depressingly familiar chronic worry voiced at each World Energy Conference with no real hint of a solution.

A perhaps surprising statistic is the high percentage of electricity that is generated in sub-Saharan Africa and South America by much the most successful renewable resource, hydropower. In sub-Saharan Africa (excluding South Africa) 73 per cent of electricity is hydro; the capacity is 13,500MW with an additional potential of 110,000MW, and in South America the figure is 74 per cent. Hydroelectric dams can also be linked with irrigation systems and the huge series of 8 dams being constructed in Anatolia will generate 7600MW and irrigate 1,600,000 hectares. Extensive grid provision is vital in these countries to improve interconnections and efficiency.

Specific technologies, such as wind power, have an important role to play in particular locations but renewable energy resources are far from being environmentally benign and pressures against even hydropower are building up strongly in Norway, Sweden and elsewhere. Wind parks, tidal barrages and wave power sites all have voluble and effective opponents. These are further examples of the growing constraints that environmental protection puts on power sources and emphasise Lord Marshall's conclusion that solving institutional problems must be our primary concern.

The importance of the consumer, particularly with energy conservation in mind, and the inclusion of consumer interests and requirements was emphasised by a number of speakers. This is an important change of emphasis in a conference which has been, and still is, largely dominated by power generators. Utility suppliers of electricity were shown to be largely unfamiliar with their customers' requirements, what real cost of "outages" are, what potential for more sophisticated, interruptible tariffs there is, how choice of supplier and use of a common carrier system can increase efficiency of electricity usage. These arguments spill over into the whole area of demand side energy use management.

Lord Marshall giving his keynote lecture.

Exhibition review

The exhibition associated with the conference was entirely dominated by power suppliers, particularly in the oil, gas and electricity fields. Perhaps when the conference next meets in three years' time in Madrid exhibitors of energy management systems, an area in which the UK excels, will show their wares. By then there will have been a change of name and the World Energy Conference will have become the World Energy Council. The exhibition itself was extremely well presented with an impressive British Electricity stand; Electricité de France was also well to the fore with, amongst other things, an attractive historical exhibition dealing with the discovery of electricity. It included a description of the Danish scientist Oersted's discovery that at the make and break of a battery (Voltaic Pile) a magnet needle was deflected. This precedes by 20 years Faraday's discovery of electromagnetic induction.

Energy planning

A good deal was said about Energy Policy and Energy Planning. The conflict in policy terms between short term, local effects and long term aims was emphasised. Public opinion, operating on politicians, often alters long term strategies to meet short term needs and pressures. Energy supply planning can improve security of energy supply, particularly electricity, but only in developed countries with mature technology.

Developing countries seem as vulnerable as ever with sub-Saharan Africa particularly disadvantaged. The steady erosion of their position since 1980, the year of the Munich meeting of the WEC, has taken place as predicted. South East Asia finds itself in a similar predicament with fuel wood shortages and lack of foreign exchange to buy oil. Countries like China and India with huge and increasing populations suffer from chronic fuel shortages from time to time. China burns 1 billion tonnes of coal per year and increases its demand by 40 million tonnes per year. It will be a long time before clean coal technologies can be introduced and it will require enormous technology transfer from the West to assist in the change over.

Global pollution

Meanwhile their contribution to the greenhouse effect dwarfs that of other nations. It is in the area of global pollution that the setting of international standards and fostering of international cooperation is paramount. Transboundary pollution monitoring of CO_2, CFC's, O_3, NO_X, CH_4 is essential; more research on global effects is needed. Short term strategies, CO_2 "capping" for instance could buy time to develop long term solutions. One speaker suggested that as the nuclear industry claimed that its pollution problems were now solved, at least technically, money could be transferred to work on clean fossil fuel technologies. Nobody seriously thought that CO_2 could be absorbed and removed from efficient gases, however.

It was again emphasised that energy conservation should play a vital, but not exclusive, part in the strategy of lowering, or at least containing CO_2 emissions at their present level. This could only be done with the enthusiastic help of the public who must be involved in key decisions and this will require an enormous effort to increase public understanding of the problems.

A looming difficulty is the adverse effect that expense committed to combating pollution will have on economic growth and it will be here that careful compromise will be required. Economic growth was seen as crucially dependent on energy price and particularly oil price. The latter is forecast to rise to $48 per barrel by 2000 and to decline thereafter as more non-OPEC is developed. Oil supply could well lead to East-West stress.

Again, developing countries will be increasingly disadvantaged as banks providing finance become more cautious; Third World debt exceeds $1000 billion much of which has been rescheduled (ie, payment delayed) several times. Political risk is becoming increasingly difficult to assess and accommodate. There may well be a move to more non-interventional energy policies which reduces political interference. Too much regulation in countries such as New Zealand is now seen as counterproductive; the private sector responds more quickly to change and is more effective. A market-led economics-based energy strategy

can be distorted however, where, for example, local pressures may override siting decisions on power stations based on economics. It is here that an attempt to calculate social and environmental energy costs is seen as crucial.

Technology issues

In the technology section of the conference there was strong emphasis on increased efficiency of energy conversion: combined cycle systems fired by gas, coal or nuclear power leading to electricity generation efficiencies of over 50 per cent were stressed, the perennial call for highly efficient combined heat and power schemes may, at last, receive more support. Also enhanced oil and gas recovery and more efficient energy transport systems, leading to fewer losses of primary energy, were described. Fuel cells, although requiring more development still, are coming into their own in the range 500 kW to 1MW.

As nuclear energy is seen as a potentially cleaner technology than coal there is a great emphasis on safety and the development of new types of simplified "inherently safe" reactors in the 300-400 MW range. Nuclear installation costs currently running at $2000 to $3000/kW must be reduced.

There will be an ever-growing demand for energy in the form of electricity. Currently one third of global primary energy goes to electricity generation and this will rise to half in two decades. Various long term technologies such as piped hydrogen to replace natural gas and for transport were explored. The road transport problem with its unfortunate environmental consequence of smog was seen as partially a technological but primarily an institutional problem with a public transport system, although unattractive to many, providing the best hope for relieving future congestion.

The WEC report "Global Energy Perspectives 2000-2020" was presented to the Congress. This is an important consensus view based on two scenarios, one moderate and one more constrained. Between 1985 and 2020 world energy consumption is predicted to rise between 50 and 75 per cent compared with a growth of 125 per cent during the period 1960-1985.

Energy savings compared with trends prior to 1973 amounted to 1 Gtoe (1 Gigatonne of oil equivalent) or 14 per cent of world consumption in 1985. Savings could reach 6 to 10 Gtoe by 2020. Even by 2000 savings could reach around 3 Gtoe through demand management and would thus constitute the largest single energy "source". Compared with the 1983 study the major change is a large fall in the forecast, for market-economy industrialised countries' demand which is down by 25 per cent. On the other hand there is a spectacular rise in demand for centrally planned Asia amounting to 100 per cent.

Although world per capita consumption is expected to rise only slightly from 1.6 toe perhaps to 1.7 toe but probably less, considerable differences between "haves" and "have nots" will remain. In the South the figure will be 0.8-0.9 toe by 2020 and in the North 4.45-5.15 toe. Within the South there is particular cause for concern for countries in transition, ie, sub-Saharan Africa plus south Asia. Here average per capita consumption will rise from 0.36 toe (1985) to only 0.39-0.46 toe by 2020. Of this amount non-commercial energy sources such as fuel wood will still supply 30-45 per cent compared with 60 per cent in 1985. In other words, a situation of chronic poverty in the energy field will continue to exist in a region whose population is expected to double from 1.4 billion to 2.8 billion by 2020, one third of the world total!

Sharply differing trends are expected to affect the supply of energy. Solid fuels will rise from 2 Gtoe in 1985 to between 3 and 4 Gtoe in 2020 but growth will be most rapid after 2000 when competition from hydrocarbon reduces. Natural gas is better placed than oil to maintain its share at current levels.

Increase in hydro capacity will be slow because of scarcity of sites in the North and financial constraints in the Third World. Forecasts for new energy resources have been modified to give a more realistic picture and the 6 per cent suggested in 1983 has been reduced to between 1.5 and 3 per cent for 2020.

Nuclear power is beset by rising costs, financing difficulties and adverse public opinion and the predicted 12 per cent share for 2020 has been revised downwards to between 7 and 8 per cent compared with 4 per cent in 1985.

Renewable energy resources, predominantly hydropower and fuel wood, will only enjoy limited growth from 17.5 per cent in 1985 to no more than 18-20.5 per cent by 2020 despite hopes raised by their partisans.

The positions of oil will be maintained to a higher degree than foreseen earlier. The 1985 forecast was for an 18 per cent share by 2020 but it is now thought oil will still be meeting 26 to 28 per cent of world energy demand in 2020 (32 per cent in 1985). This will favour a gradually rising trend in the price of oil rather than the wide fluctuation experienced in the recent past.

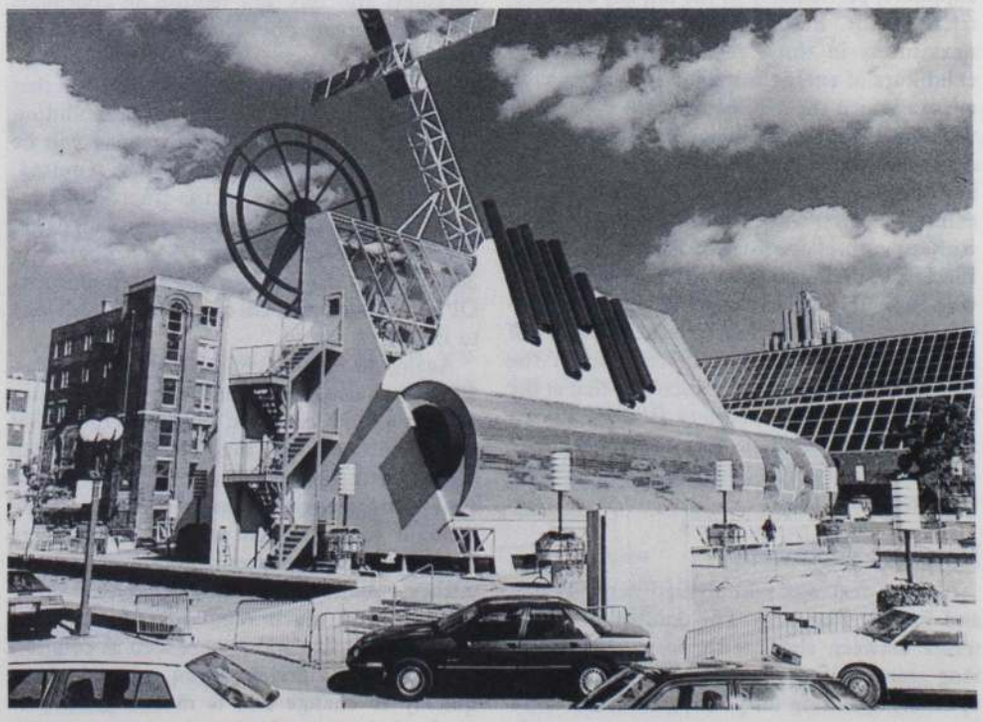
Conclusions

In a way the conclusions of the 14th World Energy Congress are optimistic. The energy resource base is not a problem in the forseeable future provided it is properly managed and exploited.

However, there are major distorting influences such as public resistance to nuclear power, uncontrolled population growth, lack of finance for energy projects in developing countries, wild variations in oil price which distort the energy market, over-optimistic perception of the input renewable energy resources (other than hydro) can make to energy supply, expectations of a "breakthrough" in new energy technologies such as fusion, over-wishful thinking that increased energy efficiency will provide a major input, tension and even wars over inequalities in oil and gas supply and, finally, the subject most discussed at the congress, the environment. Protection of the environment is expensive; not all developing countries will be able to pay the bill. Perhaps the most insidious danger is the greenhouse effect which is already upon us; restriction of carbon dioxide emission is a technologically difficult, very expensive and politically extremely hazardous problem.

To underpin the next congress, which will be held in Madrid in 1992, the WEC is instituting an ambitious new study: "Energy for Tomorrow's World — Realities — Real Options — the Agenda for Achievement".

William Daub, the Vice Chairman of WEC, in his summing-up said: "If science and technology have been the fuel of progress in the past, the political process has been the engine. Neither is useful without the other". The 14th World Energy Congress highlighted the political engine's importance in ensuring an adequate and growing energy supply whilst, at the same time, protecting the environment. □



The Canadian pavilion, Montreal.

The problem of CFC refrigerants

by Adrian Page BA, CEng, MIMechE, MInstR

The recent discovery that CFC refrigerants are responsible for damage to the ozone layer, and contribute to the greenhouse effect, has led to a general reappraisal of the use of CFCs. In the following article Adrian Page reviews the present use of CFCs, and looks at the alternatives, with particular reference to their implications for the energy sector.

IN THE UK refrigeration is widely used throughout the food chain, in air conditioning systems, and in many industrial processes. Total primary energy use of all the refrigeration systems in the UK is about 370 million GJ/year or about 4 per cent of the national energy consumption. The great majority of refrigeration systems use one of a family of refrigerants known as CFCs (see table 1).

The characteristic properties of CFCs, which include chemical and thermal stability, lack of flammability and toxicity, combined with thermodynamic properties suitable for use in refrigeration systems, appeared to make CFCs the ideal choice, not only as refrigerants, but also for aerosol propellants, foam blowing agents and solvents.

Recently, however, it has been discovered that CFCs are responsible for the depletion of the stratospheric ozone layer and for making a significant contribution to the greenhouse effect. This article reviews the present uses of the various CFCs, what effect their use is having on the environment, the alternatives available and the energy use implications of adopting the alternatives.

The use of CFCs

CFCs have a great many uses some of which are listed in table 2. R11 and R12 account for the majority of the tonnage produced and figure 1 shows the use of these in the EEC in 1986. At this time over half the total use was for aerosol propellants. This had already been drastically reduced and it is likely to become insignificant. There is a considerable amount of research already going on to identify suitable replacements for CFCs in foam blowing.

The use of the various CFCs as refrigerants in the different sectors is shown in table 3. The annual energy consumption of the refrigeration plants in the individual sectors is shown in figure 2. It is interesting to note that while the domestic sector only consumes 4 per cent of the annual refrigerant production, it accounts for 52 per cent of all refrigeration energy consumption. Conversely refrigerant use in the air conditioning sector is almost 40 per cent of the total, but the sector only accounts for 10 per cent of energy use.

In the domestic sector systems are fully sealed and hence lose no refrigerant unless the system is physically damaged. In other systems refrigerant is used both to charge new systems and to replace refrigerant in existing systems, lost through leaks or during maintenance. Replacing lost refrigerant is thought to account for 75 to 80 per cent of refrigerant use in the non-domestic sectors although the leak rate depends very much on the refrigerant used and the plant design.

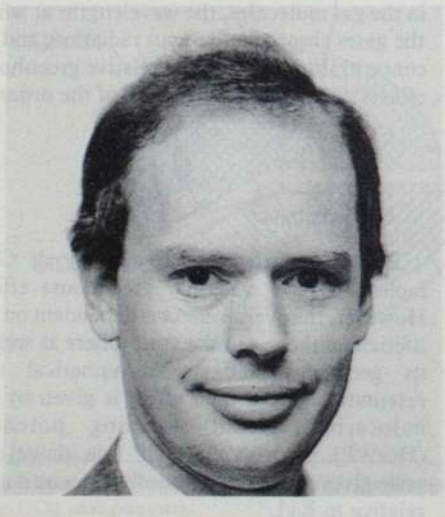
Table 1: Definitions of terms used in this article

CFC	An organic compound containing carbon, chlorine, fluorine and possibly hydrogen.
Halon	An organic compound containing carbon, bromine and possibly hydrogen, chlorine and fluorine.
Halocarbon	An organic compound containing carbon, one or more of the halogens (fluorine, chlorine or bromine) and possibly hydrogen.
R xx	There is an internationally recognised system for numbering these compounds. For example trichlorofluoromethane is R11.

The ozone layer

Ozone, a gas with a molecular structure of three atoms of oxygen, plays a critical role in the stratosphere (upper atmosphere) in protecting living organisms on the earth's surface from the harmful effect of ultraviolet radiation. It occurs naturally in the stratosphere 18 to 40 km above the earth's surface and acts as a protective shield by keeping harmful ultraviolet radiation from penetrating the lower atmosphere where it causes increases in skin cancer, cataracts and damage to vegetable crops.

It should be noted that tropospheric (ie lower atmosphere) ozone is a pollutant at lower altitudes where it causes irritation to human lungs and harms plant and animal life. At ground level it is formed largely as a result of hydrocarbons, carbon monoxide (CO) and other trace gas emissions from car exhausts.



The author

Adrian Page is currently head of refrigeration technology at the large Epsom-based consultancy WS Atkins. A Cambridge graduate, he joined the consultancy in 1981 after a period working for the Ministry of Defence. He presently heads Atkins' consultancy expertise in the specialist field of design, performance analysis and expert fault diagnosis of refrigeration plants, often large ones.

His current interests include the application of modern high-level control methods to tackle the otherwise intractable efficiency problems that arise when a cooling plant must face fluctuating loads. Other work includes promoting the concept that much improved plant performance can be obtained when process engineers (generally the end users of industrial cooling) take into account their influence on the operational efficiency of refrigeration, and work together with the refrigeration specialist to get the overall systems dynamics right.

Mr Page has recently been advising the Government's Energy Technology Support Unit on the consequences for energy policy of moving away from ozone damaging CFC refrigerants.

It is the CFCs' inherent stability that makes them particularly destructive to the upper atmosphere. Instead of disintegrating in the lower atmosphere, where ozone is unwanted, they can stay stable for decades. When they reach the stratosphere the CFCs finally break down under exposure to the sun's ultraviolet rays, releasing the chlorine radicals which then remove one of the oxygen atoms in ozone. The chlorine atoms act as a catalyst and in this way one chlorine atom can cause the breakdown of thousands of ozone molecules. The potential which each of the CFC compounds has to destroy ozone depends on the compound's atmospheric lifetime, and the type and number of halogen atoms which are released. It is characterised by their ozone depletion potential (ODP) measured relative to the ODP of CFC 11.

Table 2: Uses of CFCs

Propellants for aerosols	R11, R12, R114
Plastic foam blowing agents	R11, R12, R113, R114
Solvents for electronics industry	R113
Refrigerants	R11, R12, R22, R502

Table 3: Halocarbons used as refrigerants

Refrigerant use %	R11	R12	R22	R502	Total
Domestic		4			4
Commercial	1	18	12	17	48
Air conditioning	4.6	5	28.9		38.5
Industrial	0.5	1	7	1	9.5
Total	6.1	28	47.9	18	100.0

Ozone depletion

Concern over the problem of ozone depletion in the stratosphere led to the development in 1987 of the Montreal protocol on substances which deplete the atmosphere. The protocol controls five CFCs, as shown in table 4. (The protocol also controls the halons which are even more damaging to the ozone layer than CFCs as bromine is even more effective than chlorine at destroying ozone molecules.)

Combining data for the total use of CFC refrigerants with information on the ODPs gives the total ozone depletion potential of the refrigerants used in each sector, this is shown in figure 3.

In the protocol, the production of each of the controlled substances as measured in tonnes is weighted by their allocated ODP to give the total ODP of each group. Nations which have signed the protocol are committed to a freeze on the consumption of the CFCs products at 1986 levels by the year ending June 1990, a reduction to 80 per cent of 1986 levels by June 1994 and a reduction to 50 per cent of 1986 levels by 1999. The protocol is due for formal review shortly and it is likely to be modified to require a reduction to 90 per cent of 1986 levels by the end of the century.

The greenhouse effect

The greenhouse effect is caused by a layer of gases in the atmosphere which allow light and ultra-violet radiation from the sun to reach the earth's surface, but which prevent the escape of the resulting infra-red radiation (ie, heat). This natural process is essential to life; without it the mean temperature on earth (as a black body in space) would be about −6°C and there would be wide temperature variations such as are experienced on the moon and other planets.

The greenhouse effect has existed on earth long before life as we know it. However, in modern times, production of carbon dioxide, methane and CFCs, the most important of the greenhouse gases, has drastically increased and as a result the earth is warming up. Since the middle of the last century the mean temperature of the earth's surface has risen by about 0.8 degrees centigrade, although there are significant annual variations on this figure. If greenhouse gases continue to be emitted at the current rate some scientists predict that the global temperature will rise by 1.5 to 4.5°C by the year 2050. This increase in temperature would cause a rise in sea levels of anything up to two metres leading to flooding, crop damage and severe disruption of all life systems.

Table 4: Halocarbon ozone depletion potential (ODP)

	Substance	ODP
CFC 11	Trichlorofluoromethane	1.0
CFC 12	Dichlorodifluoromethane	1.0
CFC 113	Trichlorotrifluoroethane	0.8
CFC 114	Dichlorotetrafluoroethane	0.8
CFC 115	Chloropentafluoroethane	0.4
R 502	Azeotrope of R22 and R115	0.33
Other halocarbons not covered by the protocol		
R22	Chlorodifluoromethane	0.05
R123	Dichlorotrifluoroethane	0.5 (probably)
R134a	Tetrafluoroethane	0

Considerable differences of opinion exist as to which gases cause the observed increase in temperature, but a commonly accepted view is that shown in figure 4, with carbon dioxide contributing around 50 per cent, methane 20 per cent and CFCs and halons up to 20 per cent.

The relative effects of the different greenhouse gases are very varied. This is due to the properties of the different inter-atomic bonds in the gas molecules, the wavelengths at which the gases absorb and re-emit radiation, and the concentration effects. The relative greenhouse effects per molecule of gas are of the order of:

CO_2	1
CH_4	30
N_2O	160
CFCs/halons	17,000

To a first order approximation all CFC molecules have a similar greenhouse effect. However, the overall effect is dependent on the lifetime of the gas in the atmosphere as well as its greenhouse effect. A numerical representation of the total effect is given by the halocarbon global warming potential (HGWP). As with the ODP (see above) this scale gives a measure of the effect per unit mass relative to R11.

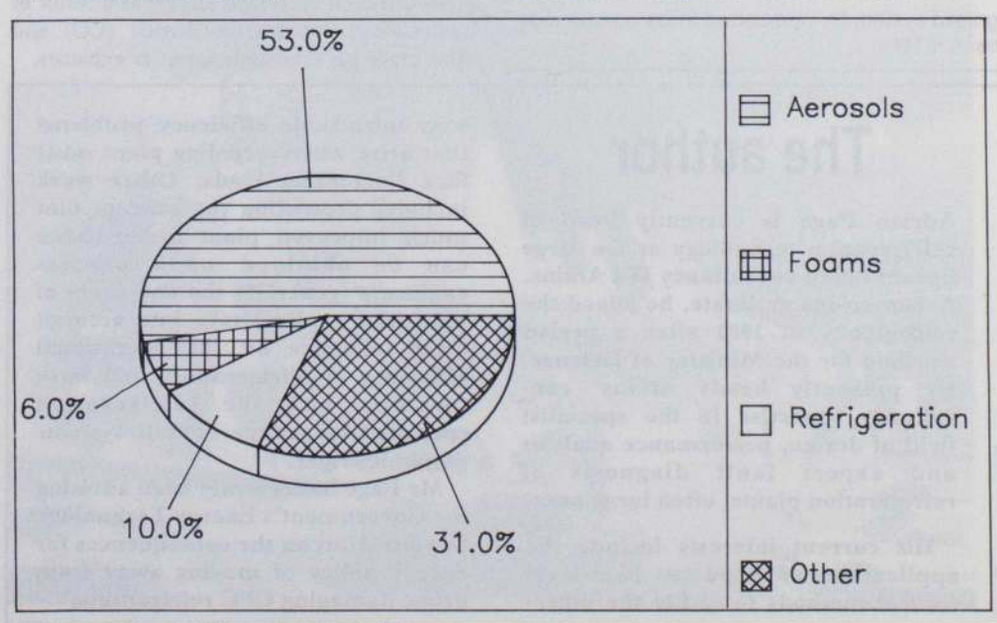


Fig. 1: R11 and R12 use in EEC 1986

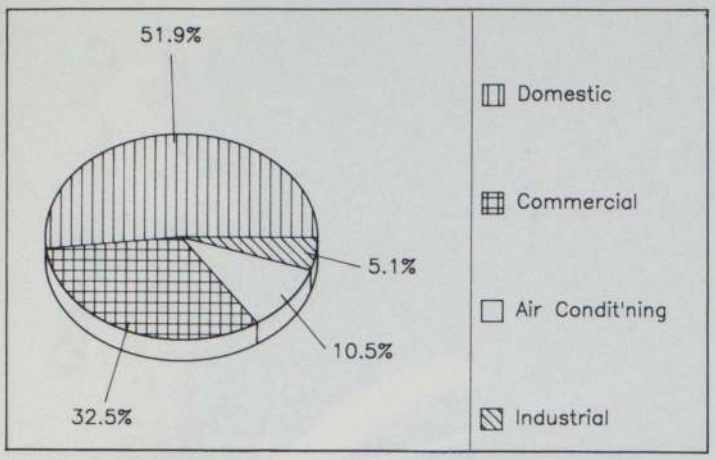


Fig. 2: annual energy consumption of refrigeration sectors. Total for 1986-87 = 117.6 million GJ

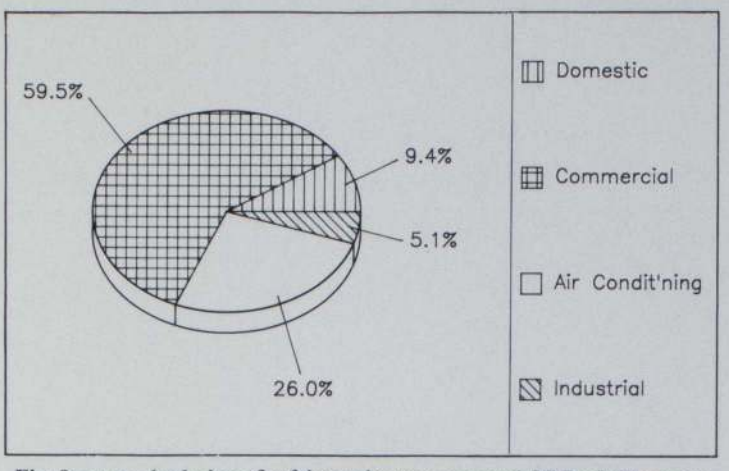


Fig. 3: ozone depletion of refrigeration sectors total ODP of all sectors = 242,703

R11	1
R22	0.29–0.47
R123	0.015–0.026
R134a	0.22–0.39

As can be seen in this table there is still considerable uncertainty about these figures, but is must be noted that 'ozone friendly' does not necessarily mean 'greenhouse friendly'.

As seen in figure 4, CFCs and halons contribute around 20 per cent of the overall greenhouse effect. They are the only greenhouse gases regulated by the Montreal protocol, which is primarily concerned with limiting damage to the ozone layer, but as a result should diminish considerably in overall importance if the agreed limits are achieved.

CFC replacement

Over the next ten years or so it will become necessary to look at ways of reducing the consumption of R11, R12 and R502 in refrigeration plant. The main alternative refrigerants which could be used in vapour compression systems are R22, R123, R134a and R717 (ammonia).

R22 is already widely used as a refrigerant and there is scope for extending its use in all sectors.

R123 has a pressure/temperature characteristic similar to that of R11, and is being promoted as a potential replacement for R11. It will not however be available for several years.

R134a has a pressure/temperature characteristic similar to that of R12 and is being actively promoted as a replacement for R12. It is undergoing toxicological tests and is due to be in bulk production by 1991 if these are satisfactory.

R717 (ammonia) is already widely used in medium and large industrial and cold storage applications. Under present safety codes it cannot be used for cooling normally occupied areas, due to its toxicity.

Energy use consequences

The overall effect of changing to less environmentally damaging refrigerants on the energy efficiency and consumption of refrigeration plant can be assessed by looking at the refrigerants and refrigeration plant currently used in the various sectors. The probable changes which would occur are summarised below.

All domestic refrigeration plant currently uses R12, and the most likely change is to R134a. This would probably be accompanied by a redesign of the compressors used. Hopefully this would improve their current poor efficiency, and would offset some of the lower operating efficiency obtained with R134a. The overall change in energy use in this sector would then be an estimated increase of 8 per cent. If R134a does not pass toxicological testing then it is likely that R22 will be used for refrigerators, and either R502 or R22 for freezers.

In the commercial sector R22 will replace R502 use and a large proportion of R12 use. Some of the smaller R12 plants will be replaced by units operating on R134a. There will be a significant increase in efficiency, mostly due to the increased use of R22, and overall energy use for refrigeration in this sector will be reduced by about 2.3 per cent.

In the air conditioning sector most new small and medium size systems already use R22. Some older plant which still operates on R12 will be replaced by more efficient R22 systems. Larger centrifugal plants using R11 will either be replaced by similar units using R123 or with screw compressors using R22. These changes are unlikely to lead to any change in energy consumption. There will therefore be an overall reduction in energy consumption in this sector of 1 per cent due to the replacement of R12 by R22.

Most industrial refrigeration plant already uses R22 or R717. The remaining plant uses either R12 or R502 and would be replaced by R22 or R717, which would result in an overall reduction in the total energy consumption of this sector of 2 per cent.

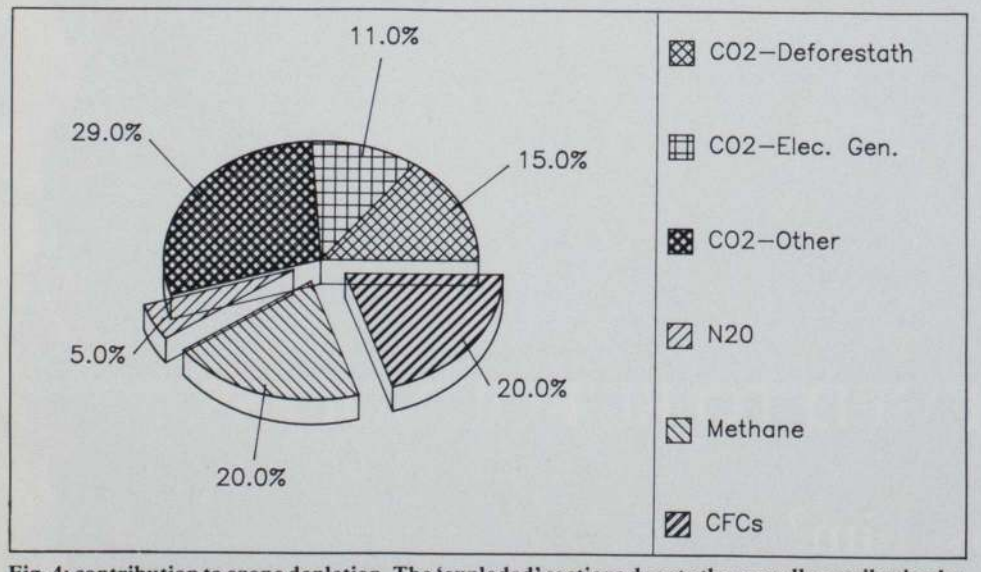


Fig. 4: contribution to ozone depletion. The 'exploded' sections denote the overall contribution by non-CO2 components.

Conclusions

It is becoming increasingly clear that the CFCs widely used as refrigerants are not as benign as has been traditionally thought. Both common sense and legislation are going to force users to change to alternative compounds.

The overall change in the energy consumption of refrigeration plant in the UK, due to a change from R11, R12 and R502 to other refrigerants, is estimated to be a 3 per cent increase in present use. This is due to an increase in energy consumption in the domestic sector and energy use in other sectors is likely to remain the same or decrease.

The benefits of good engineering practice should not be forgotten. Well over half the CFCs used as refrigerants are lost to atmosphere through leaks, and it is worth remembering that a well designed and efficient plant will require less power and hence less fossil fuel will have to be burnt in the power stations.

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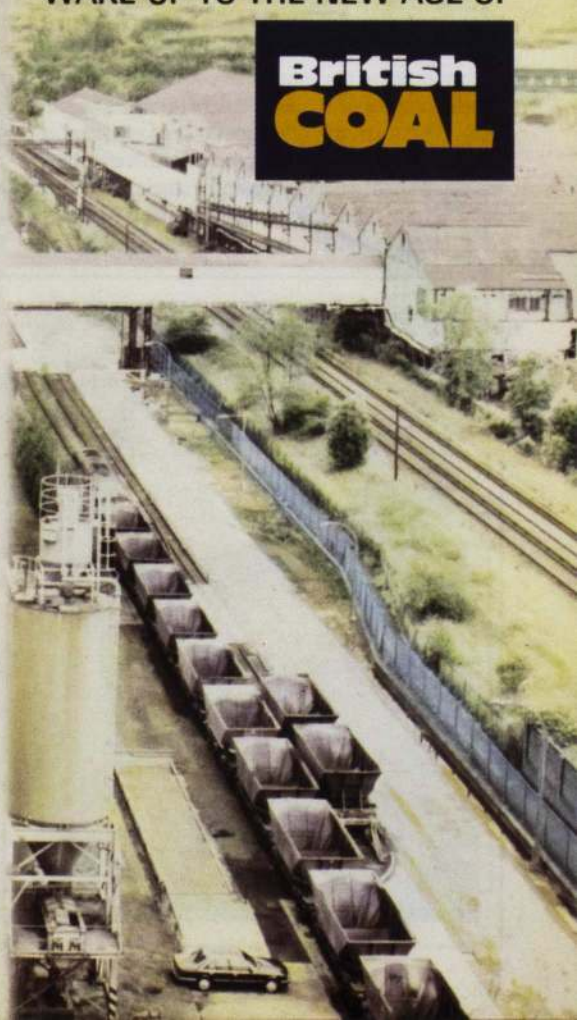


Fossil fuel combustion and the greenhouse effect

by Jeffrey Allen, PhD, BSc, CEng, MInstE

As reported elsewhere in this issue, the interaction of energy conversion and environmental effects played a prominent part in this year's World Energy Conference. Taking up this theme, Dr Jeffrey Allen, one of the Institute's Members, delivered a paper, *Advances in the combustion of fossil fuels,* which focussed attention on the different chemical reactions giving rise to what are now known as 'greenhouse gases' and the various processes which have been developed to limit emissions or mitigate their effects. The following article is based on this paper.

THE INCREASING awareness of the environmental effects of the by products from the combustion of fossil fuels has initiated significant developments in the utilisation of these fuels, particularly for electric power generation.

Nitrogen and sulphur oxides (NO_x and SO_x), the main constituents in acid rain, together with particulate matter are the major pollutants resulting from fossil fuel combustion. Recent concern has also been expressed on the increased emissions of carbon dioxide, which will result from increasing use of fossil fuels and on its contribution to the greenhouse effect.

Nitrogen oxides emissions offer the greatest challenge to the combustion engineer as these are directly related not only to fuel type but also to the actual burner design and operation of the combustion system. NO_x is produced from both the nitrogen in the fuel and in the combustion air by a complex series of incomplete chemical reactions within the flame environment.

SO_x arises from oxidation of the sulphur contained in the fuel and under normal operating conditions all the sulphur in the fuel is converted to the oxide. (In coal combustion a small fraction of the sulphur is retained in the ash). The most effective method of removal is via a specially constructed chemical plant between the furnace/boiler and stack. This can only be considered as non-cost prohibitive for very large installations. Techniques based on the injection of sulphur sorbents into the combustion system may be used in smaller units.

Particulate emissions are usually controlled by collecting outside the combustion chamber using cyclones, bag filters, electrostatic precipitators appropriate to the installations. Existing oil fired installations may not be equipped with such devices and therefore rely on burner performance to control particulate emissions, an increasingly difficult requirement as the heavier fuel oils deteriorate in quality (eg, increased viscosity and asphaltene content).

After nitrogen, carbon dioxide, should be the second largest gaseous species resulting from the normal combustion process. Carbon dioxide constitutes around 50 per cent of the total of the gases which give rise to the greenhouse effect, which if established could produce dramatic changes in world climatic conditions. Some control of carbon dioxide emissions can be achieved by increased efficiency in fossil fuel fired operations (eg, a 10–25 per cent reduction in carbon dioxide emission will be achieved by a 10 per cent increase in power generation efficiency) or by changing fossil fuel mix. Both oil and coal produce more carbon dioxide per unit of energy generated than natural gas.

Considerable effort has been applied to the combustion of fossil fuels in test rigs, pilot plants, full scale demonstration projects and commercial applications to comply with these ever increasing environmental demands. Predictive modelling techniques have been developed to further understand the processes occurring within fossil fuel fired systems. These in turn have created a demand for more sophisticated and non-intrusive sampling techniques for temperature, gas analysis, velocity and particulate trajectory measurements within the combustion systems.

Progress in emissions control has therefore been based on alterations to individual burner design, changes in burner and combustor operation and the development of fluidised bed combustion.

NO_x emission from fossil fuel fired combustors arises from two sources, the oxidation

The author

Dr Jeffrey Allen is one of Britain's leading experts in the field of combustion control and emissions suppression relating to the power generation industry. He has presented many papers at international conferences dealing with these subjects and with alternative fuels.

Dr Allen has also been a member of The Institute of Energy for almost 30 years, since December 1959. He has also served on the British Flame Research Committee for the past two years.

His career in the field began at Sheffield University where he studied chemistry and fuel technology, and chemical engineering from 1954-60. From there, he joined Pilkington Bros in St Helens, Lancs, to work on environmental aspects and fuel changeover problems in flat glass production from 1960-66.

In 1966 he moved on to join the British Steel Corporation as head of the fuel and furnace technology section, Swinden Laboratories, Rotherham, where he worked on all aspects of fuel utilisation in iron and steelmaking.

This was followed in 1972 by a move to Blue Circle Industries where he took up the position of projects manager responsible for solid fuel utilisation and minerals processing.

In 1982, Dr Allen moved to his current position as manager of special combustion projects at NEI International Combustion, Derby. Last year he undertook a lecture tour of southern India, addressing environmental issues related to the power generation industry.

of nitrogen in the combustion air and the oxidation of the nitrogen contained in the fuel. The formation of NO_X from the combustion air (thermal NO_X) is strongly temperature dependent whereas the conversion of the fuel nitrogen depends on a series of complex chemical reactions controlled by the air-fuel mixing process.

Temperature, concentration and residence time (ie, fuel and combustion air mixing) are the factors affecting the overall NO_X emission level. Burner designs for a low NO_X operation have recognised these factors by incorporating staged combustion techniques into their design. Instead of a single point injection of fuel coupled with rapid mixing of fuel and combustion air, achieved by a high swirl system, the air is split into primary, secondary and even tertiary streams within the burner register each of which can be controlled independently, as required. The fuel can be split into streams, either as double conical or lobed sprays in the case of coal and gas.

These combustion staging and rich/lean fuel effects are illustrated diagramatically in Figures 2A, B, C, which show the conventional rapid mixing burner which gives rise to high peak flame temperatures, good initial mixing of air and fuel and hence high NO_X, and the techniques adopted in the staged burner design to counteract NO_X formation, by means of lower peak flame temperatures and more gradual mixing of the fuel and combustion air.

The burner designs control the initial mixing of fuel and air producing both pyrolysis and combustion products in the near burner region of the flame. These pyrolysis products (carbon-hydrogen-nitrogen and hydrogen-nitrogen species) act as NO_X reductants, thus if present in sufficient quantity they will control the overall NO_X emission levels from the flame.

Figure 2A shows how NO_X is generated in an internally staged combustion coal burner. High NO_X levels occurring in the outer regions of the flame with a high oxygen content and temperature levels are counteracted by the reductants generated in the substoichimetric central zone of the flame.

Figure 2 (B, C, D) shows the temperature levels and the oxygen and carbon monoxide concentrations profiles associated with this same flame. These results show that NO_X emission levels from the fossil fuel flames are governed by the reactions occurring in the near burner region of the flame.

Peak flame temperatures can also be controlled by the introduction of recycled flue gas either specifically targeted into the burner system or into the overall combustion air supply. Figure 3 indicates typical NO_X reductions achieved by this technique.

Burner system operation

Over the normal range of excess oxygen encountered in combustion systems, there is a linear increase in NO_X with increase excess air or oxygen level. This factor has been utilised in the modifications of the operation of burner systems using an overfire air (OFA) technique. In this system the air to individual burners is deliberately reduced to around the stoichiometric level, the remainder of the air is introduced into the combustion chamber through separate ports located above the main burner system. Typical NO_X reduction using the OFA technique are shown in Figure 4.

A variation of this system has been used in multi-burner fired furnaces by operating a burners out of service (BOOS) technique. In this system a number of burners are deliberately taken out of service thus requiring a fuel increase to the burners remaining in service. Air can be introduced via non-firing burners to maintain the required overall stoichiometry.

In this context, the near burner flame stoichiometry can be referred to a fuel equivalence ratio which is defined as the ratio of the stoichiometric air requirement to the actual air level in this critical zone. Some work has shown that there may be an optimum fuel equivalence ratio for minimum NO_X formations which will vary with fuel type and burner operation.

An extension of the OFA technique uses fuel injection above the main burner zone to create a NO_X reducing region before completion of combustion by the introduction of further air above this reduction zone. This re-burn technique is illustrated in Figure 5. Increasing or staggering the separation of the OFA ports from the main burner system, without the fuel injection, has also been used as an effective NO_X reduction technique. Factors, affecting the NO_X reduction level with this technique include the residence time between the main burner system and separated OFA or re-burn zone, and the temperature and stoichiometry in the re-burn zone.

In power generation boilers there are two

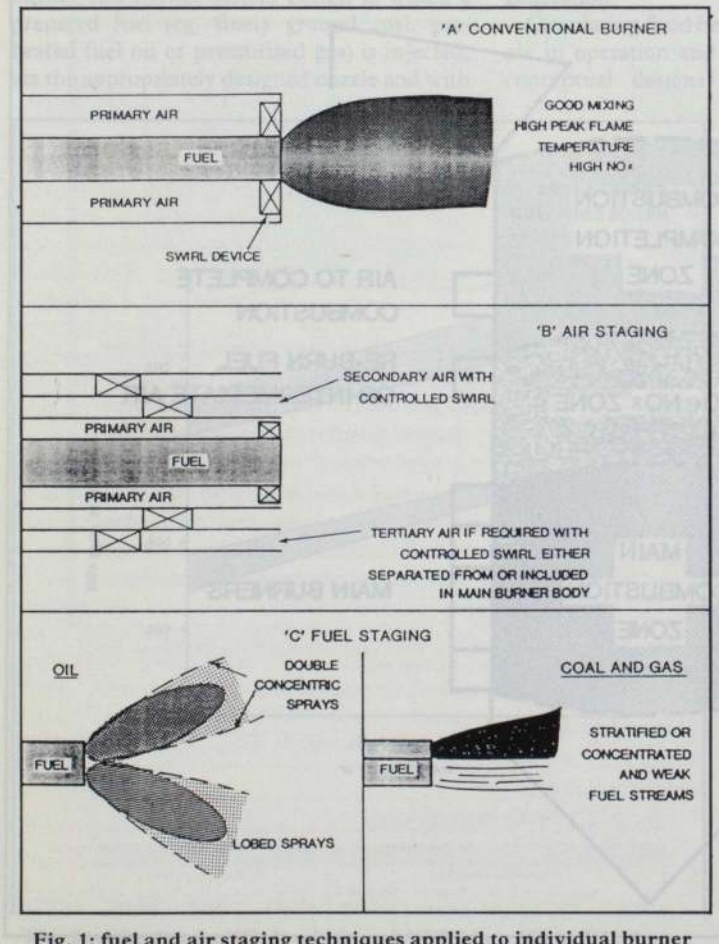


Fig. 1: fuel and air staging techniques applied to individual burner designs.

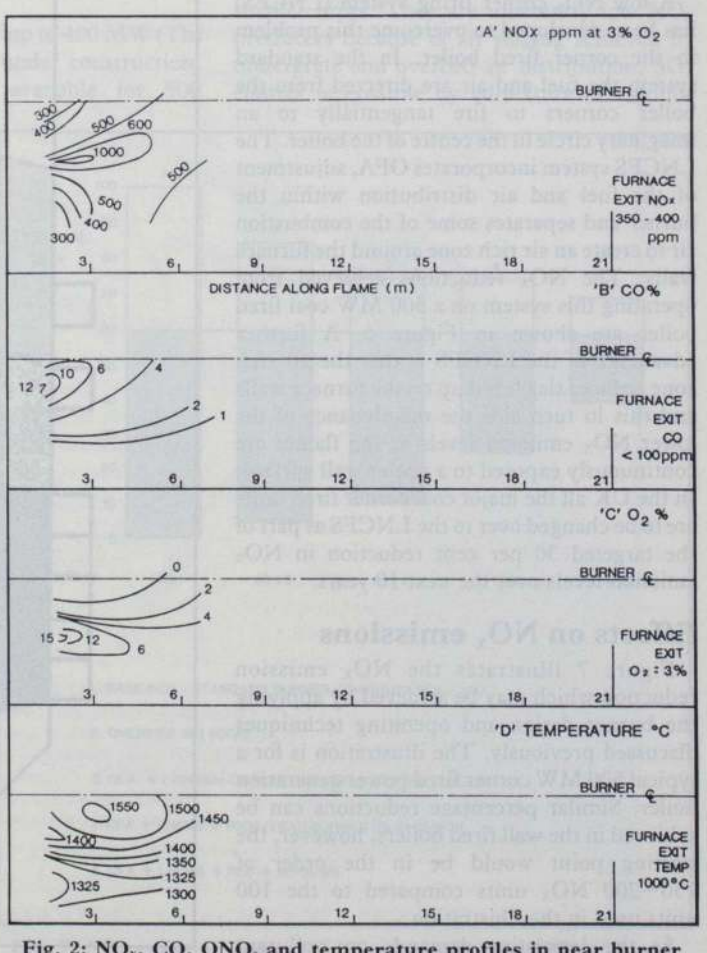


Fig. 2: NO_X, CO, ONO_2 and temperature profiles in near burner region of low NO_X coal flame.

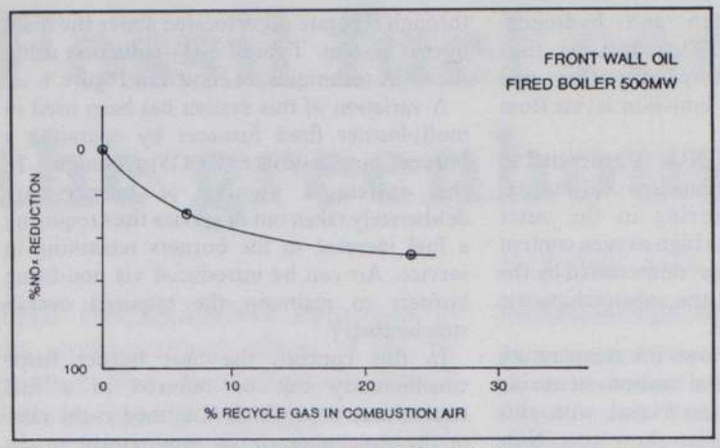


Fig. 3: effect of recycled flue gas on NO_x emissions.

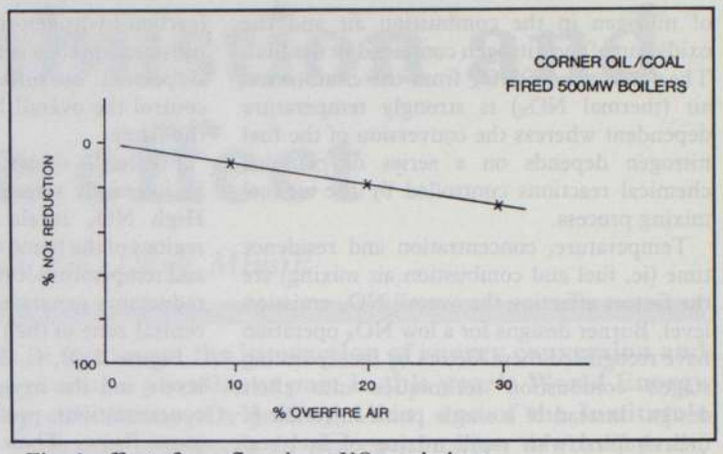


Fig. 4: effect of overfire air on NO_x emissions.

main methods of firing, known as wall and corner or tangential firing. In the former the burners are mounted in rows along one or opposite boiler walls in the latter the burners are contained in columns located at the corners of the boiler. A survey of boilers, carried out by EPRI, in the USA, shows that the corner firing system is an inherently lower NO_x producer than the wall fired system and the tendency for NO_x production increases with boiler size.

All the NO_x reduction techniques discussed previously are applicable to both types of firing system. However, care must be taken to avoid excess carbon monoxide levels adjacent to the boiler tube walls. In practice air rich wing burners, wall air curtains and staged air swirl control have been used in wall fired systems in an attempt to minimise possible CO corrosion effects.

A low NO_x corner firing system (LNCFS) has been developed to overcome this problem in the corner fired boiler. In the standard system the fuel and air are directed from the boiler corners to fire tangentially to an imaginary circle in the centre of the boiler. The LNCFS system incorporates OFA, adjustment of the fuel and air distribution within the burner and separates some of the combustion air to create an air rich zone around the furnace walls. The NO_x reductions achieved from operating this system on a 500 MW coal fired boiler are shown in Figure 6. A further advantage of the LNCFS is that the air rich zone reduces slag build up on the furnace walls and this in turn aids the maintenance of the lower NO_x emission levels as the flames are continuously exposed to a cooler wall surface. In the UK all the major coal corner fired units are to be changed over to the LNCFS as part of the targeted 30 per cent reduction in NO_x emission levels over the next 10 years.

Effects on NO_x emissions

Figure 7 illustrates the NO_x emission reduction which may be achieved by applying the burner design and operating techniques discussed previously. The illustration is for a typical 500 MW corner fired power generation boiler. Similar percentage reductions can be achieved in the wall fired boilers, however, the starting point would be in the order of 150–200 NO_x units compared to the 100 units used in the illustration.

As the legislative demands on pollutant emissions increase it is doubtful that NO_x emission requirements will ultimately be achieved by combustion modification alone. A detailed discussion of other techniques of NO_x reduction is beyond the scope of this paper but in-furnace injection techniques of ammonia or urea based chemicals can suppress NO_x emission levels. Ex-furnace techniques known as selective catalytic reduction (SCR) have also been shown to be effective in the control of NO_x emissions. Both these techniques which operate at maximum effect within a specified temperature regime, involve further capital and operating costs to the boiler user which will of course be minimised if the boiler is equipped with a combustion modified low NO_x system.

Sulphur control

Sulphur oxide (SO_x) emission from combustion systems is more easily quantifiable than the NO_x emissions. SO_x arises from one source ie, the sulphur contained in the fuel and is converted to the oxides by a series of well defined reactions with the oxygen contained in the combustion air. In coal combustion up to 10 per cent of the sulphur in the coal may be retained in the ash.

Low excess air combustion requiring careful

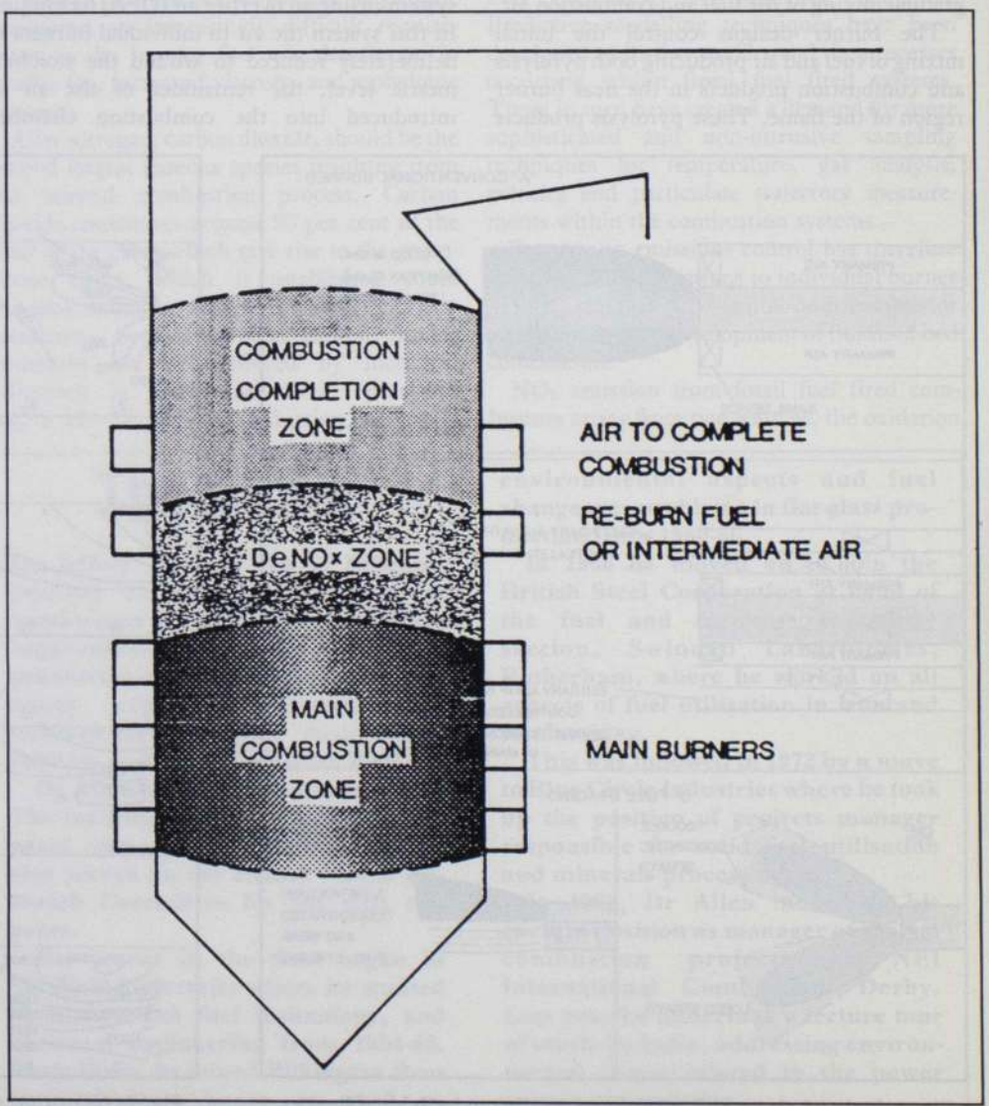


Fig. 5: the re-burn NO_x reduction technique.

attention to fuel and air mixing has, in the case of fuel oil combustion, been effective in minimising the SO_3 content of the SO_x which can cause sever corrosion problems in the cooler zones of a furnace system.

SO_x is removed from the combustion gases in large units by means of ex-furnace flue gas desulphurisation techniques (FGD). These techniques can remove at least 90 per cent of SO_x from the waste gases and be adopted to produce useable by-products in the form of gypsum, sulphuric acid or elemental sulphur.

Desulphurisation chemicals, or sulphur sorbents, commonly used include limestone, dolomite and calcium or magnesium hydroxides. On smaller units they can be injected directly into the furnace or admixed with the fuel itself to achieve a measure of SO_x reduction. These techniques are not as effective as the ex-furnace FGD methods, probably achieving at best 60 per cent sulphur capture compared to the minimum 90 per cent capture available from FGD.

The main problems within furnace injection techniques are the production of reactive lime (CaO) from the injectant used, either $CaCO_3$ or $Ca(OH)_2$ (this occurs over a relatively small temperature range 850°C–1050°C) and the decomposition of $CaSO_4$ to release SO_2 above 1200°C. On this basis the point of injection has to be selected very carefully and admixture of sorbent with the fuel has consequently, a limited effectiveness.

Dynamic and static bed combustors

The previous discussion was related to burner and burner system design in which a prepared fuel (eg, finely ground coal, pre-heated fuel oil or pressurised gas) is injected, via the appropriately designed nozzle and with controlled admixture of combustion air, into the combustion chamber.

In the dynamic or fluidised bed combustor fuel is burned in a hot bed of refractory particles kept in a dynamic or bubbling state by means of air injection at the base of the combustor. Static bed devices cover the various forms of stoker used for the combustion of lump coal.

Considerable work has been carried out in the development of the fluidised bed combustor particularly as a means of coal combustion. Two techniques have evolved namely the bubbling bed and the circulating fluid bed combustor (CFBC). Operation under pressure has also been carried out (PFBC) in order to minimise overall plant size and improve efficiency.

The nature of the operation of these combustors eg, low temperature, around 850°C, staged combustion by the use of controlled under and over bed air, ease of addition of sulphur sorbent and subsequent intimate admixing with fuel, provide the ideal conditions for NO_x and SO_x emission control.

The use of fluidised bed combustors in combined cycle (steam and gas turbine) power systems has indicated overall cycle efficiencies well over 40 per cent compared to the maximum of around 39 per cent from a conventional burner fired power generation boiler. A typical combined cycle based on a fluidised bed combustor is illustrated in Figure 10.

Despite these inherent advantages the fluidised bed combustor has not yet been widely adopted for large scale power generation.

Circulating fluid beds of up to 400 MW (Th) are in operation and are under construction, conceptual designs are available for 500 MW(e) units. Pressurised fluid bed systems up to 130 MW are undergoing commercial installation.

The operation of these units with respect to high temperature cyclone equipment (particularly with the CFBC), in bed tube erosion and peformance of the gas turbine in association with the PFBC installations will determine the rate of introduction of these systems for power generation, assuming the problems of large scale operation (300 MWe and above) can be overcome.

Greater efficiencies may be obtained from fluidised bed power generation systems by using what is described as a topping cycle, which can combine fluidised bed gasification with a FBC system. Part of the coal and char from the gasifier is burned in a PFBC the rest of the coal is converted to a low CV gas in a fluid bed gasifier. PFBC gases and this low CV gas then produces a high temperature gas (ca.1300°C) for expansion through a gas turbine system, heat for a conventional steam cycle arising from the gas turbine exhaust and also the PFBC.

The significance of these increased cycle efficiencies, as well as minimising NO_x and SO_x pollutants for power generation, may also be a control on the carbon dioxide emitted and its subsequent influence on the greenhouse effect.

In contrast to the fluidised bed, static bed devices or stokers have received little development over recent years probably because of their size limitation and limited tolerance to range of coal properties. However, the 1970's oil crisis revived interest in the stoker firing of smaller units. They are inherently low NO_x producers because of air staging achieved by undergrate and overbed air distribution. SO_x control is possible by admixture of sulphur

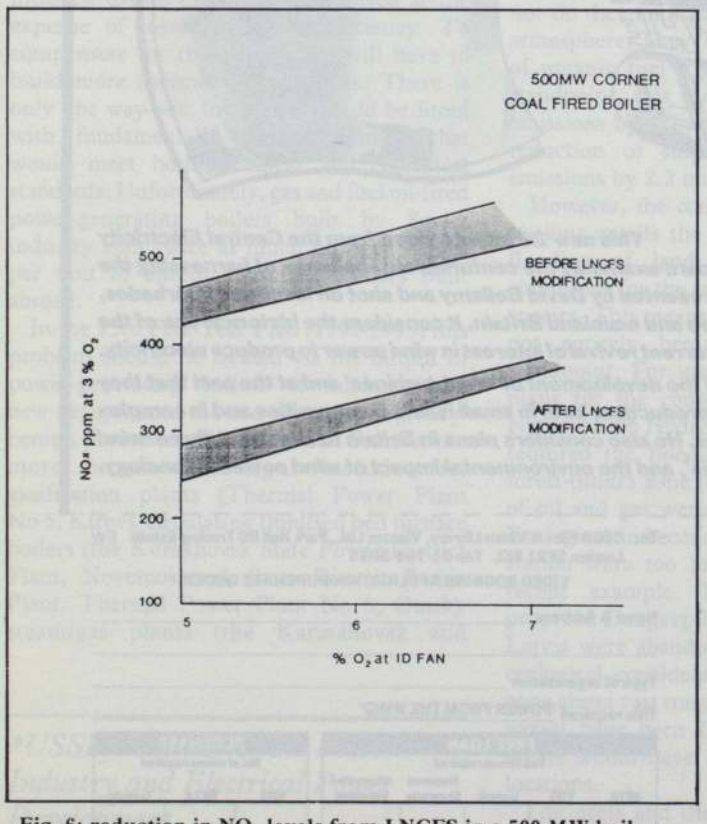


Fig. 6: reduction in NO_x levels from LNCFS in a 500 MW boiler.

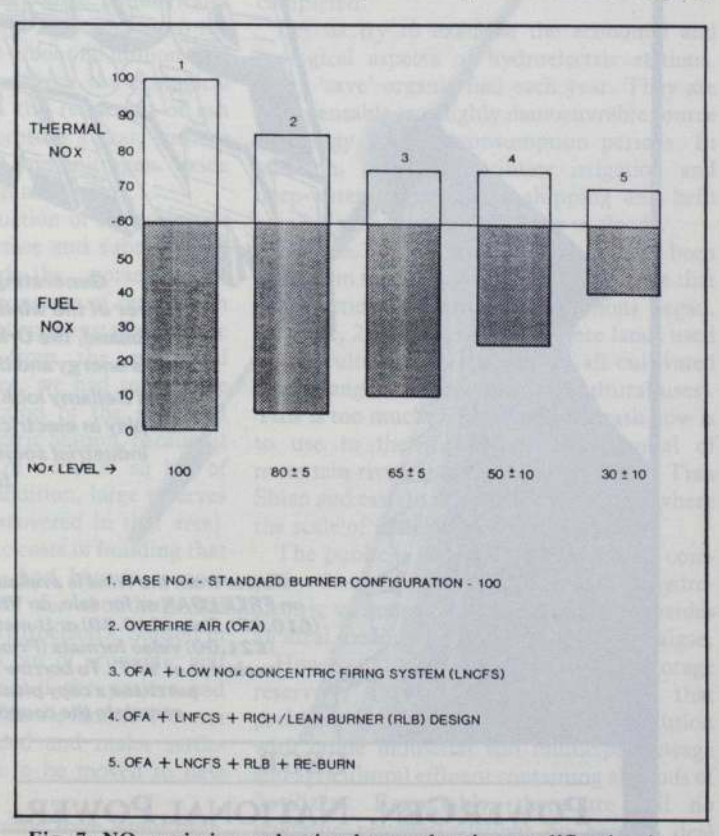


Fig. 7: NO_x emission reduction by combustion modification in a 500 MW corner coal fired boiler.

sorbent with the coal feed to hopper fed grates or by sorbent injection with spreader stoker fired grates. Bed temperatures can be higher than those achieved in the fluid bed, thus for sulphur capture some attention will be required to bed temperature control, ie, by improved under-bed air/secondary air ratio control and bed temperature control by means of recycled flue gas, which will also of course minimise NO_x emissions.

Performance prediction

Mathematical models are becoming more extensively used in the attempt to predict velocity, turbulence, temperature, heat transfer and pollutant formation in fossil fuel fired combustors. Gas fired combustion performance can be predicted with a reasonable precision, acceptable for most design requirements, oil and coal fired systems present much greater difficulty. Simulations of the atomising process and of the formation and decay of soot and cenospheres complicate the oil firing situation while coal combustion requires simulation of the rate of volatile release and burning, char particle burn out and the effect of char and ash particles on the radiation characteristics of the flame.

With all fuels, a better understanding of the process in the near burner region of the flames is required to predict burner stability and the formation and fixation of pollutant species. In order to prepare and improve the predictions and achieve acceptance of these mathematical modelling techniques, validation measurements in pilot plant and industrial combustors are required. Some data are available from small scale carefully controlled experimental units operated by research organisations and the universities but very few, if any, reliable data are available from the larger scale industrial units.

Data from the experimental units are collected basically by intrusive sampling in the combustion system by means of water cooled probes. These techniques may be acceptable in the outer boundaries of the combustor eg, in the flame tails and flow regime between the flame and furnace walls. However, data from intrusive sampling in the near burner region of the flame, to provide information on pollutant information, temperature and burner stability can be misleading.

Because of this requirement for the collection of performance data from combustion systems, without disturbing the critical areas in the system, non-intrusive sampling techniques based on laser technology are being developed. These include laser doppler anemometry and laser sheet illumination to define particle velocities and trajectory. Techniques known as CARS (Coherent Anti-Stokes Raman Spectroscopy) and PAMS (Pico-second Absorption Modulated Spectroscopy) are being developed for temperature measurement and chemical species analysis.

Sonic pyrometry is also being investigated as a means of non intrusive temperature measurement in combustion systems.

Conclusions

Recent advances in the combustion of fossil fuels have been based on the requirement for minimising the emissions of potential gaseous and particulate pollutants.

Many burner design and burner fired combustor operation concepts have been developed to minimise NO_x production all requiring a detailed knowledge of system aerodynamics.

In-furnace injection techniques for SO_x suppression require a detailed knowledge of temperature gradients within the system as do injection techniques for further in-furnace NO_x suppression.

Fluidised bed combustors with in built NO_x and SO_x suppression have been developed up to the small-medium commercial scale. These combustors offer the route to increased efficiency of power generation, when used in combined cycle operations.

In order to understand fully the complexities of the environmental-friendly combustion systems in operation, non-intrusive sampling and analytical procedures are being developed. This understanding will produce more effective predictive methods as an aid to combustion system design. □

The Soviet power industry and ecological concerns

*by Yuri Semenov**

Following the Chernobyl disaster, the Soviet Union has had to reappraise the role of its nuclear power capacity within the energy industries. In the following article, Yuri Semenov, the Soviet Minister responsible for the power industry outlines the various options for the future of electricity generation in the Soviet Union with special reference to their ecological implications.

WE KNOW from experience that the power, chemical and some other modern industries cannot be 100 per cent ecologically safe. All of them to a greater or lesser extent produce an adverse impact on the environment. However, the economy cannot develop without electric power. This is why there cannot be a clear-cut choice of the power industry or ecology. However, that does not mean that we should not try to minimise the negative effects of man's activity on nature.

Unfortunately, as of now, the thermal power industry (its output is 235.2 million kW) is one of the main contributors to environmental pollution. In 1988 it accounted for about 25 per cent of the aggregate amount of ash, sulphur and nitrogen oxide emissions in the USSR.

The ministry is of course taking measures to reduce the influence of thermal power plants on man and nature. For instance, it has ordered the modernisation of ash collectors. Special technological means are used to suppress nitrogen oxides in boilers. Natural gas is being increasingly used as fuel for power plants. Four new pilot plants for sulphur neutralisation have been built. As a result, the emission of harmful substances into the atmosphere has gone down by 2.8 million tons in the past seven years.

In view of the fact that in the coming decades thermal power plants will still be playing the leading role in electric power generation, their modernisation cannot resolve the problem. For instance, a 20-30 per cent suppression of nitrogen oxides in boilers is achieved at the expense of losses in boiler efficiency. To compensate for these losses we will have to build more thermal power plants. There is only one way out: the plants should be fitted with fundamentally new equipment that would meet both technical and ecological standards. Unfortunately, gas and fuel oil-fired power-generating boilers built by Soviet industry emit twice as much nitrogen oxides per unit of output as similar boilers built abroad.

In the 13th Five-Year Plan (1991-1995) this problem should be tackled via the output of power-generating boilers of fundamentally new designs, and the use of new ecologically-benign processes of burning fuel. Some of the more promising designs include coal gasification plants (Thermal Power Plant No 5, Kirov), circulating fluidised bed furnace boilers (the Kurakhovsk State Power District Plant, Novomoskovsk State District Power Plant, Thermal Power Plant No 6, Omsk), steam/gas plants (the Karmanovsk and Nizhnevartovsk State District Power Plants, Thermal Power Plant No 5, Kirov, etc).

Hydroelectric stations

Hydroelectric stations (the current total output of which is 62.7 million kW) can also cause serious ecological problems. Hydroelectric stations do not, of course, pollute water nor do they emit harmful substances into the atmosphere. They 'save' about 80 million tons of organic fuel a year. From the ecological standpoint, this means the reduction of ash emissions by 1.2 million tons a year, and the reduction of sulphur and nitrogen oxide emissions by 2.2 million tons a year.

However, the construction of hydroelectric stations entails the surface and subterranean flooding of land and the worsening of conditions for the reproduction of certain fish species. This means that such installations are not entirely benign from the ecological standpoint. For instance, we had to give up plans for the construction of the proposed Nizhnaya Ob Hydroelectric Station, because it required the flooding of 135,000 sq km of forest-tundra zone (in addition, large reserves of oil and gas were discovered in that area). Ecological and economic costs of building that station were too high. And here is a more recent example. Plans for building the proposed Daugavpils Hydroelectric Station in Latvia were abandoned out of economic and ecological considerations: if the project had gone ahead vast tracts of fertile land and forests would have been flooded and major settlements would have had to be moved to new locations.

The press and the public have lately been hotly debating plans for building the Turukhansk, Katun and other hydroelectric stations. Plans for the Turukhansk station have already been scrapped for reasons of environmental protection. The construction of the proposed Katun hydroelectric station will not begin before a thorough ecological study of the project and its public discussion have been completed.

Let us try to examine the economic and ecological aspects of hydroelectric stations. They 'save' organic fuel each year. They are indispensable as a highly manoeuvrable source of energy at peak consumption periods. In addition, they can facilitate irrigation and deep-water large-tonnage shipping and help combat such natural calamities as floods.

In all, 6.2 million hectares of land have been flooded in the Soviet Union since the time that construction of hydroelectric stations began. Of these, 2.5 million hectares were lands used in agriculture (five per cent of all cultivated land changed to other than agricultural uses). This is too much. This is why the task now is to use to the maximum the potential of mountain rivers in the Caucasus, Pamir, Tian Shian and eastern regions of the country where the scale of flooding will not be so large.

The public is absolutely right when it complains that water in storage reservoirs of hydroelectric stations is polluted, and this provides an ideal medium for the development of algae.

However, it should be noted that storage reservoirs themselves do not create that problem. It is rather the result of pollution with crude industrial and municipal sewage and agricultural effluent containing all kinds of fertilizers. Regrettably, there are still no scientific recommendations on how to deal with the pollution of water storage reservoirs.

**USSR Minister of the Power Industry and Electrical Power Development*

As for the damage caused by dams to the fisheries industry, much is being done in this field. For instance, hydroelectric stations pay for the establishment of fish breeding enterprises, and the construction of fish passages and other protective facilities.

Following the Chernobyl accident in April 1986, the pace of development of the nuclear power industry (its current output is 33.6 million kW) has slowed down. This is quite understandable: nuclear power safety standards have become more rigorous and experts are now more exacting in the choice of sites for proposed nuclear power facilities. The hostile attitude of the public to nuclear plants has also played its role.

With due regard to the causes and consequences of the Chernobyl accident, the authorities concerned carried through a series of technical and organisational measures that raised the safety of nuclear power plants impressively. For instance, additional neutron absorbers have been installed in RBMK channel-type uranium-graphite reactors (of the type used at Chernobyl), and the speed of operation of emergency systems has been increased.

The human factor was also taken into consideration. A number of additional safety devices have been introduced to limit the interference of personnel in the operation of reactors. In addition, Soviet nuclear power plant staff have undergone re-training, with special emphasis on action in emergency situations.

Analysing the balance of fuel resources in the long term, we arrived at the conclusion that the country cannot do without nuclear power plants.

Alongside efforts to enhance the safety of operating plants, it is planned to build new nuclear power facilities of new designs that will enhance their dependability and safety.

The attitude to nuclear power in the country is far from uniform. Numerous studies and estimates made by Soviet experts lead one to the conclusion that the development of the nuclear power industry is the most radical way to solve many energy and ecological problems in the European part of the USSR. Not all agree with that conclusion. According to one school of thought, energy and ecological problems can be tackled via scaled up energy and resources-conservation efforts, and the use of alternative sources of energy. Nonetheless, the reality is such that there is no alternative to the development of the nuclear power industry.

Let me explain what I mean. Organic fuel is becoming more and more difficult to obtain, because it is located in areas with complicated geological conditions. The reserves of such fuel, primarily oil, are dwindling. Of course, coal reserves in the eastern part of the country are impressive. However, for the time being there are no ecologically and economically acceptable solutions for burning such coal on a large scale. Besides, the combustion of organic fuel by power plants leads to massive emissions of carbon dioxide which promote the greenhouse effect, which poses a threat to all humankind.

The development of nuclear power can check and limit the use of organic fuel, thus promoting the cause of environmental protection. As for nuclear power plants, their impact on the environment is negligible, if the rules of operation are strictly observed.

It seems that the future of the power industry in the Soviet Union is certain to be based upon a combination of nuclear, thermal and hydroelectric facilities. In the European part of the country where fuel and natural energy resources are relatively modest, preference is to be given to nuclear power plants. There are different estimates as to the possible scale and pace of the development of capacities in the nuclear power industry, but it is clear that the figure will be lower than planned.

In the eastern part of the USSR, with its vast coal reserves and high power-generating potential of rivers, reliance will be on the construction of hydroelectric stations and thermal power plants.

Ecologically benign renewable sources of energy (solar, wind, geothermal, etc) look quite attractive, but you cannot use them to solve global energy problems. Their importance will be limited to the local level and they will serve only as an addition to the traditional power industry and as means of saving fuel. □

Energy labelling

Dear Sir,

The President, Professor Brian Brinkworth, in presenting a Viewpoint on energy labelling, *Energy World*, August 1989, questions what he might learn from the public's reaction (or lack of it) to the sensible use of energy. Is it a market forces argument or some bending of the minds under large scale advertising campaigns by the product makers?

The recent massive expenditure on media advertising by the two new electricity companies, National Power and Power Gen, has served negligible purposes, save to enhance the turn-over of the advertising companies themselves. Furthermore, it could be debated on what authorisation such a campaign should have been sanctioned. These companies have not yet been 'floated' on to the market and thus remain responsible to the Secretary of State for Energy. This type of advertising does a disservice to the energy industry as a whole.

Energy labelling has on most domestic appliances long been common place, well before the Energy Conservation Act of 1981, which the President mentions. Expenditure on this is well justified as against that mentioned above.

What is lacking is the public's appreciation and understanding of energy consumption of the domestic appliances they own. Most appliances today give notice of their electricity or gas consumption and from householder's meters it is a simple arithmetrical calculation to find the answer to the amount of energy consumed. Why can this not be done, despite assistance from some domestic appliance retailers? The answer must lie with poor educational standards.

What is an essential requirement is the adoption of improved education schemes to give energy understanding and knowledge to all persons. More efforts are needed in schools from an early age to achieve a clearer understanding of energy use. It is too late for the present adult population I fear, but tomorrow's householders need energy education today. For adults, another Energy Efficiency Year, like that of 1986 may help.

I am sure projects such as CREATE, if properly administered and funded will do most to assist us in the future. I have no doubt than even a small percentage of the mammoth amount of money spent by the new electricity companies in advertising, could have been far better utilised in supporting the aims of projects like CREATE.

F John L Bindon *(Member)*
Bangor, Gwynedd

Are you an 'ACE' engineer?

Dear Sir,

Much has been said by Chartered Engineers concerning their status as perceived by society. They state that it does not compare favourably with that of those in the legal and medical professions.

It seems that one major difference between engineering and these more esteemed professions is that they are subject to statutory control while engineering is not. It is illegal to practice as a doctor unless one is properly qualified and registered, whereas anyone can practice as an engineer whether qualified or not.

We have all heard of disasters which have occurred when people who are unqualified have made unsound engineering decisions in safety critical areas. If these decisions were required by law to be approved by registered Chartered Engineers then it is likely that many of the risks would have been foreseen and avoided. It is probable that society would favour such legislation especially where public safety is concerned. This is the type of change which would enhance and protect the reputation of the Chartered Engineer.

Some Chartered Engineers feel that The Engineering Council will look after their interests and its policies may, in time, raise the status of the engineering profession. There is no doubt also, that the Engineering Institutions do much to promote the reputation of the Chartered Engineer. However, not many advertisements for senior engineering staff currently stipulate membership of a chartered institution as a requirement even when safety is involved.

While the Chartered Engineer is hampered by being referred to as an engineer, it is unlikely that the improved status which is being sought will be attained. We are informed frequently by the media that the engineers are again considering strike action. The general public does not at present appear to differentiate between the engineer who is threatening to strike and the Chartered Engineer who is not. If however, both the title and the licence to practice as a Chartered Engineer were protected then visibility would increase and society is more likely to be able to discriminate between the different types of engineer.

Changes of this nature are unlikely to happen by chance and if Chartered Engineers feel that existing organisations are not doing sufficient to bring about these changes then they could seek to alter the policy of these organisations. Otherwise they must accept that the changes can only occur in the fullness of time.

Some Chartered Engineers are concerned about the implications of 1992 when they will be in direct competition with many engineers who are multilingual, have received longer periods of higher education and have statutory registration. Will obtaining the title EurIng really improve the position of the British Chartered Engineer in relation to his/her continental counterpart?

If current attempts to improve status fail then perhaps an alternative approach should be tried. Chartered Engineers from the various Institutions could get together and take the initiative by joining an association which would be under their direct control. The Association of Chartered Engineers (ACE) would not attempt to displace The Engineering Council or the learned Institutions but would do for Chartered Engineers what the British Medical Association has done for doctors.

The opinions expressed in this article are my own and do not necessarily represent those of any organisation with which I am associated, however, they do appear to be in sympathy with the feelings of many other individuals.

I would be pleased to receive the views of Chartered Engineers on this matter. Do they believe that the existing arrangements will meet their needs or would they like to try the "ACE" approach?

P Howser *CEng*
Reigate, Surrey

A 'sunrise' industry

'Applications of Photovoltaics'
Edited by R Hill

Prof Hill leads the Newcastle Photovoltaics Applications Centre at the Newcastle upon Tyne Polytechnic and his group have achieved international recognition for their work in the past decade. In this concise text, he has asked a few leading experts in the field to join his colleagues, Drs Pearsall and O'Keefe, in presenting an overview of the whole range of terrestrial photovoltaic applications. In his preface, Prof Hill points out that the photovoltaics industry is growing rapidly throughout the world. The early markets for cathodic protection and telecommunications are still growing and newer applications in the developing countries have passed beyond the development stage into an acceptance of these systems as a reliable engineering solution to specific problems.

There are five chapters in the book; each is self-contained and is written for those with no specialist knowledge. Indeed, Prof Hill makes the point that the book ". . . treats the solar cells as black rectangles which convert light into electricity and concentrates on the ways in which this electrical power can serve human needs". The first chapter, by Dr Michael Starr, covers the background and history of terrestrial applications of photovoltaics. He uses the accepted classification of the market into three categories. The first is the consumer market for small electronic devices such as calculators, battery chargers or garden lights. The second is the professional systems market. In addition to cathodic protection and telecommunications systems, this includes remote sensing, navigation lights and various military applications. The third is broadly classified as the "social benefit" market. This would include electricity provision for remote houses and villages as well as water supplies or emergency telephones. For the long term he identifies a fourth category for grid-connected systems providing electrical power to buildings of all types or serving as central generators. Starr includes sections on market prospects and developments.

In the second chapter, Phil O'Keefe outlines a conceptual planning framework in which the role of photovoltaics can be discussed. This is an important contribution as it places the detailed applications chapters in their national context. The third chapter covers various applications in the developing countries. Here Bernard McNelis of IT Power draws upon experience with a number of well-documented applications, including the World Bank solar-powered pumping project, and points out that for vaccine refrigeration and telecommunications these systems are already cost-effective for off-grid locations. Alan Dichler of Solapak describes photovoltaic systems for professional applications in the fourth chapter. These include portable crop sprayers and street lighting systems, and some hybrid systems such as the diesel — PV or wind — PV combinations are also examined. In the final chapter, Prof Hill and Dr Pearsall concentrate on the low-power applications with particular reference to the consumer product and leisure industries. This is the largest sector by value in the market and has helped to fund amorphous silicon research activities.

This is a first-class guide for the non-specialist energy professional who needs to be aware of the tremendous potential and achievements of this rapidly developing "sunrise" industry. It should also appeal to all those involved in the political, social and economic aspects of energy policy, both nationally and internationally.

Dr Cleland McVeigh

Published by Adam Hilger, Bristol, England, 1989
150 pp. £17.50

Recently published

'The Story of Coal'
by D Chandra

Available from: Dr D Chandra, Dept of Applied Geology, Indian School of Mines, Dhanbad-826004, India. 35 pp. Price: Rs 16.00 (approx US$1).

Small scale CHP has potential market

'Potential for Small Scale CHP in UK Public, Commercial and Domestic Buildings'
Energy Technology Support Unit Market Study Number 8

This is one of a series of market studies carried out by ETSU. Others cover industrial heat recovery; drying, evaporation and distribution; refrigeration; refurbishment potential in school buildings, office buildings and public houses; and other topics. It is clearly an important series of original research and reinterpretation of earlier work.

The conclusions are that a general case for CHP for large buildings and groups of buildings cannot be made. However, there is a large potential market. Installed CHP in buildings amounted to 7 MW(e) at 170 sites at the end of 1986. The potential market of economic CHP is given as 320 MW(e) at 4,000 sites saving overall £40 million per annum in energy costs. With a capital cost quoted of £466/kW(e), the market potential is about £150 million, ie, about an average of £40,000 per site.

The greatest potential is for hospitals, about half the total. The energy savings would contribute about £17 million per year in lower energy costs. Payback time averages four years.

Generally payback time varies between two and a half and five years. High rise flats, although relatively limited in unit size, give the best return on investment.

The public sector represents the largest part of the potential market with 70 per cent and, on the whole, these installatioins have the largest units.

As regards size, there is a potential market for about 5,000 small units, of say, 15 kW, 2,500 medium of 40 kW and 300 large of 400 kW or more. A CHP plant is more likely to be installed when heating plant needs replacement or the building requires refurbishment.

The first chapter in the report reviews the method of assessing the economics of CHP in buildings. It takes into account energy demand patterns, energy costs and tariffs, equipment and installation costs, maintenance, plant sizing, operation and administration costs. Probably the most uncertain factor is the payback expectations of the decision makers.

Hotels expect payback periods of less than three years, hospitals, leisure centres, etc, up to five years, although there are instances of acceptance of longer payback times in some cases. Clearly the current high interest rates must reduce the viability of some schemes felt to be economic in this report.

There follows details of test cases for high rise flats, a hotel and a general hospital. These cases are followed by a detailed market survey. The final section covers sector reports on public sector buildings, commercial buildings, ie, hotels, slaughterhouses, laundries and domestic high rise flats, sheltered housing and housing estates. There is a final section on standby generation.

The sheltered housing test case has a payback time of four and a half to five years, but only small units can be used. The most favourable conditions are therefore required in this case to justify installation. CHP installations are least likely in private sector sheltered housing.

The report will be most useful to manufacturers of plant, government departments and, in particular, the National Health Service, local authorities and owners of hotel chains. This is a report for use, not for general reading, although its conclusions are of wide interest.

N G Worley
Published by Energy Publications in association with ETSU, Newmarket, England, 1988
133 pp. £35.00

A useful reference book

'Industrial Energy Markets'
Energy Efficiency Series No 9

This reference book is in four parts. The first covers trends in energy consumption between 1973 and 1987, with estimates of the contribution made to the reduction in total demand by changes in industrial structure. Part 2, which deals with the structure of the market, reveals the high concentration in demand, pointing out that 600 establishments account for 60 per cent of energy purchased. An analysis of expenditure by industrial sub-sector, with energy costs shown as a proportion of production costs or gross output, is provided in Part 4.

Most of the meat, however, is in Part 3. Here there are 41 pages of tables listing the quantities of energy consumed in 1979 and 1984, in 23 industrial sub-sectors. These listings are banded in various ways, eg, by number of employees, quantity of energy purchased, or the fraction of purchases attributable to energy. These tabulations enable the reader to build up an accurate profile of any class of manufacturing industry with relatively little extra computation.

Part 1 (with its emphasis on reporting and explaining the trends) is of less practical use, although its conclusions about the impact of energy efficiency are interesting. It attributes annual savings of 5.37 billion therms to efficiency improvements alone between 1979 and 1987.

Many of the tables are computer lists, but these are all neat and perfectly legible. Some sections have been originated with a desk-top publishing package of poor quality, while others have been typeset and pasted-up. This mish-mash of styles results in an inconsistent and sometimes amateurish appearance, but that is of little consequence in a reference work of this nature. The only real problem is that Table 6 has, unfortunately, suffered from having rows that do not quite line up across the page, making it easy to misread entries from the fifth row downwards.

On the whole, this is an excellent source of information for anyone marketing energy-related products and services.

Vilnis Vesma
Published by HMSO Publications Centre, London, 1989
166 pp. £40.00

A conference overview

'Wind-diesel and Wind Autonomous Energy Systems'
Edited by H Nacfaire for the Commission of the European Communities

If you are trying to find a new field of energy research which can be centred on the Greek Islands, this is the book you have been looking for. It gives an overview of a European Community conference held on Mykonos in the Aegean in 1988. All those in Europe who are receiving CEC funding for wind-diesel and autonomous wind energy systems are represented in this volume and it has very appropriately been edited by the co-ordinator of the Wind Energy Demonstration Programme in Brussels.

It may be true in many countries that only large groups of wind turbines connected to the electrical power network can make a major impact on the energy scene. It is nevertheless equally true that the majority of wind energy companies and research teams are involved with stand-alone systems using storage back-up or diesel stand-by. Typically such machines and systems are smaller than those with power system applications in mind, but there are a great many of them around the world. Most of the leading European activities are included here, although it is surprising to see the Netherlands not represented; they have a major national commitment to wind power but are evidently concentrating on larger, power system applications.

Wind-diesel and autonomous wind energy systems can be competitive where fuel costs (including transportation to site) are high. These and the more detailed conclusions set out in the book are as authoritative as can be expected from an R D&D conference.

There are contributions from wind turbine manufacturers, utilities and users but it is claimed that there is not yet sufficient information between these organisations to make a final evaluation of the economics. There never is, of course, or much of the central support for R D&D would disappear, whether the evaluation was favourable or unfavourable. If you could show that wind-diesel systems were inherently uneconomic, you would not waste money doing any more development. On the other hand, if you could show that they *were* economic, they could safely be left to industry and market forces to develop without the need for further support.

To summarise, this book gives an authoritative overview of work in progress on isolated wind power systems, with and without diesel back-up. Some important and encouraging conclusions can be drawn and favourable situations have been identified, eg, in the Greek Islands but, in general, the economics of such systems cannot yet be settled.

Prof Donald T Swift-Hook
Published by Elsevier Applied Science Publishers, Barking, England, 1989
193 pp. £25.00

Sir Christopher Ball outlines 'major challenge' to UK

AT A conference in London in October, Sir Christopher Ball, Chairman of the Royal Society of Arts (RSA) Industry Matters Education/Industry Forum, and BP/RSA Fellow for Higher Education, identified what he saw as the major challenge facing the UK, namely that of labour: its quality, its price and its mobility.

The conference, *Graduates & industry: the recruitment challenge,* was organised by The Engineering Council, the Association of Graduate Career Advisory Services and the Association of Graduate Recruiters.

Sir Christopher was referring to a recent CBI report which stated that the British workforce was under-trained, under-educated and under-qualified.

He stated: "We have failed to meet our existing needs. The needs of the future will be different and even more demanding. And the demographic trend presents a further challenge.

"Whose responsibility is it to provide an adequate supply of well-educated and trained labour? For a century industry has left this to government and the education system. This has not worked.

"It is the responsibility of the employers to secure the supply of adequate labour in the same way as they recognise their responsibility to secure the supply of materials.

"It is industry's responsibility to resolve the scarce skills problem.

"Likewise when engineering courses fail to recruit it is the responsibility of heads of department and course leaders to secure their supply lines.

"The major impediments to expansion of higher education are a culture resistant to education and a system designed to produce a small elite."

Sir Christopher has been conducting a study for BP and the RSA which sets targets for expansion of further education of 10 per cent by the year 1995 and 50 per cent by the year 2000.

"Resources are the key problem," he continued. "Government has willed the end but not the means.

"The burden of cost of £450 million — a 17 per cent increase in existing funding — by the year 2000 must be shared between three contributors. The first third to be met by a reduction in unit costs; the second third by an increase in public funds; and the third by charging students fees — £450-750 per annum depending on the rate of remission to needy students."

On a more general level, Sir Christopher expressed the need for higher education to be seen as part of the entire system of post-compulsory education rather than as a separate entity. He saw the potential for an increase in the number of part-time students. In the UK just over a third of students study part-time, where as in the US, the majority of students are part-timers. However, the predicted number of full-time students suggest that the increase will be no more than 20 per cent.

Sir Christopher did not see research growing at a similar rate:

"The primary commitment in the 1990's is to provide students with a useful education," he said. "For most academics and institutions, research must take second place."

It's a good job

BRITAIN'S qualified engineers have received pay rises over the last two years which give them an overall increase in purchasing power. They are increasingly satisfied with their initial training. Two thirds of them would recommend engineering as a career giving job satisfaction as the main reason. Some 9,500 of them are chief executives. And more than 22,000 of them take part in school/industry links.

These are some of the facts revealed by the 1989 Survey of Chartered Engineers, Incorporated Engineers and Engineering Technicians, published by The Engineering Council in October.

The biennial survey sampled 27,000 of the 189,000 engineers and technicians under the age of 65 with UK addresses on the Council's 285,000-strong register.

Categories covered by the survey include: earnings, employment, occupation, employment group, qualifications, location, levels of responsibility, language knowledge, trade unions, fringe benefits, overtime, further training and attitudes.

Both chartered and incorporated engineers have received increases comfortably in excess of the RPI which has resulted in an overall increase in purchasing power for both groups.

The average total earnings per year were £24,705 for chartered engineers and £17,825 for incorporated engineers, compared to £20,387 and £15,124 respectively in the 1987 survey. Some 64 per cent of all chartered engineers are now earning more than £20,000; 37 per cent earn more than £25,000; and 21 per cent are now earning more than £30,000.

The survey shows that unemployment, particularly among incorporated engineers, has fallen, which suggests that the profession is healthy and that prospects are good. Overall, only 0.6 per cent of engineers in the two groups were unemployed on the survey date of 1 April, 1989.

Reflecting the low unemployment rate, 52.7 per cent of chartered engineers now work an average week in excess of 42 hours, compared to 46.7 per cent in 1987. In the incorporated engineer group the corresponding figures show an increase from 41.2 per cent to 43.8 per cent.

The survey reaffirmed the trend in the declining numbers of engineers belonging to a trade union, which had been identified in previous surveys. The current survey shows 34.8 per cent of chartered engineers, and 49.6 per cent of incorporated engineers are members of a trade union. The 1987 survey revealed figures of 36.7 per cent and 50.5 per cent, respectively.

The 1989 Survey of Chartered Engineers, Incorporated Engineers and Engineering Technicians, comprising more than 70 analytical tables, price £100 (incl p&p) is obtainable from The Engineering Council, 10 Maltravers Street, London WC2R 3ER.

Registration matters!

A JOINT campaign to raise the standing of engineers was launched in London in November by The Engineering Council and the Engineers' and Managers' Association (EMA).

A leaflet being sent to all 41,000 members of the EMA sets out why they should register with The Engineering Council.

The Council, which has 285,000 chartered engineers, incorporated engineers and engineering technicians on its register, is seeking to increase the numbers in all three categories with greater emphasis on incorporated engineers and engineering technicians.

Mr Denis Filer FEng, director general of The Engineering Council, said: "The titles are a statement of an individual's professional competence from the profession itself and a hallmark of quality assurance. In Europe there has always been a strong emphasis on the holding of titles and qualifications. From now on, pan-European and global concerns will examine closely the technological profile of those companies they are considering doing business with."

Accounting for the need for a registration campaign, Mr Filer said: "The historical reasons that created conditions of decline in UK engineering over much of the present century and particularly during the post war period to the late 1970s are complex. If one was compiling an inventory of blame for that decline, it would be difficult to find a group that was entirely blameless. Governments, industry, educationalists and the unions all contributed to a greater or lesser extent. It has to be said that professional engineers themselves cannot be excluded from blame. In particular the profession has been hindered by its fragmented nature. Despite some rationalisation in recent years there are still nearly 50 professional engineering institutions today. Above all engineers seemed to lack belief in their own profession.

"I can assure you, however, that 'Registration Matters!' is not merely a campaign to massage the feeling of engineers. It offers very real benefits to the individual and thereby the profession and to industry. That in turn is good for the country."

Mr John Lyons CBE, General Secretary of the EMA, said: "Registration gives recognition of what an individual has achieved in terms of education, training and experience. It strengthens the position of the individual in terms of career and earnings potential and raises the standing of engineers in the community at large."

Mr Lyons is a former (founder) member of The Engineering Council and the EMA was a prime mover, during the late 1970s, in pressing the Government of the day to set up a committee of inquiry into UK engineering. That led to the Finniston Report and ultimately to the setting up of The Engineering Council.

Flexible couplings

Designed to transmit power between a prime mover and a driven machine, Vokes' Genflex universal couplings are available in eleven power ratings up to 15kw (20hp), assuming a steady load.

They are suitable for use with electric motors and internal combustion engines in a wide range of applications, including generators, pumps and fans where the angular displacement does not exceed 5°.

The couplings are designed around two flanged hub members, which are fitted to the shafts to be coupled and separated by a floating centre assembly containing four equispaced rubber blocks with reinforced cores. Formed to accept uniform stress and deflection throughout, the blocks are preloaded to permit considerable deflection and can absorb large amounts of torsional vibration as well as shocks and uneven pulses.

Couplings can be supplied with the bores machined to size and with keyways, or pilot-bored to the minimum standard bore ready for the customer to open out and finish. Dynamically-balanced shafts and coupling assemblies are available for applications where the misalignment is greater than 5° or where the two machines are some distance apart.

For further information contact Vokes Ltd, Henley Park, Guildford, Surrey GU3 2AF.

BS 1042 announced

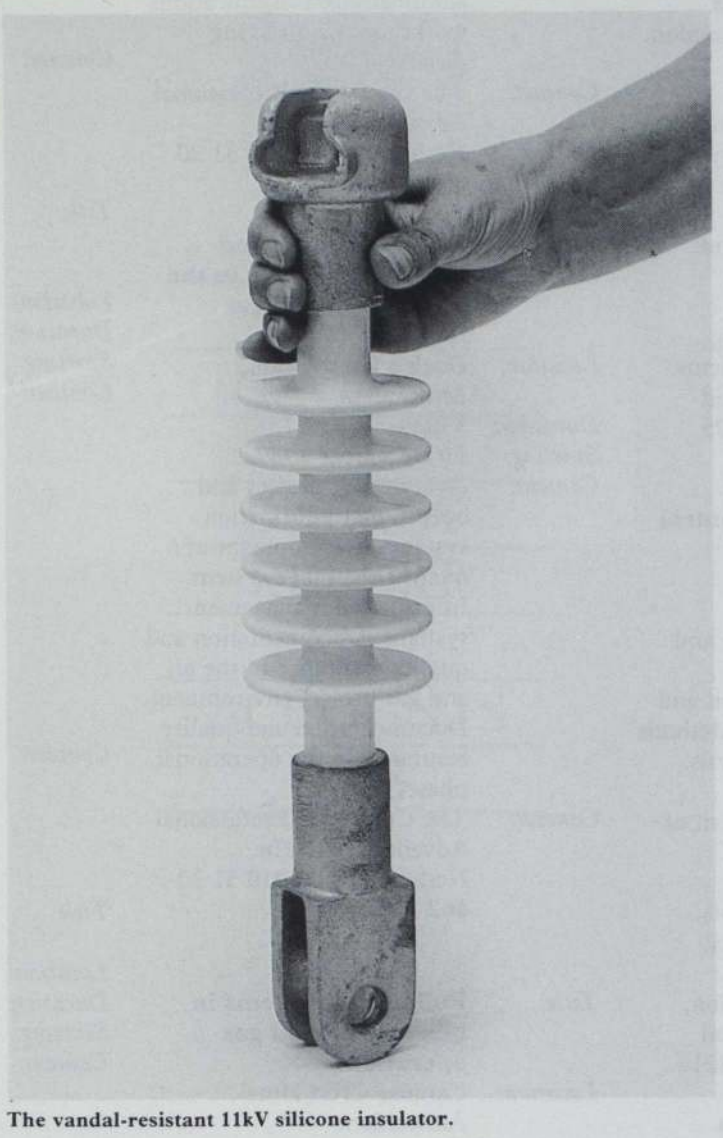
BSI announced in October the publication of BS 1042: Measurement of fluid flow in closed conduits. Section 2.4 *Method of measurement of clean water flow using current meters in full conduits and under regular flow conditions.*

It describes a method of determining the volume flowrate in a closed conduit using propeller type current meters in full conduits under regular flow conditions, the fluid being water.

The new standard also deals with the calculation of flowrate and calibration of the current meter. No current standard is superseded.

Copies of this standard are available from BSI Sales, Linford Wood, Milton Keynes, MK14 6LE.

New vandal-resistant silicone insulator



The vandal-resistant 11kV silicone insulator.

Permali Gloucester Ltd has introduced a new 11kV 80kN tension insulator with a silicone rubber housing designed to provide maximum resistance to malicious damage and vandalism.

The design is based on Permali's successful range of TDL insulators and, like them, it features a core of GRP pultrusion potted with epoxy resin into ball and clevis end fittings of galvanised cast iron. The housing is formed from a highly track-resistant silicone rubber moulded in a transfer press. The insulator, designed for overhead lines carrying over 1000V, is extremely robust and is rated 80kN.

Silicone rubber can operate over a wide temperature range (from −60 to −250 degrees C) and is extremely resistant to ozone and UV radiation. In service the housings show only a minimal increase in hardness and tensile strength.

Permali has conducted extensive testing to prove the strength of the construction, its resistance to water penetration and to establish the impulse and wet-power frequency performance. Independent electrical tests have been carried out to IEC Publication 383 and BS 137 Part 1.

The insulators were also subjected to attack by firearms including small-bore rifle and shotgun. The silicone housing absorbed the energy of the projectiles, with numerous pellets remaining embedded in the rubber. Yet the insulator was still able to withstand the routine test load of 40kN, showing that even direct hits with 0.22 bullets would be unlikely to bring the line down.

Silicone rubbers have already proved their value in similar applications. After exhaustive tests, British Rail established that these materials offered excellent tracking and erosion properties and are using them to protect the sheds of porcelain insulators against vandals.

Remote controlled monitoring

Bruel & Kjaer's Gas Analysis Division recently announced a rugged but highly sensitive toxic gas monitor designed for long-term unattended monitoring.

The Type 1306 Toxic Gas Monitor can be used for plant-wide detection of accidental gas release, or monitoring of process emissions, in accordance with environmental protection and occupational health and safety requirements. Running costs are low since the system functions under extreme environmental conditions with minimum attention. Frequent self-test guarantees reliable operation. Recalibration and filter replacement are the only routine maintenance required, typically at three-monthly intervals.

The measurement technique is based on photoacoustic infrared spectroscopy which offers advantages over existing methods in speed of response, sensitivity, and immunity to interferents. The instrument is highly selective by virtue of a wide choice of optical filters, enabling detection of almost any gas which absorbs infrared light while compensating for the effects of water vapour. The detection threshold is gas-dependent and in the parts per billion to parts per million region. Wide dynamic range allows measurement of concentrations for orders of magnitude higher than the detection threshold.

Bruel & Kjaer supplies software enabling one to 31 gas monitors to be controlled by an IBM PC or compatible computer. Highly graphic screen displays and simple on-screen selection of commands make the system very easy to operate. The user selects a normal measurement interval which is supplanted by intensification and alarm modes when present thresholds are exceeded. When alarm levels are detected, measurements are made continually. Storage is provided for the most recent measurement and self test sequences, the data being available on request without disrupting operation. Results can be printed or plotted if required.

For further information contact John Bancroft, Bruel & Kjaer (UK) Ltd, 86 East Road, Longsight, Manchester M12 5GY.

Title: **Trends in industrial energy management**
Location: Institute of Energy, London.
Duration: 1 day.
Starting: 12 December 1989.
Content: Examination of the changing scene in today's energy environment. Current government attitudes. Technical advances and management issues. Workshop with an opportunity to develop solutions to real problems.
Contact: Courses Secretary, Mid-Career College on 0223 312850.

Title: **Gaseous effluent control**
Location: Loughborough.
Duration: 3 days.
Starting: 12 December 1989.
Content: Control of particulate and gaseous components. Overview of legislation and of design strategies. Methods of sampling and analysis. Removal of gaseous components. Treatment of sulphur oxides and of odours. Removal of particulate components. Consideration of dusts, smoke and aerosols.
Contact: The Conference Section, Institution of Chemical Engineers on 0788 78214.

Title: **Contracting pitfalls**
Location: Crest Hotel, Amsterdam.
Duration: 3 days.
Starting: 13 December 1989.
Content: Introduction and overview. Project characteristics. Contracts development and administration. Incentive contracting. Significant pitfalls in contracts development and administration. Applications workshop. Contracting pitfalls.
Contact: The Centre for Professional Advancement, The Netherlands on 010 31 20 662 30 50.

Title: **Documentation and quality assurance in the offshore oil and gas industry**
Location: Doelen Crest Hotel, Amsterdam.
Duration: 3 days.
Starting: 13 December 1989.
Content: Overview of project and operational information systems. Development of a quality assurance system. Information management systems. Documentation and quality assurance in the oil and gas project environment. Documentation and quality assurance in the operational phase.
Contact: The Centre for Professional Advancement, The Netherlands on 010 31 30 662 30 50.

Title: **Pollution problems in offshore oil and gas operations**
Location: Caransa Crest Hotel, Amsterdam.
Duration: 4 days.
Starting: 18 December 1989.
Content: Review of drilling and production operations. Discharges associated with offshore oil and gas operations. Environmental policy and legislation. Environmental monitoring. Environmental audit. Environmental impact assessments and statements.
Contact: The Centre for Professional Advancement, The Netherlands on 010 31 20 662 30 50.

Title: **Shell and tube heat exchangers — mechanical aspects**
Location: Hotel des Indes, The Hague.
Duration: 4 days.
Starting: 19 December 1989.
Content: Describing shell and tube heat exchangers. The tube side. The shell side. Interactions between shell and tube sides. Codes and standards used in the United States. Inspection. Specification writing and interpreting. Maintenance and repairs, schedules and procedures. Troubleshooting. Cost estimating.
Contact: The Centre for Professional Advancement, The Netherlands on 010 31 20 662 30 50.

Title: **Atomiser and spray technology**
Location: UMIST.
Duration: 4 days.
Starting: 9 January 1990.
Content: Fundamentals of atomisation. Characterisation of sprays and atomisers. Theory and practice of measurement techniques. Performance of atomisers. Modelling atomisation and sprays. Applications and case studies.
Contact: Dr A. Yule, Dept of Mech Eng, UMIST on 061-200 3705/3702.

Accessing Energyline

The Institute is now able to offer to members an on-line database search facility, accessing Energyline; a worldwide bibliographic database covering energy topics, including research policy and current energy news.

Using one of our microcomputers, Institute staff will search on-line, using the specific keywords provided by the member concerned.

The basic fee for this service is £25 (inclusive of VAT), but the Institute will have to charge more for lengthy searches.

Responsibility for obtaining the actual reference material itself (from places such as the British Library) will of course remain that of the member.

For further information on this service please telephone Christine McCarthy on 01-580 0077.