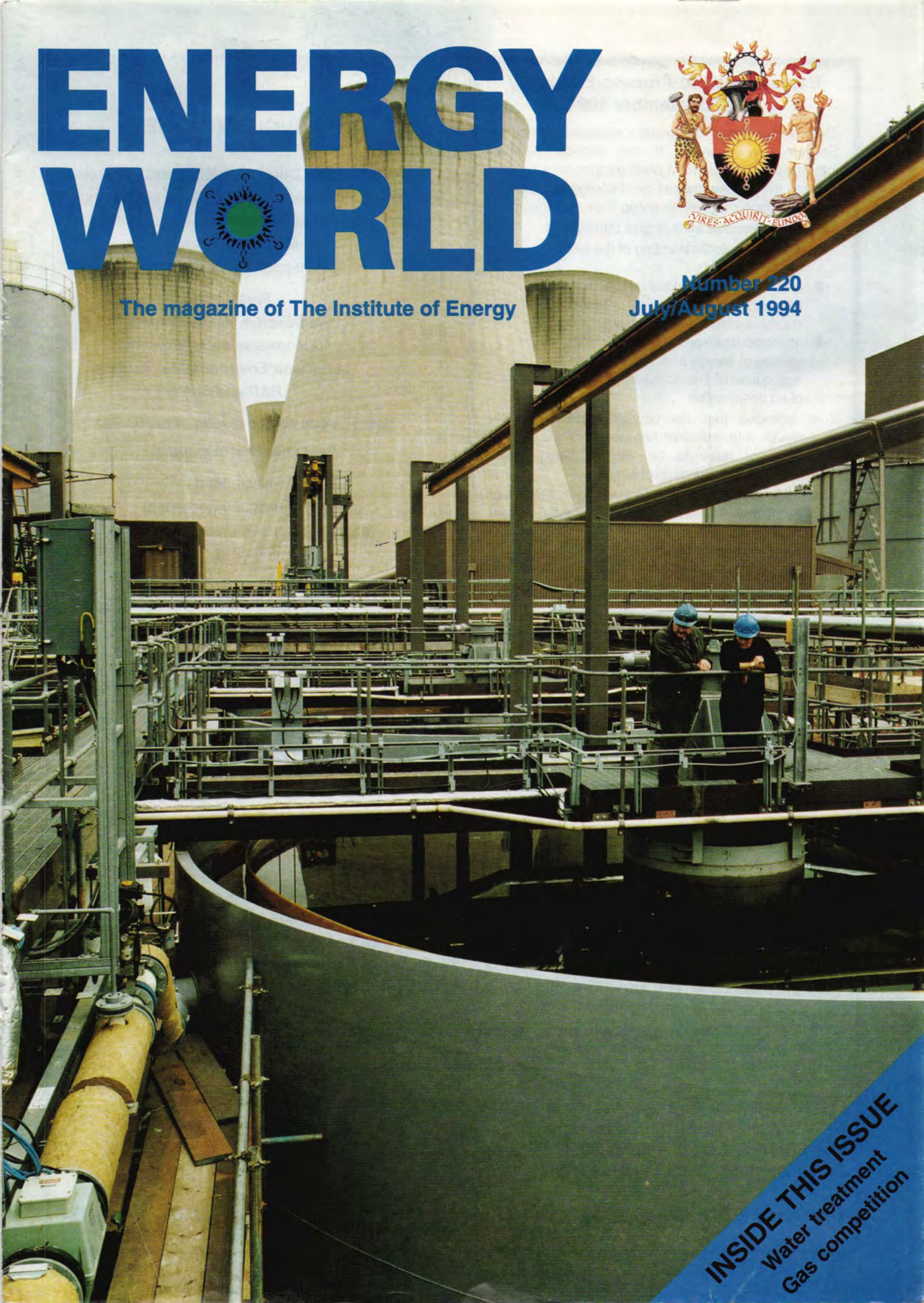
ENERGY WORLD



The magazine of The Institute of Energy

Number 220
July/August 1994

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Water treatment
Gas competition

Exergy Route to Process Efficiency
20-21 September 1994

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The Parliamentary Office of Science and Technology has just published a comprehensive assessment for Parliament of the technical issues related to the Nuclear Review.

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1994 ROBENS COAL SCIENCE LECTURE

The lecture will be presented by Professor Harry MARSH,
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Southern Illinois University at Carbondale, USA.
The lecture will be held on Monday, 24 October 1994, at 1730 (tea 1700)
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The subject will be - ***COAL: WHENCE and WHITHER***

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COVER

This month's cover picture shows Thompson Kennicott's water treatment plant at National Power's coal-fired Drax power station. Thompson Kennicott, a member of the Rolls Royce Industrial Power Group, are specialists in the area of water treatment, and have contributed to an article on the subject in this month's Energy World (see pages 17—19).

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The long-awaited review

IN MAY 1994, after more than four years of waiting, the Government announced its promised Terms of Reference for the Nuclear Review. Under those terms the review will focus on the future prospects for nuclear power, including (without commitment) its privatisation. The review will also examine the economic and commercial viability of new nuclear power stations. In short, the Government believes the future role of nuclear power in the UK's electricity supply industry will depend on the nuclear utilities proving themselves competitive, while maintaining rigorous standards of safety and environmental care.

1994 hopefully, may well prove itself to be the year in which the UK Government finally shows its firm commitment to nuclear energy, not with words, but through action, in giving the green light to the nuclear industry for further nuclear power station construction.

In 1989, and again in 1990, the Government clearly acknowledged the benefits of nuclear-generated electricity. Yet it could not bring itself to support fully the development of future nuclear expansion because of fears that such actions may have caused unwanted interference with the ongoing privatisation process. Instead, it delayed action yet again on a major issue, which led to the creation of Nuclear Electric plc and Scottish Nuclear Ltd. By the formation of these two companies, the Government may well have unwittingly done the industry a good turn.

Since the formation of these two nuclear utilities, their financial and operational performances within the privatised market for electricity have been great success stories. Over the last four years, Nuclear Electric has increased the use of its operating stations by as much as 44%, and doubled its productivity. In terms of 'lost time' industrial accidents, down to 78% since 1990 the collective radiation dose has been reduced by 42% over the same period. Nuclear Electric now stands as a company which has a well-established management capability well suited to the commercial sector. SNL's performance is similar, and both companies should be attractive to the prospective private investors within the privatised electricity industry.

The Government believes our nuclear future lies in these two companies proving themselves. What greater proof is needed than the records set each year since 1990. Nuclear Electric with SNL generates 25% of the UK's electricity. If this example of excellent management is still not enough for the Government, one has to ask what further evidence is necessary?

There are, of course, a number of obstacles, and some Government action is necessary to overcome these. Nuclear Electric's assets include eight Magnox stations (two currently being decommissioned), five AGRs with one PWR about to deliver electricity to the grid later this year.

The Magnox stations are all ageing plants, which despite the technology still give excellent operational performances. They will all be permanently closed around 2005, leaving a capacity gap. In order to maintain a balanced diversity of supply, this loss of nuclear generation must be replaced, and it is therefore imperative that an order for another PWR is announced very soon, given the long construction timescale for new plant. The Government must not delay.

Diversity and security of supply is paramount for the UK's industrial and commercial base. The miners' industrial dispute of 1983-84 clearly illustrated that.

Following privatisation, the electricity supply industry acted on its new found freedom for Government interference by adopting gas as the fuel for new electricity generation, from both the RECs and the independent companies, the two generators — National Power and PowerGen , commenced building CCGT stations to combat their loss of market share.

At present most CCGT stations operating, or about to commence operation, have signed long-term contracts with gas suppliers. It is an open question as to what will occur once these contracts expire, early in next century. Gas resources are limited, despite prophesies from suppliers. Further, gas prices like oil, could become extremely volatile.

It would be difficult to accept and would indeed be depressing should the Government decide that nuclear power has no future in the UK. The outlook for an industry which employs thousands of skilled workers (and many more indirectly) would be doomed, an outcome too difficult to contemplate.

Currently the PWR station at Sizewell is almost complete and ready for commercial operation. Many highly professional engineers, backed by a very skilled workforce have shown the world an example of UK engineering excellence, supported by a highly efficient project management system. These persons are at the threshold of their future careers, as well as the engineering profession itself.

All that is required for a sustainable nuclear future is for the Government to indicate now its complete commitment by the ordering of another PWR at Sizewell. Any unnecessary delay will be a catastrophe, not just for the nuclear industry, but for UK industry and commerce as a whole. Complete loss of the knowledge and expertise so soundly built up over the last 72 months at Sizewell B may be lost for ever. It would be enormously expensive to recover such skills if time is allowed to pass without more nuclear capacity being ordered.

Of course, should agreement be reached for the start of a twin reactor PWR station at Sizewell, the Government must give guarantees that political interference at either national or local level will not impede the project.

For example, it is known that the Suffolk County Council has objected to another PWR station at Sizewell and so we will have another public inquiry on our hands. Such an inquiry must not be allowed to run as long as the Sizewell B inquiry. The Government must make it absolutely clear its firm intention to restrict such an inquiry to a few localised matters.

Recent announcements from Nuclear Electric demonstrate its overriding objective is privatisation. If this happens, the Government must take over commitments and liabilities for the Magnox plants, and ensure that the competition for electricity generated by nuclear means is not liable to any adverse obstructions by the Regulator.

Eur Ing F John L Bindon
Senior Fellow of The Institute of Energy

Thirsty Thailand accused of 'dam warfare'

BANGKOK: Hit by a series of droughts in the past decade, Thailand is casting covetous eyes on the riparian resources of its poorer and less industrialised neighbours, *writes S Satyanarayan for Panos.*

Thai planners are so concerned about the impact of water shortages on the country's booming economy that they are working overtime to push through a series of ecologically controversial reservoir projects in rivers along the country's borders with Myanmar (formerly Burma), Laos and Cambodia.

Feasibility studies are underway for eight hydro-electric dams along the Salween and Moei rivers on the north-western border with Myanmar. On the north-east border, the irrigation department is working on a major project to divert water from the Kok and Ing, two important tributaries of the Mekong river that also flows through neighbouring Laos and Cambodia.

Both projects are primarily intended to ensure steady supplies of water to the Bhumibol and Sirikit dams that are the main source of irrigation and drinking water for Thailand's densely populated central plains region, including the Thai capital, Bangkok.

The US$1.2 billion Kok-Ing diversion project aims to provide more than 2700 m cubic metres of water a year, and the US$5 billion Salween dams are expected to supply 5040 m cubic metres of water, as well as more than6000 MW of electricity to energy-hungry Thai industries.

Apart from taking up such projects on its own, Thailand is also offering incentives to governments in neighbouring countries to initiate large hydro-electric projects from which it would benefit.

It is a strong temptation for the government of a poor country such as Laos. Assured of a steady market for electricity in Thailand, which has a power demand growth rate of 1000 MW a year, Laotian planners are studying feasibility of 24 major hydro-electric projects.

The water alarm was first sounded in Thailand after the failure of last year's monsoon left the Bhumibol and Sirikit dams with very low reserves. Environmentalists in Thailand put much of the blame for the water crisis on poor management, combined with changes in rainfall as a result of widespread deforestation. They point out that apart from the reduced volume of water in Thai rivers, even available resources are becoming polluted by indiscriminate discharge of industrial effluents.

A 1990 report on the environmental impact of industrialisation by researchers at the Thailand Development and Research Institute (TDRI) said that the number of factories identified specifically as 'water polluting' rose from 159 in 1969 to 5393 in 1979, and to 20 221 by the end of the 1980s. Water-polluting industries constituted nearly half of all industries registered in the country.

Inefficient water use is also causing concern on the agricultural front.

But projects to solve the water crisis have run into controversy on both political and environmental grounds. The plan for diverting water from the Ing and Kok has already led to a major diplomatic row with Vietnam, afraid that reduced water river flows will affect its rich rice-producing Mekong delta.

The controversy over the proposed dams, expected to generate more than 4500 MW of electricity, would flood more than 1000 sq km of forested land, affecting the lives of thousands of people along the Thai-Myanmar border.

Describing the projects as a case of 'dam warfare' by the Thai and Myanmar governments against two ethnic groups — the Karen and the Shan — an editorial in the Bangkok-based daily *The Nation* warned that 'the resulting human tragedy would weigh heavily on Thailand's humanitarian conscience.'

But with demand for domestic and industrial water growing at a rate of over 12% a year, it is doubtful whether such considerations will deter Thailand's planners, who have set their country on a 'pollute now, pay later' path of industrialisation.

The future of THERMIE

THE current THERMIE programme, the European Commission's programme of support for the demonstration and dissemination of new, clean and efficient energy technologies, expires at the end of this year. Since its inauguration in 1990, THERMIE has had a budget of 706 MECU for demonstration projects and promotional activities in the areas of energy efficiency, renewable sources of energy, the clean use of coal and hydrocarbons.

As the first evaluation report concludes, THERMIE is an effective instrument for achieving Community objectives and should be continued when the current programme expires. It also shows how THERMIE can play a part in pursuing energy and other policy aims, including improved competitiveness of European industry, environmental protection and regional development. The EC proposes to ensure that THERMIE activities can continue after the end of 1994.

On 10 March 1994, the EC adopted, as one of the specific programmes forming part of the fourth Framework Programme on Research and Technological Development (RTD), a programme on non-nuclear energies. This will cover two phases: research and development, and demonstration. The demonstration phase will ensure that a large part of the current THERMIE programme continues after 1994: demonstration of the technical risk associated with new energy technologies. The fourth Framework Programme will also provide the basis for activities relating to the dissemination of these technologies with particular reference to the OPET network, and some cooperation with third countries in this area. The principle of this action as well as the four-year budget framework were established by the political agreement on the fourth Framework Programme on 21 March.

However, this will not enable the full range of THERMIE activities to be continued after 1994. The programme does not permit three major aspects of the current programme to be supported. These are dissemination projects and those where a tested technology is being demonstrated under different economic conditions; the second, dissemination of technologies arising from projects funded by member states' demonstration programmes or by industry. Nor does it permit international cooperation in these areas.

For these reasons the Commission adopted on 13 April a draft proposal for additional instruments to complement the demonstration phase of the specific programme within the fourth Framework Programme. This programme (THERMIE -II-bis) would allow these three types of activities to be supported after the current programme expires. The proposal is now under consideration by the European Parliament and the Council of Ministers.

These two proposals would, if adopted by the European Parliament and the Council of Ministers, (hopefully before the end of November 1994), be implemented in parallel and share the same objectives and sectors of application: rational use of energy, renewable energy sources and fossil fuels.

In the way the Commission hopes to continue to promote the improved market penetration of new, clean and efficient technologies, with the added benefits in terms of Community economic, environmental and employment policy beyond 1994.

Trading outside the Pool

A CASE has not been made for significant changes so as to allow widespread trading outside the electricity Pool: so concludes Prof Stephen Littlechild in his report *Trading outside the Pool* published in July.

"Trading outside the Pool could have potential benefits to those involved, but so far there is little tangible evidence of the gains likely to be secured, and it would be time-consuming and costly to make the necessary arrangements," said Prof Littlechild. "Changes could also have potential detriments to competition and new entry, both from a thinner and less transparent market and from placing new entrants and smaller competitors at a disadvantage in securing rights to despatch. These detriments have to be given particular weight in view of the present positions of market power on both sides of the market."

The report also covers possible changes to the pricing mechanism. Prof Littlechild commented: "The great majority of market participants opposed a change in the pricing mechanism to pay generators their bid prices. This would represent a major change which seems likely to have disadvantages in terms of increasing risks, particularly for the smaller generators, without a strong likelihood that prices will be lower. In the longer term it could lead to higher prices. For these reasons, I cannot conclude that paying generators their bid prices would be a desirable basis for Pool pricing."

Efficiency challenge

HOME owners within Leicester's city challenge area are being invited to have free energy surveys and efficiency improvement work carried out on their homes.

More than 4500 homes will be targeted in the two-month promotion, which runs until September this year.

British Coal's last annual report

BRITISH COAL made an operating profit of £186 million in its last full year of operation in the public sector. But the overall loss for the year 1993/94 was a deficit of £238 million.

In its ongoing operations, taken separately, the Corporation's operating profit before exceptional items was £243 million. Of that, core mining contributed £203 million of which £163 million was achieved by a major reduction in costs.

The exceptional items which wiped out the operations profit included costs of closures and restructuring for privatisation and totalled £305 million. Net interest charges of £119 million are payable, mainly to the Government. A further provision of £122 million has been raised to cover costs associated with collieries after closure.

And so the last full year of public ownership ended as did the first — in financial loss (the 1947 annual report declared an overall loss of £23.25 million, amid jeers of 'we told you so' from the ranks of the press). But there the similarity ends.

The industry taken into the public domain in 1947 was large, ramshackle, inefficient and demoralised. Technically, it was the most backward in Europe, wasteful of manpower, and dangerously under-capitalised. Even the coal owners on the prestigious Reid Committee were anxious to be shot of it and endorsed public ownership as the only way of survival.

Nearly a thousand pits employing three-quarters of a million people produced 200 million tons of coal in that first year, at an overall productivity of slightly over one ton a manshift. Coalfaces employed the bulk of the men, shotfiring the exposed face and loading the product by shovel on to antiquated conveyor systems which in turn decanted into trains of tubs hauled by endless rope haulage. That was almost the entire extent of mechanisation in British deep mines after years of penny pinching between the two world wars.

Contrast that picture with what is being offered back to the private sector. Only a rump of the industry remains — 958 pits have become 19 and 718 000 workers are whittled down to just over 10 000. But over the past 47 years productivity has grown fourteen fold, largely due to the revolution in underground mechanisation brought about by the industry's own research scientists and engineers with the co-operation of equipment manufacturers. What was once Europe's most backward mining industry has led the field in technical innovation, to the extent that many deep mines around the globe survive today because they have adopted mechanised longwall systems pioneered in Britain. The devastation of the British coalmining industry has nothing to do with technological failure. The failures are economic and political.

According to the British Coal chairman, the primary aims of the last 14 months have been to match capacity to demand, reduce costs, respond to market opportunities, achieve operational flexibility, and offer unwanted collieries for lease and licence.

"The price has been high," says Neil Clarke, "falling most heavily on those mining communities which had to come to terms with closures. Our results for the year 1993/94 reflect the provisions and charges resulting from capacity reduction. But for our continuing collieries to have the chance of a sustainable future, it was a price which had to be paid." Where have we heard that before? Plus ca change ...

Welsh Select committee gives boost to wind power

A POSITIVE boost was given to wind energy in July with the publication of the Welsh Affairs Select committee's report.

The report views wind energy as important for reducing atmospheric pollution, saying that it can make a significant contribution to national electricity needs.

● TriGen Windpower is submitting a revised plan for a 36-turbine windfarm at Blaencorrwg, near Glyncorrwg. The proposed site is in the upland forest between the Rhondda and Afan valleys, and could provide 80 construction jobs.

Demand continues to rise

ELECTRICITY demand on the UK public electricity supply network remained high in May, despite warmer weather, and the Governemnt's 'helping the earth' campaign.

A year-on-year comparison, published by the Electricity Association, shows a growth of 4.8%: the tenth monthly increase in the last year.

Demand over the last twelve months to May is estimated at 308.1 TWh, representing an increase of 2.6% compared with the previous 12 months.

The Electricity Association collected their data from the 21 major electricity companies they represent throughout the UK.

Summer shuffle

FOLLOWING the recent Cabinet reshuffle, President of the Board of Trade, Michael Heseltine, has announced the new ministerial team at the Department of Trade and Industry.

The Rt Hon Richard Needham MP, Minister for Trade has responsibility for oil and gas projects outside the UK, while Tim Eggar MP remains Minister for Energy. Charles Wardle MP, Parliamentary Under-Secretary of State for Industry and Energy will support Mr Eggar on all energy issues. Ian Taylor MP, as Parliamentary Under-Secretary of State for Trade and Technology has responsibility for environment and energy technologies.

'Overwhelming' forces at Bilsthorpe

THE ROOF collapse at Bilsthorpe colliery which killed three miners last year was so great that any form of support would have been overwhelmed, the independent report into the tragedy, following the public inquiry held by Sir Bernard Crossland, concludes.

The collapse was the result of a movement in roof strata which, at the site of the accident, was insufficiently supported at the waste side, thus causing a cantilever effect which the roof bolts in the roadway were incapable of controlling. The magnitude of the failure, says Sir Bernard, would have overwhelmed any other system of support in normal use in UK mines.

Sir Bernard believes that rock bolting, which has been strongly criticised by some mining unions, has in fact led to significant improvement in safety in mining. But he points out that where skin-to-skin working was employed (in which new roadways are driven parallel with and close to old abandoned roads) as at Bilsthorpe "support of the cantilever depends on the confining stress generated by compaction of waste in the neighbouring abandoned workings." The high proportion of sandstone in the roof was atypical and may have generated a 'blocky' waste which did not fragment and compact adequately to generate sufficiently high confining stress. Sir Bernard also suggests, therefore, that supplementary rock bolting which was used in the abandoned working might have contributed to the blockiness of the fallen waste and consequently to the fall.

"If I am correct, this is a circumstance which could not reasonably have been foreseen," he said.

The recommendations reflect in the main those of the Health and Safety Executive's report, published in February. These include that skin-to-skin working using bolts or arches without additional support by chocks or packs installed during the driving of the original road or face should be discontinued. Where inspector's exemptions involve the approval of rock bolting or other systems of support, examinations should also consider the strata deformation process which has to be controlled, the action of the bolting system in controlling the deformation, and the ability of the monitoring system to detect the deformation. Each mine should have a system of recording falls, so that annual figures could show up detectable trends.

Frank Davies of the HSC says the Commission accepts Sir Bernard's recommendations in full.

IGCC goes in to BAT

INTEGRATED gasification and combined cycle (IGCC) technology will most likely be the best available technology (BAT) on offer to the power generation industry to meet requirements of Her Majesty's Inspectorate of Pollution (HMIP), according to the Inspectorate's director and chief inspector, Dr David Slater.

At a presentation in Oxford to Oxera (the energy utilities group), Dr Slater urged power generators to turn to new ways of reducing pollution to protect the environment.

He said that current technology within the industry was making insufficient impact on the problem and new approaches would have to be developed. The Inspectorate sees gasification via IGCC as a way forward and will be looking to the generating companies to meet the challenge.

"The current situation is far from ideal," said Dr Slater. "The most obvious way to clean power generation is to use a clean fuel, and natural gas is the obvious choice."

However, long-term price increases in natural gas are likely as more generating capacity comes on stream, and lower cost alternatives would probably be considered. After reviewing other developments such as flue gas desulphurisation (FGD), coal cleaning, and combined cycle gas turbines (CCGT), Dr Slater regards IGCC as likely to be the best available technology for the near future.

The process fuel is gasified to make a synthetic gas which is then combusted in a combined cycle turbine. "This route cleans the dirty fuel before combustion, thus avoiding diluting the pollutants with large quantities of air. Their removal is made easier and the size and cost of the clean-up plant is reduced compared with FGD," he said.

"The current electricity supply industry is a major contributor to pollution. Under the concept of integrated pollution control inaugurated by the Environment Protection Act the Inspectorate are taking steps to control those releases. FGD and other available techniques are able to clean SO_2 and other acid gas releases but not without producing other waste (including gypsum) that will have a significant environmental impact. IGCC represents an environmentally attractive alternative. The Inspectorate will be keeping a close eye on developments to ensure that such alternative technologies are fully considered by the industry."

Dr Slater said that IGCC demonstration plants were being built in several places, including Spain and Holland — although there was unfortunately none in Britain. "The UK power generators are conservative and are waiting to see the outcome of these projects. It is possible that the process of natural gas on long-term contracts starts to rise.

"Siting a plant close to an oil refinery would make a lot of sense. The increasing demand for low-sulphur transport fuels has started to give refiners a problem and they are producing increasing quantities of high-sulphur heavy fuel oil in the face of shrinking markets. Significant quantities of this fuel oil residue could be available to a gasifier adjacent to an oil refinery.

"Once IGCC has been demonstrated more widely, solid fuels would also be gasified. The main impedance to that at present is the building of solids handling facilities rather than any technological difficulties."

Seeing the light

DRAMATIC electricity cost savings are being achieved at a large education college in Bolton, Lancashire, which is undergoing refurbishment, following the installation of automatic presence detection lighting control systems.

The need to cut spiralling electricity costs at Bolton Institute was immediately identified by building maintenance manager, John Hayward. An increasing number of students and a huge growth in computerisation had contributed to the growing electricity demands.

"As electricity is not used for heating, we had to look at lighting control as the only route to cutting electricity costs," said Mr Hayward. "Switching lights off when they are not needed is a difficult culture to instill in both students and lecturers.

"Lights tended to burn from 6 am when the cleaners arrive until late at night when the caretakers did their rounds — yet there were periods during the day when lighting was not required."

He carried out a survey of the lighting control market to find the type of system that would meet his specific needs: maximum cost saving potential, reliability & ease of installation and use. He settled on automatic presence detection controls using ultrasonic and microwave technology from Ex-Or Ltd. These ensure lights are kept off when areas are unused, and come on when people are present and low light levels dictate the need for lighting.

Controls and sensors were installed in two corridors, three classrooms and a number of small offices. At the same time some lighting systems were upgraded to a high frequency. This combination led to cost savings of up to 80%, with the Ex-Or presence detection controls alone producing savings of between 20-30%, depending on the situation.

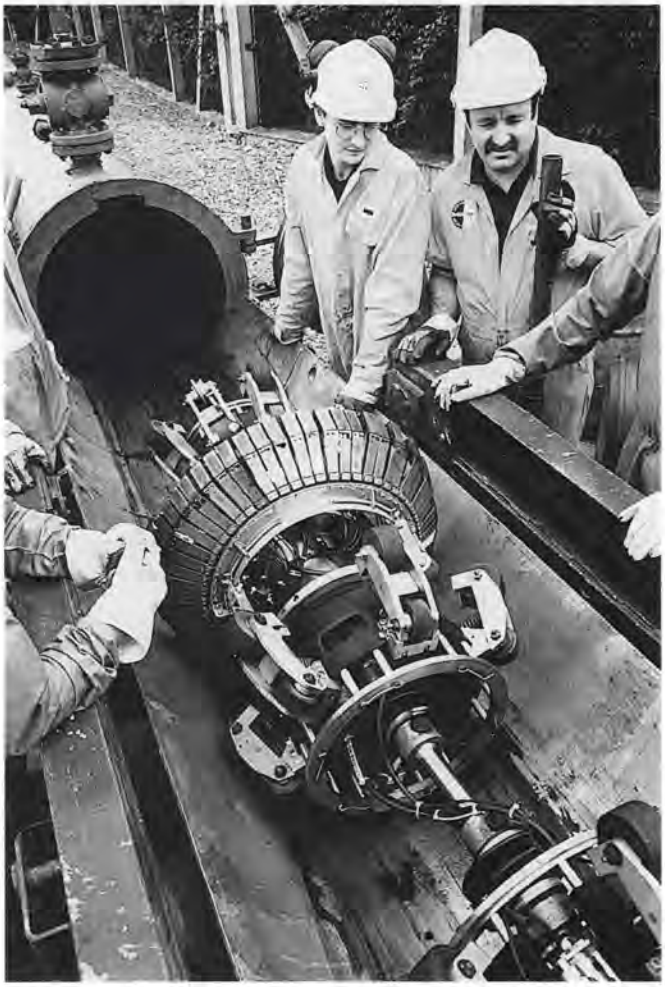
Where existing lighting was used, the retrofit control systems resulted in a payback period of under three years.

Water treatment for CHP plant

MEMCOR Ltd is to supply a water treatment system for installation by Energetica Ltd, at SCM Chemicals' Stallingborough, Humberside, site.

The Memcor unit will provide low silica, high quality water for a new 15MW CHP plant, being built by Energetica on behalf of Cogeneration Investments Ltd, a wholly-owned subsidiary of British Gas, established to build, own and operate CHP cogeneration plant.

High quality water is needed in the CHP plant for the waste heat boiler and injection of steam into the gas turbines, a method of reducing NOx emissions and increasing power output. The Memcor plant will polish deionised water from an existing water treatment unit to a quality of 0.2 microSiemens/cm and 0.02 mg/litre of silica. In an emergency the equipment can be configured to process untreated mains water. Commissioning is scheduled for October 1994.



A new business unit was set up by British Gas in June: Pipeline Integrity International. The unit will market BG's pipeline technology skills worldwide, and will offer an integrated inspection, assessment, maintenance and repair service for gas, oil and chemical pipelines.

BG's acquisition of Kershaw International Ltd, a leading pipeline cleaning company, will play a major role in the development of Pipeline Integrity International. Main centres for the new unit will be BG's On Line Inspection Centre at Cramlington, and in America, BG inspection services Houston, USA. Repair services will be based at Ambergate in Derbyshire. The new service will include every aspect of cleaning, fault diagnosis, defeat, detection, evaluation, repair, maintenance and consultancy advice.

The picture above shows BG engineers checking a pipeline inspection vehicle for signs of wear and tear.

Noise control

A CHP plant designed to be one of the quietest in the world was officially opened in June, by Neil Hamilton, Parliamentary Under-Secretary of State for Corporate Affairs.

Commissioning of the new £4 million CHP plant completes the first stage of BP Energy's £20 million 10-year partnership agreement with Chartham, a major international paper producer, based near Canterbury in Kent. The new plant which was designed, built and operated by BP Energy generates all Chartham's electricity and steam needs.

The paper mill's location at the heart of the village of Chartham — a designated conservation area — makes environmental considerations a high priority. BP Energy worked closely with Canterbury City Council to ensure the best possible environmental standards for the local community, both in terms of noise and appearance of the new plant.

The additional investment in containing and absorbing noise is about £100 000. The gas turbine, air intake and exhaust systems are fitted with extensive sound attenuators and all equipment is enclosed in buildings using high performance materials. The noise level at 35 metres from the plant is 52dBA, which is inaudible above the normal background of everyday noise.

Chartham's energy centre comprises a combined cycle CHP plant delivering 6 MWe of electricity and 18 tonnes an hour of steam. The new 4.5 MWe Centrax KB7 gas turbine plant and heat recovery boiler are housed in their own specially-designed building adjoining the existing boiler house, which has been refurbished and extensively re-equipped.

Construction began in May 1993, and the first power was produced from the new plant in January 1994.

David Smith, managing director of Chartham, said: "This project enables us to concentrate on our core business and skills as the world's largest manufacturer of translucent papers.

Consultation and competition

by Clare Spottiswoode, director-general of gas supply

In an increasingly competitive energy market, the monopoly enjoyed by British Gas since its privatisation was bound to be a thing of the past. Clare Spottiswoode, appointed director-general of gas supply at the end of 1993, details the progress towards liberalising the gas market.

FOLLOWING references made to the Monopolies and Mergers Commission (MMC) in 1992, reports were published after a year-long investigation into the gas industry. The Office of Gas Supply (OFGAS) submitted 12 volumes of written evidence, in addition to many oral contributions, and the industry itself — British Gas and its independent competitors — also had considerable input.

The MMC inquiry developed into a comprehensive investigation into the developing competitive gas industry, and reported a number of key findings. A conflict of interest was identified: with BG as both a seller of gas and owner of the transportation system, which independent competitors had no option but to use. The lack of neutrality in the transportation system was likely to reduce competition in the non-tariff market.

The MMC recommended divestment of BG's trading activities by 31 March 1997. It was recommended that the threshold for monopoly supply be reduced from 2500 to 1500 therms. This should be dependent on both safety and security of supply, however, and might have to follow three to five years later. In setting transportation charges, the rate of return used should be 6.5 to 7.5% on new investment, with the tariff formula adjusted from the current RPI-5 to RPI-4, to take account of the reduction in the monopoly threshold from 25 000 to 2500 therms. In addition it was recommended that the powers of OFGAS be extended to provide concurrent jurisdiction with the Office of Fair Trading in the contract market.

The report concluded that in the key areas of transportation and storage BG were operating against the public interest, and under the Gas Act 1986, OFGAS is required to remedy the situation. The MMC suggested that this should be done through the physical, financial and organisational separation of gas trading from transportation and storage, with OFGAS regulating relations between the two separated businesses. The report required OFGAS to set new price terms and a regulatory regime for the transportation and storage business.

A period of public consultation followed publication of the reports, and ended in November 1993. In December the President of the Board of Trade, Michael Heseltine, made his announcement on the future of the gas industry. Although broadly in line with the MMC recommendations, Mr Heseltine did not require BG to divest of its trading arm, although he still required separation of the trading and transportation and storage businesses. He further announced the intention that BG's tariff monopoly will end in April 1996, with competition phased in by April 1998. The non-domestic market would be open to competition from April 1996.

Phasing in competition to an industry which has always been a monopoly is a highly complex business, especially when important safety issues, as well as security of supply to the end user, are a major considerations.

Competition has already been introduced into over 2500 therms (mainly industrial and commercial sector, but including some larger domestic customers), and took off much faster than expected. This caused unforeseen problems for BG Transportation and Storage (BG T&S), who had found difficulty coping with the extra administrative load. OFGAS intends to make sure that BG T&S are in a position to cope with demand when the next tranche of competition begins. In order to predict accurately the level of interest, a limit of 5% (one million) customers will be set in

The author

The appointment of Clare Spottiswoode as director general of gas supply for a term of five years was announced by Tim Eggar, Minister for Energy in September 1993. She took up her appointment on 1 November, taking over from the first director general, Sir James Kinnon, who held the post since 1986.

Ms Spottiswoode graduated in mathematics and economics at the University of Cambridge in 1975. She was awarded a Mellon Fellowship to Yale University, and took further degrees in economics, after which she began a career as an economist at H M Treasury in 1977.

She left the Treasury in 1980 and combined starting a family with her first business, which traded in gifts. Having sold the business as a thriving concern, she went on to found Spottiswoode & Spottiswoode Ltd, a software company specialising in the financial and corporate markets.

Ms Spottiswoode sold the company in 1988, remaining as managing director and chairman until 1990. Since then she has extended her family while working part-time, in both executive and non-executive capacities, for several companies, and as a tutor at the London Business School's Centre for Enterprise.

PHOTO: KAREN ROBINSON

Clare Spottiswoode, director general of OFGAS.

the first year, with an additional 5% being open to competition in the second year of transition. OFGAS is committed to work alongside the legislative timetable to produce draft licence conditions, including the draft public gas supply licence.

Supplying domestic customers on a large scale would require a major commitment of resources, and independent gas suppliers would need to be certain of a licence being granted before making such a commitment. Licences would be granted in advance of competition beginning, to give independent suppliers the chance to make the necessary preparations. Any transfer of business from BG to an independent supplier would be recorded by BG T&S, and accordingly, outside suppliers should inform BG of any changes, ie, if business passes from them to another independent player. The monthly publication by BG T&S of the number of customers will keep competitors informed as to the state of the development of competition, within the defined 5% and 10% limit. If competition extension should exceed these limits, no further conversions would be permitted.

Although slow and complex, the phased method of introducing competition does has several advantages. It eliminates discrimination between suppliers or customers, dealing with conversion requests on a first come, first served basis. Following the problems experienced by BG in the earlier round of competition, these proposals provide a realistic target for the company to process. OFGAS believes that a new Gas Act will be necessary in order to provide a firm basis for the future development of the industry along these lines.

The timetable announced by the President of the Board of Trade has been planned to coincide broadly with the extension of competition in the electricity supply industry, providing what is hoped will be a 'level playing field' in the liberalised energy markets.

As part of the continuing consultation process, a joint consultation document was published by OFGAS and the DTI in May of this year, which attempts to examine details that are both complex and controversial. The publication of this document opens up the debate to both industry and the public, and it invited views on many issues.

But as of now it is largely the industrial end of the market which is open to competition. Any premises consuming in excess of 2500 therms per annum can buy their gas from an independent supplier. This includes most shops, offices, schools, hotels, factories and sports centres, to name but a few. Of the thousands of customers who have switched, most find their independent suppliers undercut BG. Prices are negotiable, and the risk to security of supply minimal: all customers enjoy the same guarantee of supply as BG customers. Even in the unlikely event of a supplier going out of business, BG has an obligation, and has undertaken not to refuse to supply a customer in these circumstances.

The joint consultation document, published in May, is entitled *Competition and choice in the gas market*. Following an overview of the objectives of the document, the paper looks in detail, chapter by chapter at transitional arrangements; safety; assurance of supply; pricing; standards of service; metering; efficient use of gas; pipelines, storage and terminals; the institutional framework of Regulation, and concludes with a chapter called 'Next steps'. Each of the eleven chapters ends with suggested topics for further discussion and submissions. All submissions had to meet a deadline of either the end of June, or the end of July.

A number of very interesting topics were raised by the document: from the appropriateness of the basic model, to the extent of the legal powers of the Director-General. Because of the structure of the existing gas supply industry, and the way it was originally privatised, the role of OFGAS is likely to change, as the industry itself transforms. The penultimate chapter of the consultation paper invites views on whether the role of consumer representation and protection should be integrated into OFGAS, or continue to be performed by an independent body. If the Gas Consumers Council remains an independent statutory body, should its structure or role alter?

The final chapter gives an undertaking that future legislation concerning the industry will be framed in the light of responses to the paper, and that further discussions may need to take place with participating parties. The report concludes with the following words: 'We hope Parliament will agree the appropriate legislative changes to enable domestic gas consumers progressively to enjoy the benefits of competition in the market from April 1996." ❑

Independent gas supply

by Johanna Fender

Eastern Electricity was the second of the regional electricity companies to form an independent gas company. Gas From Eastern Electricity is also part-owned by a subsidiary of US-based Utilicorp. *Energy World* met the venture's general manager, Trevor Turner.

THE PROSPECT of increased competition in the electricity supply industry has, for many of the traditional suppliers — the regional electricity companies (RECs) — meant a real decrease in their market share. In a pattern reflected throughout the privatised energy utilities, their response has been to diversify their operations.

Midlands Electricity, for example, last year opened its own Electricity Technology Centre, specialising in electroheat applications. Some RECs have taken a step in the direction of extending their operations into the area of gas supply.

Gas from Eastern Electricity, a subsidiary of Eastern Electricity, first began its operations before privatisation of the ESI. Following the relaxation of rulings concerning the use of gas for power generation, both in the UK and the EU, the company bought gas for its power station at Peterborough. The company is currently considering a new 350MW CCGT power station at King's Lynn in East Anglia, for which consent has been granted. The company is also involved in the joint venture constructing the power station at Barking Reach in London. Discussions over gas supply to the new station are in progress.

Existing infrastructure

The move into gas from electricity supply is not the enormous step it might at first seem. After all, much of the infrastructure for dealing with customers is already in place. General Manager of Gas from Eastern Electricity, Trevor Turner, stresses the company's flexible approach to the energy market, and added: "Unlike some participating companies, we are in the gas business for good." The wider the net is spread in a marketplace of dwindling market shares, the greater the chance of survival.

Mr Turner praised the consultation document published in May by OFGAS and the DTI. In a complex emerging market there are myriad details to thrash out, but he feels that the vital step has already been achieved, and that the key principles behind extending competition are established by the paper.

The privatisation of first the gas, then the electricity industries, has opened up opportunities for energy companies that fifteen years ago would not have been dreamt of. The RECs never successfully broke into the domestic space heating market, and Eastern Electricity decided that if it couldn't beat 'em, it would join 'em.

In April last year Eastern announced that it had signed a deal to buy the entire output of a North Sea gas field for their retail gas market. The Johnson field is situated 7 km east of the Ravenspurn North gas field, and has reserves of around 11 years. Over that period Eastern estimated that they will buy in excess of £200 million worth of gas from the field. The first delivery is scheduled for October this year, subject to DTI approval, coming ashore at the Dimlington Terminal, near Hull. The Johnson field is owned by a joint venture, operated by Hamilton Oil Company Ltd, a subsidiary of the Australian Broken Hill Proprietary (BHP) conglomerate. Other consortium members include LASMO North Sea plc, British Gas Exploration and Production Ltd, Monument Resources Ltd, Hardy Oil & Gas (UK) Ltd, Offshore Oil & Gas Development Company Ltd, Enterprise Oil plc and Brasoil UK Ltd.

No conflict

But where does the consumer stand in the battle to improve market share in an increasingly competitive sector? Trevor Turner stresses the customer service angle: "It is vital that opening the market to competition does not cause any drop in standards of service." Here lies, he argues, the value of regulation. He is in full agreement with the point made in the consultation paper: that there is a need to extend the powers of OFGAS, as presently it is only empowered to regulate British Gas. From his own company's point of view, he sees no conflict: "There is no reason why we can't provide a service to our customers to their satisfaction, whilst giving our shareholders an appropriate return."

But how does a small company, like Eastern, compete with a giant like BG? Mr Turner is anxious to point out that with a customer base of three million, Eastern are only second in size the BG. Also, he adds, it is much harder for a company with a large, fixed infrastructure to reinvent itself. This puts smaller suppliers at an advantage, and in the case of Eastern, their large customer base gives them a distinct advantage at the marketing end. Against this background it is not so surprising that Gas from Eastern Electricity aims to become one of the top three independent gas suppliers in the UK. Mr Turner envisages that the majority of their business will be in the domestic sector, but in line with the flexible approach, the company is by no means discounting the commercial and industrial sectors.

Early response disappointing

Given the relatively poor uptake — so far — in the extension of competition in electricity supply, how do Eastern intend to achieve the minimum 2-3% of the domestic market they would need to stay in the gas supply business? Trevor Turner believes it will take time, but will nevertheless be easily achievable. "It will require a major shift in people's attitude to energy supply. With privatisation a massive cultural change has taken place. A generation on, it seems much easier — look at Mercury, for example."

The upper end of the market is already open to competition, and problems are beginning to emerge. There are, in Trevor Turner's opinion, too many independent companies for the amount of gas so far made available, this has led to a fall in the price of gas, at the retail end, close to unsustainable levels. There are simply too many companies chasing too few customers.

But despite the problems ahead, Gas from Eastern Electricity is in the business to stay. Mr Turner emphasised the company's long-term commitment. His company is not in the gas supply industry to 'cherry pick'. "We are here to provide a utility service above all else. We are not 'cherry pickers', such activities are not possible in a truly competitive market, and that is what we wish to see OFGAS create." ❑

Electronic water purification

by Syd Garvey CEng FInstE

ONE would not normally expect an article on water treatment development in building services to appear in an energy journal, but much of the application of the process described here, and the experience gained, refer to water storage and quality control. They afford us the opportunity to look further afield, to assess the vast potential where, in many cases, chemicals alone have failed to eliminate problems in water systems. Refinery, petrochemical, steel, power, food production, horticulture are all industries in which electronic water purification will find a role.

The UK Health and Safety Executive (HSE) now fully accepts this 'alternative' water treatment regime for the control of Legionellosis, including Legionnaires' disease (HS(G) 70, 1993 edition). The document also proposes that hot water calorifiers should be maintained at 60°C as a safeguard. However, it is now known that this temperature was insufficient to control Legionella in a major UK hospital , where silver/copper ionisation finally succeeded. In any case, there are many installations where the boilers and calorifiers cannot maintain even 60oC and the replacement cost involved would be prohibitive in these depressed times.

Electronic water purification will, in time, establish its capability as the most successful method of preventing the proliferation of waterborne pathogens and then there will be confidence in reducing calorifier temperatures to more practical levels to prevent scalding when this is a consideration in the use of the hot water. The impact on the reduction of energy consumption in the UK will be considerable. Meanwhile this will only come about when more knowledge is gained by those responsible for the process' application.

Microbiology is not a subject normally studied by engineers. Perhaps, for the future, all engineers should be indoctrinated in this fascinating subject in order that the problems microbes can cause are considered at the design stage, rather than as clean-up operation. Corrosion, for example, under scale and under slimes in water systems carried by anaerobic bacteria cost industry much in maintenance and plant renewal, yet it is still often ignored until problems arise. The technology referred to in this paper and other systems are here to 'prevent' as well as 'clean up' — or is it that engineers do not like to be multi-disciplined?

The use of silver and copper ions for water purification is well known, determined perhaps 2000 years before the birth of bacteriology. The merit of chlorination as a means of destroying bacteria in water is beyond dispute and the process is firmly and universally established. However, in recent years resistant strains of bacteria, the discovery of Legionellae and other problems associated with chlorine compounds have promoted the interest in alternative water treatment regimes, amongst which ionisation is prominent.

There is adequate documentation to illustrate the efficacy of silver and copper ions in water treatment, although most is from the USA where new technology is more rapidly assimilated. We in the UK in our wisdom, prefer to reinvent the wheel, and come to our own conclusions. In the present business climate, the acceptance of the technology of water ionising can only be beneficial to commerce and industry. I would like to highlight in this article the need, and demonstrate the efficacy of this alternative water treatment regime. One issue that can be addressed following this amendment is the urgent need for an on-stream treatment, which can be effective in controlling Legionellae, and the many types of bacteria and viruses found in stored water. The 'dead legs' created by dormant systems provide the breeding grounds for the bacteria, especially as temperatures in these systems can at times exceed the 20oC below which it is recommended to maintain water in storage. Obviously the long life residual of silver and copper ions, not affected by temperature, would be an essential in overcoming the potential health risk.

Further consideration can now be given to the need for annual cleaning and disinfecting of water storage and systems. There is no doubt that many tanks do not yet meet the current guidelines. However, the present recommendation, draining, physical cleaning of tanks and calorifiers, followed by chlorination to 50 ppm for up to eight hours with draw-down through the user points to ensure disinfection of the whole system is not always practical in all facilities. The cost of the operation and waste of water apart, especially where weekend working must be used, the potential lost production, the situation where shutting down in virtually impossible, the corrosion of chlorination can cause: there are many reasons why an alternative viable disinfection method can be seen as essential.

The electronic water purifier is a sophisticated system for dispensing ions of silver and copper into water. The purification by this means has been known and used for numerous years in the disinfection of water. Silver and copper are known to affect a number of micro-organisms including bacteria, viruses and algae. They are believed to interfere with enzymes involved in cellular respiration and to bind at specific sites to DNA. Much research and development of ionising systems and their application in industrial, commercial and domestic facilities has been undertaken in recent years. However, one aspect of the process is believed not to be available in all ionisers; the capability of automatic compensation for changes in water conductivity.

The waveform environment unit consists of an electronic control which is powered by a single-phase 240 volt supply. The power is converted to DC in a double-wound transformer and then to the electronic circuitry. A current is supplied from the electronics to

The author

Syd Garvey became an Associate Member of the Institute of Fuel in 1960, when developing evaporative cooling systems for the steel industry, original projects undertaken together with George Critchley, past President of the Institute , for Babcock and Wilcox Ltd. Since then he has been involved in business development for several major international contractors in the refinery and petrochemical industries.

More recently he has been a consultant in the field of energy conservation and environmental matters. He has been involved in the development of the application of electronic water purifiers for the past ten years and is now a consultant in environmental health and pollution control. Mr Garvey is a chartered engineer and a Fellow of the Institute of Energy.

sacrificial anodes of silver/copper alloy which are arranged in a chamber through which water to be treated is pumped. One anode or pair of anodes is positively charged and the other negative. The current is reversed every few minutes to give equal wear on the anodes. The ions of silver and copper released into the water are in a ratio such that the silver is sufficient to deal with the bacteria load and other protein mass to include viruses and the copper with the algae and fungi and in breaking down biofilm in which bacteria is harboured.

Control of the ionisation is set by the potentiometer on the control unit. The unit is set up and monitored by a simple test for copper levels in the treated water. The copper level in the water is checked before start-up and then the ioniser is operated at a high rate, usually 80% of its capability, for a period of time determined by the quantity of water to be treated, then the copper level is monitored regularly until it is at a predetermined level above the original level, at which the silver ions dispensed will be in proportion to the anode composition. When the copper level is reached the control can be adjusted back to maintain a steady output. Several adjustments may be necessary in achieving the ideal setting.

It must be understood that the silver present in the water as revealed by a laboratory test will vary considerably, especially when the ioniser is cleaning up a dirty system, as silver deviates to the protein mass in the water during which process the silver deproteinates the bacteria and viruses, and is thus not available for further use. Other factors having an effect on the ion output are pH, metallic levels in the water, chemical reactions that have taken place in the water and the effect these may have on measuring low concentrations of silver.

The need for automatic compensation for changes in water conductivity becomes obvious when different water supplies are considered. In a basic ioniser the ions produced are controlled by the output of the transformer. This output will be influenced by the conductivity of the water; the higher the conductivity, the more ions will be produced. Conversely, when the conductivity of the water is low there will be less ion production. It would be necessary to reset the output to meet any changes in water conductivity to produce a set of number of ions.

The simplest explanation of the use of the conductivity compensation is in the application of the unit to a Jacuzzi. Where a simple ioniser is installed in the circulating system, usually after the sand filter, it replaces or compliments the chemical biocide injection. When people enter the Jacuzzi pool, there is a rapid change of conductivity of the water due to the body fats and other contaminants they provide. The increase in conductivity causes a corresponding increase in ion production. The only redress is to hand set the control, or over-production of the ions could lead to excessive copper levels which may have harmful and cosmetic effects on the bathers.

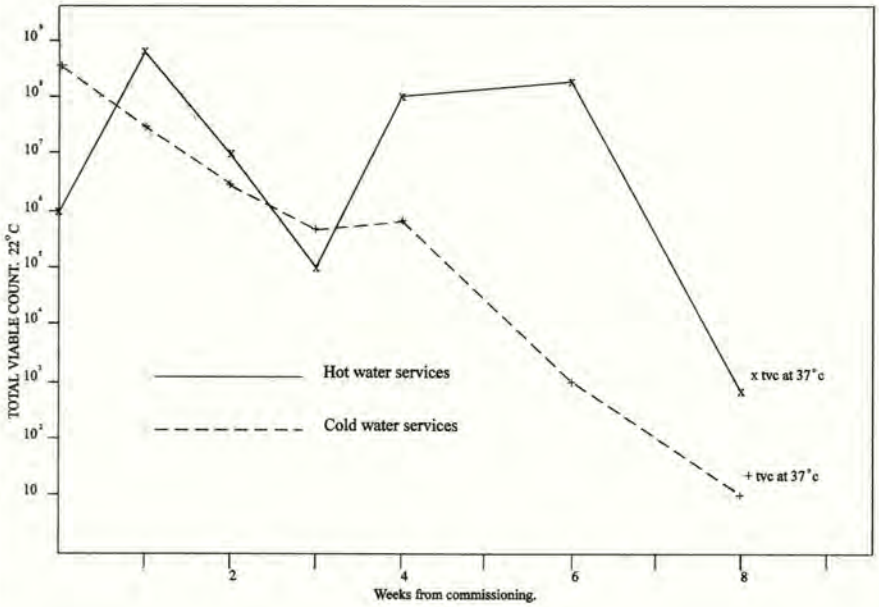
The automatic compensation capability of the waveform environmental unit in such a system prevents the over-production of ions as the ion output is cut back on rising conductivity to ensure the rate, as set originally, is maintained. The control method is via the electronics, thus overcoming the need for conductivity probes. This feature is important in many, if not all applications of the ioniser.

Where there is more than one water supply, for example from a borehole with mains alternative or supplies from two different dissolved solids level. An ioniser installed in such case requires the automatic compensation capability to ensure that, under the changing conditions the ion production rate is maintained as intended. A shortfall in ion production could, potentially, lead to a biologically unsafe water system. Over-production can be wasteful of anode material and can in some ionisers lead to burn-out of the electronic system.

Where the hardness in water, such as may be experienced in an unbalanced swimming pool, is very high the conductivity also being high, the anodes would require more frequent cleaning and again the electronic system may become overloaded if this is ignored. The automatic compensation reduces this risk.

The automatic compensation feature becomes of more importance in rapidly changing conductivity systems such as the jacuzzi mentioned above, plunge pools and cooling tower sump tanks. It also facilitates the unit to perform to its setting even when the anodes are near their replacement and the gap between them is very much greater than in the original state.

For industrial, commercial and large domestic systems a standard anode chamber is used. It has provision for two or four anodes as required. Where larger water treat-



Typical TVC reduction in an office domestic water system. The yo-yo effect is due to biofilm dispersal releasing bacteria in the system. The calorifier outlet temperature was 50°c max

Figure 1: This result from an actual application where the calorifier could only raise hot water to 50°C is included as it demonstrates what to expect in commencing with an old water system in which Legionella had been recorded on numerous occasions. Although the break tank from which the domestic water services was supplied has been cleaned, the mains supply in this development area in a major city varied in TVCs to higher than 10^5 from time to time. The office block was not fully occupied and to prevent over-ionising the system the output was kept low with the ioniser operated via a timer device. In the third week the ioniser was increased in output and run for longer periods which appeared to disperse biofilm in the system, releasing bacteria to the water services after which the TVCs fell dramatically.

This initial disinfection is to be expected. Chlorination alone does not rid the systems of biofilm, hence the need for on-line continuous disinfection by ionisation to maintain the hot and cold water services in a biologically safe condition.

During the above commissioning programme, Legionella was isolated in a sample from a dead leg where a tap was not frequently used. A second test after pulling ionised water through the tap proved negative.

ment requirements exist, units can be arranged in parallel. This provides for one unit to be serviced when others can remain on line. Each chamber requires its own electronic control unit.

The chamber is of materials approved by the Water Research Council. Connections are by 'T'ing off the flow with suitable isolating valves to facilitate servicing. By arranging the unit across a flowline valve, adjustment of this valve will provide sufficient flow through the anode chamber. Alternatively, a pumped circuit can be arranged to provide the flow through. Connections for flow and return are arranged to prevent sludge build-up in the chamber and to ensure sufficient flow across the anodes. The cover seal is by 'O' ring. The standard chamber is designed for 6 bar working pressure, but special units can be provided for higher pressures and where non-domestic water is to be treated.

When the ioniser is energised, ions of silver and copper are dispensed into the water. The actual quantity of ions produced is considerably more than is required for a particular application. The ions not immediately deviated to protein mass and algae in the water system remain as a long life residual. Actually, unless the ions are used up in the deviation process they remain indefinitely. This residual is all important. Chemical biocides are quickly dispersed and their efficacy reduced, depending on various conditions such as temperature and, in pools, the increase in surface area due to the wave of 'boiling' effect. Other water treatments such as ozone, UV, ultra-filtration and reverse osmosis provide no residual, therefore, a chemical biocide has been used. The ioniser provides a more permanent residual.

Whereas silver and copper ions are known to be effective in killing all known waterborne pathogens and reducing the bacteria and algae load in a water system, the time required to achieve this is longer than for chemical biocides such as chlorine. However, the concentrations required for chlorine to be totally effective against some bacteria such as Legionellae pneumophila are too high for practical and general use and can cause problems such as system corrosion. The research undertaken in USA clearly shows a synergy between silver and copper ions and low levels of chlorine, such that the bacteria load reduction is much more rapid when these are used together. A level of 40µg/l of silver in combination with 0.4 mg/l of free chlorine can achieve a reduction of a factor of 10 in Legionella levels in under 120 seconds. At this level chlorine is not detected in normal water supplies and is not considered to be harmful to humans. A chlorination device can be installed immediately after the anode chamber where other provision for chlorine injection is not present.

The initial setting up of the ioniser is described above. Once the copper level is stabilised, usually at 0.5 to 0.6 mg/l, depending on the system being treated, the unit will be functioning correctly. Silver tests taken in the first weeks of operation do not normally reflect a level corresponding to the copper level as the biofilm and other contaminants in the system are being dislodged. For most applications the copper level can be stabilised but the silver level rises and falls according to the water treatment taking place. For example, mains water entering the building can vary considerably from day to day in TVC (total viable count) levels, hence the silver will be deviated to reducing the bacteria. Resetting the ioniser control should not be necessary unless the TVC levels in the treated water remain high.

When the chlorine is injected at 0.4 mg/l the synergistic effect will assist in maintaining the silver at a more steady level but resetting should not be undertaken without determining the need for this action and in any case should not be based on silver levels alone.Monitoring at regular intervals is essential. The copper and chlorine levels should be taken by Lovibond comparator test kit or similar. These tests can be taken daily where the bathing load in swimming pools is heavy, or weekly for lightly used pools. It is normal also to test for pH at this interval, although the ionisation process is tolerant of pH. It is preferable to maintain the pH between 7.2 and 7.6, but in many applications this is not achievable: for example, where incoming mains exceed these levels and further correction is not warranted. For other applications, domestic water should be monitored in the storage tank at least monthly and similarly at the point of use. The various dispensing points, taps, mixers, showers should be tested in rotation. More frequent testing and action should be taken if TVC's at any point are high.

After commissioning a domestic system, flushing through all outlets regularly for several weeks will clean out the system after which the residual ions should maintain the system for long periods in a biologically safe state. Dipslide tests can be taken at intervals as a guide. A full laboratory test is required to determine the TVC and it is preferable to obtain a silver test at the same time, the first being at the first cleaning of the anodes, one or two months after start-up.

The anodes require to be checked at regular intervals and cleaned by wire brushing to remove scale or other deposits. Turning is required to even the wear. The ioniser potentiometer may need to be reset when the anodes are cleaned. Cleaning is usually every two months initially until a regular pattern of fouling is established, but for jacuzzis and plunge pools, and where hard water is treated the interval should be reduced.

Normally a contract service to clean the anodes and service the ioniser installations can be offered together with the recommended laboratory tests undertaken by an independent laboratory who issues the certificates.

In areas where the calcium salts in the water are high, scale will form in the water systems. Regardless of whether the pipework is plastic, copper or steel, it has a greater potential than the water and thereby attracts the minerals in what is referred to as seeding, nucleating and crystallising back to scale. Apart from the effect this has on heat exchange leading to higher fuel usage, the scale harbours bacteria. Scaling of the anode in the electronic water purification process leads to a severe reduction in ion output.

Waveform Environmental have developed an electronic scale prevention unit producing low frequency radio waves in the water in piped systems. The properly focused magnetic effect on the water created by the unit simply amplifies the potential (electromotive force) in the water making it greater than the potential of the pipework, therefore, the scale-forming minerals are reattracted to the water and the system is gradually cleaned up, thereafter remaining scale-free. Apart from harbouring bacteria the scale can cause corrosion due to the electrolysis between the scale and metal pipework. Therefore this is an essential part of the water treatment process and is much preferred to water softening where the replacement of the calcium by sodium produces aggressive water.

The Scale Prevention Unit can be applied to industrial, commercial and domestic water systems, whether or no the silver/copper ioniser system is installed.

In order to meet the requirements of the NHS estates for hospitals, and other potential outlets for the Waveform Environmental electronic water purification, to ensure accurate control of the levels of ionisation, two monitoring systems have now been developed. These will provide an on-line record of the silver and copper levels in the treated water which will permit safety in lowering domestic hot water temperatures.

The silver monitor was developed specially for the government adviser on Legionella control. The current comparator copper testing method cannot compensate for varying fluctuations in copper levels in the treated water. These monitors are a significant advance and should permit a wider use of ionisation.

In conclusion, this process has been applied to many problematic water systems with success; notably overcoming Legionella in large office blocks, etc, and in treating the spray-coil air humidification units in large air handling systems. It is also applied to horticultural water treatment. ❑

The author wishes to acknowledge the contributions of Major R E I Reid and Noel Parkinson.

Direct smelting

— shaping the iron and steel industry in the 21st century

*by R J Batterham, J F Abbott and B J Stone**

The following article is based on the 21st Idris Jones Memorial Lecture, delivered to the South Wales and West of England branch of the Institute of Energy, by one of the authors, Dr Robin Batterham. The lecture, sponsored by The RTZ Corporation plc and CRA Limited, was well attended in the delightful surroundings of Cardiff Castle, in April of this year.

FOR SOME time, North America, Western Europe and Japan have been suffering from over capacity, stagnant or falling demand and increasing environmental pressures, resulting in a need to produce less steel of better quality, in a cleaner and more cost effective manner. The disintegration of the former USSR has left the steel industries of Eastern Europe and the CIS in a state of disarray. By contrast, Asia, excluding Japan, the Middle East and Latin America have generally experienced strong growth in steel demand, and although to date this has primarily been in long products, the need for flat products from which to produce automobiles, whitegoods and other higher quality consumer goods is rapidly growing.

The combined effects of regional shifts in steel production through both technological change and the emergence of major new steel producers in the countries of the developing world, the crisis in the ex-Soviet bloc countries, and the creation of new regional economic areas (eg NAFTA), is driving substantial change in the structure of the world's steel industry.

During the 1960s and '70s, the trend was to build large integrated blast furnace/basic oxygen furnace (BF/BOF) steel plants with capacities ranging between 3 and 5 million tonnes per annum (Mtpa) in pursuit of economies of scale, with less attention to environmental considerations than current legislation requires. This trend has been reversed more recently in favour of smaller, cleaner, regionally focussed mini-mills, (perhaps now more appropriately termed midi-mills), typically with capabilities between 0.5 and 1 Mtpa.

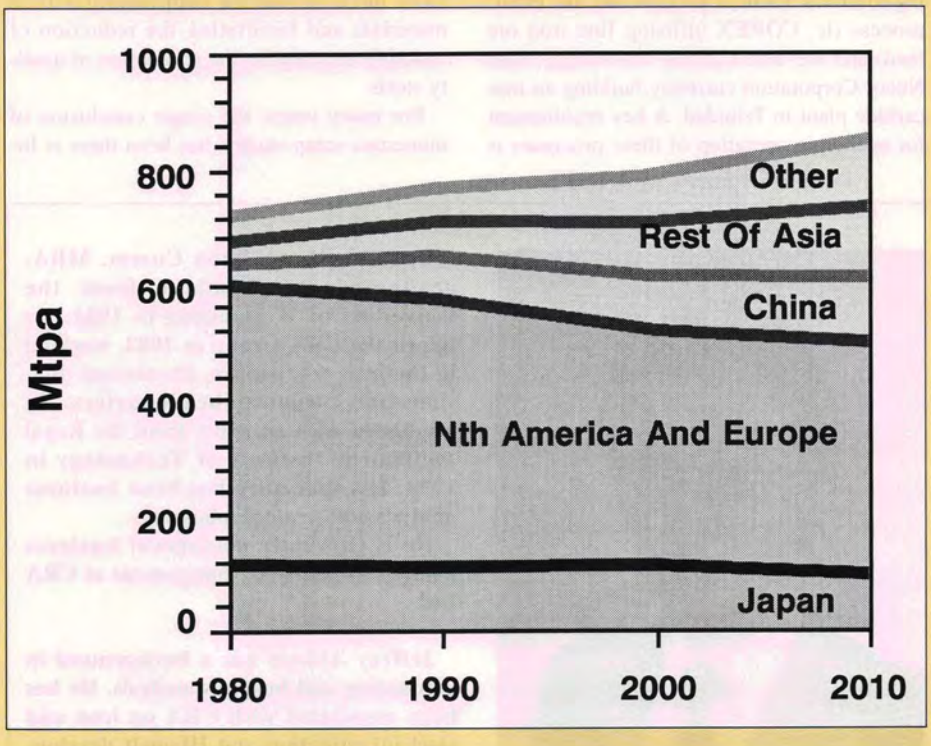


Figure 1: Projections for world crude steel production.

Lower barriers

As the capital cost of these smaller electric arc furnace (EAF) based units is much lower than the large integrated plants, the lower barriers to entry are expected to increase the number of new operators, as has recently been observed in the US, steel scrap may therefore be in short supply in developed countries.

While China's crude steel expansion plans appear committed to the traditional BF/BOF route for the foreseeable future, notwithstanding South Korea's recent and both Australia's and Taiwan's currently planned integrated steelworks expansions, with perhaps the exception of India, the most likely choice for the developed countries and the rest of Asia, the Middle East and Latin America, is an expansion of capacity via the EAF route.

With some exceptions, the countries of the developing world are generally deficient in raw materials, iron units in the form of steel scrap or direct reduced iron (DRI), and energy for steelmaking. Accordingly, if these nations are to entertain the expansion of EAF based steel capacity, they will need substan-

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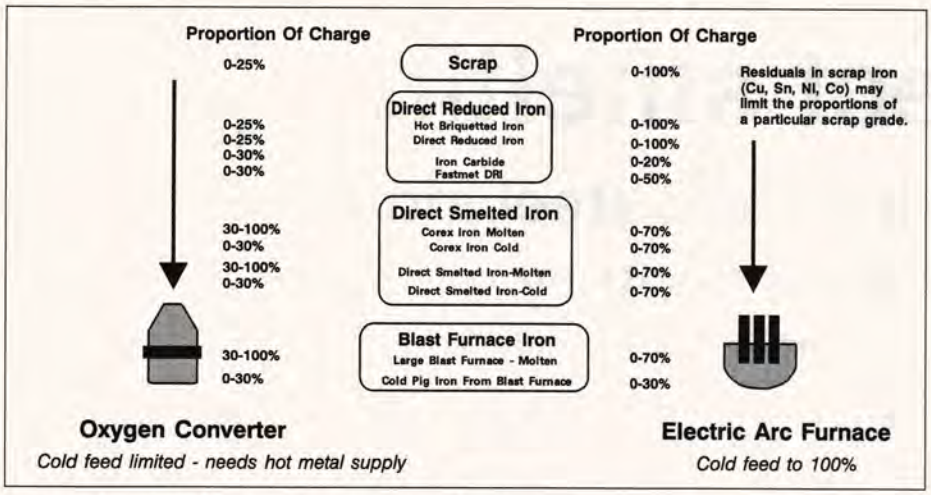

Figure 2: Technical limits on iron units for steelmaking.

tial increases in the availability of both iron units and electric power.

Because of problems in the supply of steel scrap in the developing countries, there is increasing interest in technological developments that hold the potential to allow greater utilisation of substitute iron units. While this is especially true for the EAF sector, it also holds for the integrated producers who may seek additional steel making capacity to expand downstream activities.

Existing technologies

Approximately 60% of world steel production is currently based on the integrated BF/BOF process route, utilising iron ore and coking coal as the major raw material inputs. Hot metal (or pig iron as it is known in its cold state) has been made in blast furnaces (BFs) for more than 500 years, and during that time, BFs have evolved into highly efficient reactors. However, they require intermediate products in the form of sinter and coke, which are costly to produce and have associated environmental disadvantages. Furthermore, for the blast furnace to be efficient, it must be very large, which makes it expensive to build.

Notwithstanding incremental improvements have been a feature of the BF/BOF technology's development, and despite the sophistication and maturity of the process, the industry's ability to further improve should not be underestimated. Environmental pressures on conventional ironmaking are intensifying. These reasons, combined with the market forces already discussed, suggest that favourable conditions exist for new approaches to ironmaking.

There are a number of other DRI processes under various stages of development, including Midrex's 'Fastmet' process and the 'Finex' process (ie, COREX utilising fine iron ore feed) and the 'Iron Carbide' technology, with Nucor Corporation currently building an iron carbide plant in Trinidad. A key requirement for economic operation of these processes is access to high quality iron ore feed stocks to minimise the slag production and higher energy consumption in the EAF which results from the gangue content in the DRI. So far, the plants tend to be located close to low cost natural gas supplies.

There is already considerable demand for a new direct smelting technology as evidenced by the worldwide interest, and number of orders placed or under serious consideration, for the 'COREX' process. The second generation of direct smelting processes have yet to reach commercialisation and, as the title of this paper suggests, will have their impact in the 21st century.

Technical limits

There are many sources of iron units for steelmaking, but all face technical limits on the proportion that can be utilised associated with the convenience of charging, heat loads, gas generation and removal, slag formation and removal, rates of melting and the chemistry of the melt and the slag. Without discussing these limits, it is noted both the EAF and oxygen converter can use a range of metallic feeds in proportions dependent on availability, price and technical factors.

Electric furnaces generally produce steel from steel scrap, or a combination of steel scrap, pig iron or DRI. With the trend towards producing higher quality steel products via the EAF route, the availability of high grade (low residual) scrap is under increasing pressure. To a degree, other metallics in the form of pig iron and DRI have been providing supplemental feed materials and facilitating the reduction of residuals in scrap for the production of quality steels.

For many years, the single conclusion of numerous scrap studies has been there is lit-

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Pictured right, Dr Robin Batterham.

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tle likelihood of a shortage of ferrous scrap in the foreseeable future. While that general prognosis, in a macro sense in terms of the total scrap pool, is most likely correct, the past pattern of producing only low to medium quality steel from the electric furnace sector is no longer valid, and as a consequence, a new level of demand for high grade metallics is developing. The EAF sector now produces much more than long products.

The quality aspect of scrap is becoming increasingly more important, and there are a number of concerns including residual impurities (tramp elements), the increased level of coated materials in the scrap pool which are being accelerated through recycling programs, and more stringent environmental regulations on both the processing and transport of the material. Scrap availability varies considerably from region to region, and in purely quantative terms, worldwide supply appears to be reasonably equated to demand, the main problems being wide price fluctuations, quality and local supply/demand imbalances.

In the quest to produce intermediate products in terms of seamless tube, SBQ and wire rod, mini-mills have required progressively better grades of scrap to meet customer specifications for quality steel. This has required cleaner metallics in the form of pig iron or DRI/HBI in their scrap charges, to dilute the impact of low grade (high residual) scrap inputs. More recently, flat products, where quality is crucial, are also being manufactured via EAF based technologies.

If as is forecast, electric furnace capability worldwide grows from its current level of around 30%, to 40%, or even 50%, and if a sizeable portion of that new capacity is dedicated to produce intermediate and flat products, then the demand for high grade (low residual) iron units must increase dramatically.

Estimates of international merchant pig iron trade suggest levels of something in excess of 25 million tonnes per annum. This merchant iron has typically originated from excess BF/BOF capacity in the western world, Eastern Europe and the CIS, and Latin America.

The availability of regular supplies of BF/BOF sourced merchant iron and its subsequent use in EAF steelmaking appears to vary extensively. Among the reasons put forward for this situation are:

- uncompetitive cost relative to scrap for non East European/CIS 'social' merchant iron;
- reluctance by iron producers to allocate the relatively small volumes of hot metal required for merchant iron in terms of total hot metal production;
- the higher margins from steel in times of strong demand giving preference to hot metal for steelmaking over merchant iron, and thus irregularity of supply;
- problems of slow melting and subsequent carbon boils in electric furnaces when using large 'pigs' rather than 'piglets' or granulated iron, and thus irregularity of supply;
- technical limits to the amount of cold BF/BOF pig iron than can be charged to an EAF (up to 30%).

Unpredictable

This said, pig iron from excess blast furnace capacity is a source of supply that is difficult to predict.

With world direct reduced iron (DRI) capacity estimated at around 30 Mtpa and production during 1993 of some 23.9 Mtpa, (1992 was 20.7 Mtpa) despite significant new capacity under construction of which most is captive, the absolute volume of the material is not, at present, a significant source of iron for the world's steelmakers.

CRI is produced by four main process technologies, namely: Midrex, Hyl, SL/RN and FIOR. Although Midrex is currently developing its Fastmet process based on iron ore fines and coal, the only commercial fines based process at present is FIOR.

Plans have recently been announced by FIOR, in concert with Voest Alpine, to develop a 1 Mtpa capacity FIOR II production facility in Venezuela. The FIOR II plant is understood to be an enhancement of the original FIOR I process which has operated successfully in Venezuela for almost 20 years.

The merchant trade in DRI/HBI is slowly growing, with 1993 merchant sales of 5.1 Mtpa (1992 was 3.6 Mtpa) being some 21% of world production.

Production facilities to date have been built to provide a source of captive iron in the gas-rich, scrap-deficient areas of the world, and this trend is expected to continue.

Iron carbide or Fe_3C, is described as a chemically pure, residual-free, granular solid, similar to beach sand in consistency. The iron carbide process uses hydrogen and carbon monoxide gases, rather than coke, to reduce iron ore in a fluid bed reactor. Operating costs are said to be about the same as for a Midrex plant, except that all costs of agglomerating iron ore into pellets and agglomerating the end product are avoided.

Nucor is constructing the world's first commercial iron carbide plant in Trinidad, scheduled to come on stream in mid 1994 and expected to produce the first useable product early in 1995. The majority of Nucor's production, if successful, will be utilised within the company's own steel plants.

Although it has yet to announce its intention, vis-a-vis installing an iron carbide plant, North Star Steel has been studying the process, in conjunction with Cleveland-Cliffs Inc for a number of years. An association between the two companies has been formed, with Lurgi being retained to flow sheet a commercial plant.

Mitsubishi Corporation of Japan, together with Clevelend Cliffs Inc have acquired licences for the iron carbide process in the Asian Pacific rim, including China, Malaysia, Brunei, Indonesia and Western Australia. Mitsubishi has also gained access to natural gas supplies in the foregoing countries. In the longer term, should the process prove successful at a commercial scale, iron carbide developments could herald a new source of substitute iron units.

FastMet is a process under development by the Midrex Corporation, based in Charlotte, NC, and described as suited for

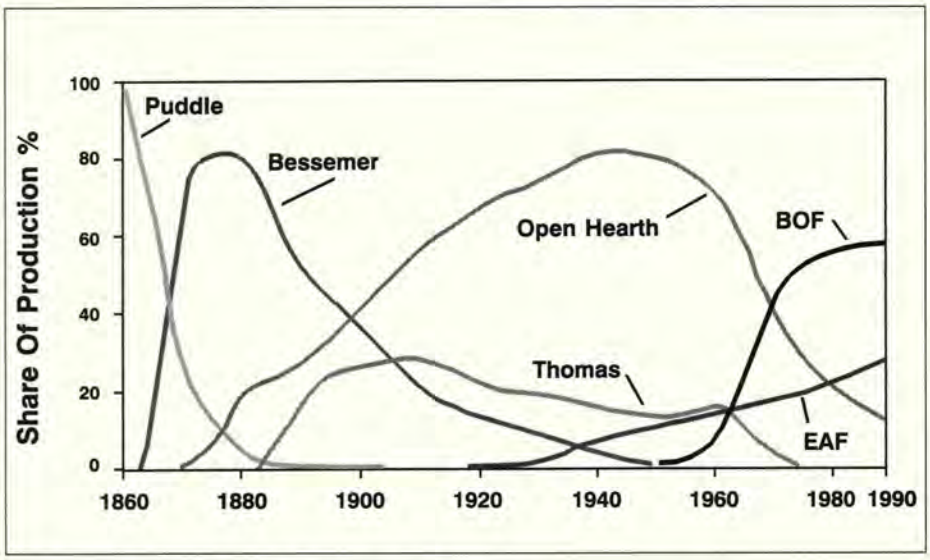


Figure 3: Changes in world steel production by process.

processing domestic iron oxide concentrates and coals. In FastMet, iron ore concentrate, reductant, and binder, are mixed together and pelletised. The green pellets are heated in a dryer to 125°C to remove moisture, and fed to the rotary hearth furnace where the pellets are placed on a rotating hearth in an even layer, one to two pellets deep. As the hearth rotates, pellets are heated to 1250-1350°C and the iron oxide is reduced to metallic iron. Residence time in the hearth is typically eight to 20 minutes. Metallisation can be controlled and adjusted up to 95%.

As a coal-based process, FastMet will not be tied to any specific country as far as energy costs are concerned. However, the product will contain impurities from the coal and high slag volumes will occur during steelmaking. The process still remains to be proven at scale.

There appears to be a considerable demand for new direct smelting technologies as a source of supply for virgin metallics.

However, the new smelt reduction processes under development are not expected to replace a significant proportion of the world's ageing blast furnace facilities until the next century. In addition, it is expected the product will find a significant market within the EAF sector, as a substitute for steel scrap, particularly in terms of the intermediate and flat product range of steels. As well, the iron from direct smelting may also be utilised by existing producers as they expand or replace downstream facilities.

Penetration rate of new technologies

History would suggest that the steel industry will move slowly towards any new, competitive steel making process. Bessemer steelmaking moved from the first commercial unit in 1855 to 75% of world steel production by 1870, after which it was steadily replaced by the open hearth and Thomas processes and later, the EAF. A century later, the BF/BOF process, which was first commercialised in 1948, became established during the 1950s, and expanded in the following 15 years. The OHF share of world steel production has declined from the majority of world steel output in 1950 to about 12% in 1992, with the BF/BOF and EAF technologies taking an increased share of the world market.

Although the EAF is in fact older than the BF/BOF process, it is only since the '70s that is has become a major steelmaking process. During the first half of the 20th century, EAF steel output grew very slowly, accounting for only 2% of worldwide production in 1930. Following a very long development and commercialisation period, the technology has been adopted by the steel industry, with production increasing tenfold over the period 1950—1990, from 20 million to 200 million tonnes.

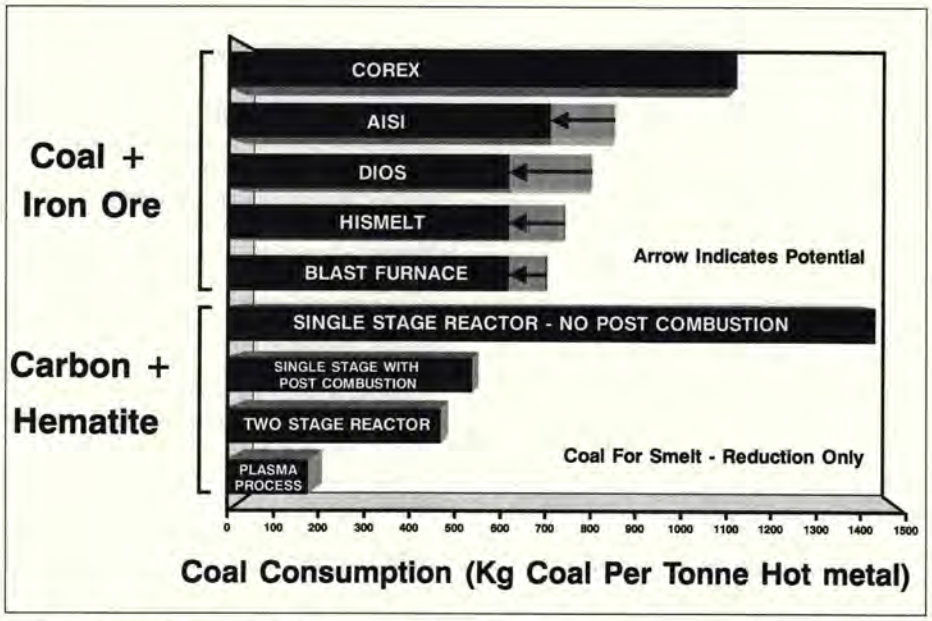


Figure 4: Coal consumption for various iron making processes.

The extent to which BF/BOF performance may be improved in the future will have a direct bearing on growth of the EAF sector, and the ultimate timing and degree of penetration the new direct smelting technologies may enjoy next century. The increased use of pulverised coal injection (PCI) is one avenue open to the integrated producers to reduce coke consumption rates and thus extend the economic life of existing coke making facilities. Tuyere injection of fine iron ore may also combine with PCI to lead to a reduction on BF/BOF costs. The oxygen blast furnace is another possibility with trials run in Russia some years ago. A cold blast nitrogen free furnace, known as CHAR DIN is also under development involving blowing cold oxygen through tuyeres of a slightly modified blast furnace, the top gas being recovered, CO_2 removed and recycled into the bosh to effect an efficient pre-reduction of the mineral burden. With a reduced capital cost, increased productivity and less polluting emissions, this process could be attractive.

Integrated producers are not likely to give up, but rather to continue to find ways of reducing costs, extending plant life and controlling environmental emissions. To the extent the BF/BOF operators are successful, they may provide some respite to the EAF penetration rate, but the race will still continue to develop a competitive direct smelting technology.

Based on past experience, adoption of direct smelting technology by the world steel industry is likely to be slow, and may provide some respite to the EAF penetration rate, but the race will still continue to develop a competitive direct smelting technology.

Based on past experience, adoption of direct smelting technology by the world steel industry is likely to be slow, and may take a considerable time to become a major source of iron supply.

Steelmill of the future

Views of the steelmill of the future have been articulated by several companies. As an example, Australia's Broken Hill Proprietary Ltd (BHP) has been establishing a number of downstream roll-forming businesses in Asia based on sheet produced and exported from Australia. With the growth in Asia and the trend towards domestic steel production and tariff barriers and other forms of protection, BHP has recently announced a strategy for participation in Asia's growing steel industry.

BHP is currently studying the feasibility of a A$4.2 billion project involving Pilbara iron ore, offshore Western Australian gas and a string of Pacific Rim mini-mills. The study involves the development of a A$1.1 billion DRI plant based in the Pilbara with at least 2.0 Mtpa of annual capacity. Energy would come from the development of a A$1 billion offshore gas field.

The third component involves the development of six mini-mills around the Pacific Rim at a cost of A$2.1 billion, acting as a captive market for the Pilbara DRI. Such a strategy reflects industry trends into the 21st century, as the EAF based mini-mill, servicing a regional market, becomes the dominant steel making technology in the world industry. It should be noted that BHP are also active in the development of thin strip casting and that the combination of an EAF mill with thin strip casting may yield compelling economic advantages.

As mentioned earlier, what may be regarded as the first generation of the new direct smelting technologies known as the COREX

process is currently operating in South Africa. Several second generation development projects are under way in a number of countries around the world, including CRA's HIsmelt project at Kwinan in Western Australia; the DIOS project in Japan; various developments by European steelmakers; and the AISI project in North America.

There are three key drivers in the development of direct smelting processes: energy costs, the elimination of coke and the use of fine iron ores rather than lump ores, sinter of pellets. Consider first the energy costs, focusing on the prime cost, viz coal (which may be in the form of coke).

Steelmaking has long been a fertile field for the efficient and cost effective use of energy. Modern steel works are well integrated with waste heat recovery, use of waste gas for preheating, avoidance of solidification and remelting, use of residual heat in hot metal for ladle or torpedo treatment, etc. The blast furnace itself is a very efficient counter current reactor, both chemically and thermally. Against this background and with the pressures mounting to minimise production of greenhouse gases, smelt reduction processes might be considered to bring some improvements in the coal consumption for steel making. Improvements here however may be fairly small.

Consider first a theoretical smelt reduction process running on hematite and pure carbon in a single stage reactor. As shown in Figure 4, the carbon required for the heat for the endothermic reduction, expressed as an equivalent amount of coal, is of the order of 1450 kg per tonne of hot metal produced. This is under the condition where the gas leaving the reactor is in equilibrium with the melt in the reactor. Under that condition, the gas is largely CO and only about 20% of the heating value of the coal has been utilised. This is fine if the huge volumes of gas can be utilised elsewhere.

Post combustion

More normally, we need to combust the CO to CO_2 and transfer the heat to the melt — a process called post combustion. The carbon requirement expressed as a coal equivalent is dramatically reduced to the order of 570 kg per tonne of hot metal for a single stage reactor and to around 500 kg per tonne of hot metal for a two stage reactor in which the hematite is preheated by the exit gases. This is still well ahead of the requirement for reduction only of around 180 kg per tonne of hot metal. Plasma processes which supply all of the energy externally can approach this limit.

For real processes running on coal and iron ore, the consumptions are somewhat higher. COREX, with its coproduction off-gas is the highest energy consumer of the

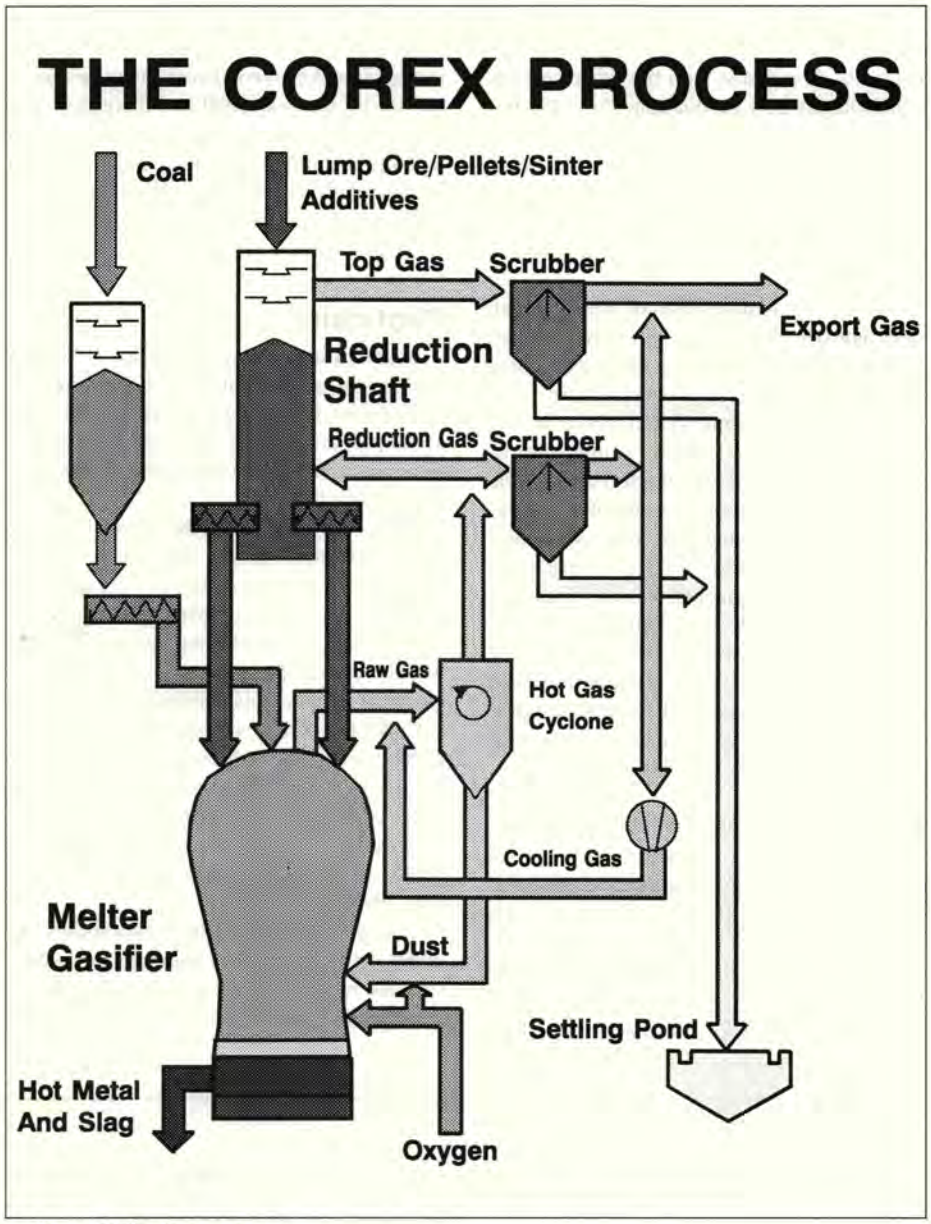


Figure 5: The Corex process.

smelt reduction processes. The others are comparable and approach the levels of an optimised blast furnace in an integrated works — quite an achievement for an inherently simpler process. The blast furnace figures are given as a coal equivalent but do not include the coke consumed in the sinter plant.

The common thread of all direct smelting efforts is to develop an iron-making process that does not depend extensively on coke.

- The COREX process is a first generation direct smelting process with features between the existing blast furnace process and later direct-smelting technologies. It uses coal rather than coke and thus overcomes the need for coke ovens. Iron ore is fed to the process either as lump or pellets. Deutsche Voest Alpine (DVA) has constructed a demonstration plant in South Africa which, after significant initial operating problems, is achieving production rates close to a nominal capacity of 0.3 Mtpa. DVA is now vigorously promoting the COREX process worldwide.

An essential component of the economics of the COREX process is the effective utilisation of the high calorific value off-gas. There is considerable interest, particularly in areas where excess off-gas can be used economically to generate power in combined cycle generators.

- The American National Project (AISI) was approved by the US Government's Department of Energy (DOE) in 1989, at which time they undertook to provide US$22 million in funding for the project, in addition to the US$7 million which the American Iron and Steel Institute (AISI) was contributing. More recent reports indicate the US has earmarked a further US$18 million to take its project up to the end of 1993. Limited test

work is continuing into 1994 where the focus of activities involves steel works dust smelting trials. In contrast with the other projects which target iron production, the AISI has stated a long-term objective of developing a direct route to steel and the process is being configured to produce a semi-steel product (low carbon content hot metal) which will be continuously desulphurised and converted to steel.

To meet the requirements of the American steel industry, the process will utilise a pellet feed pre-reduced to wustite and is also stated to have the ability to smelt scrap. The process employs submerged combustion in a foaming slag which exhibits similar performance and operating characteristics to the Japanese DIOS process. Testing of a conventional vertical steelmaking vessel was completed in 1991. The vertical vessel was replaced with a horizontal vessel which was reported to employ two smelting zones and utilise countercurrent flow of metal and slag to achieve a low carbon product and high process intensity. The AISI recently installed a third vertical vessel as the horizontal vessel experienced problems with liquid containment.

- The Japanese National Project (DIOS) involving eight major Japanese steel mills in collaboration with the Coal Mining Research Centre, and with financial support from MITI, have been developing the direct iron ore smelting (DIOS) process since 1988. Like the AISI, the DIOS process is a deep slag process. It is also designed to directly reduce non-coking coal and fine iron ore without the need for sintering, as a reluctant for aging coke ovens forecast to be out of service by the year 2000 and thereafter. The exclusion of coke ovens and sinter plants will significantly reduce the captial cost of a commercial plant and the utilisation of non-coking coals will enable flexible raw material supply sources.

Pilot plant

A pilot plant was constructed at NKK's Keihin works and commenced operations on 14 October 1993. Design capacity was 500 tonne per day and the pilot plant is claimed to be currently producing 40-60 tonnes each two to three hours.

On 7 February 1994, the Japan Iron and Steel Federation (JISF) announced that the planned 144 hours continuous operation had been successfully completed the previous day during the second campaign and that this was the critical prerequisite to the final goal of 20 days continuous operation.

Under the current schedule, DIOS plans to conduct campaigns three through six (comprising extended continuous operation and water cooling tests designed to extend vessel life) during the 1994 fiscal year, and campaigns seven through nine during the fiscal year 1995.

Several smelt reduction technologies are under development that use the less expensive and more abundant iron ore fines directly rather than lump ore, sinter or pellets. The processes are environmentally superior to current BF/BOF technologies and with the absence of sinter plants and coke ovens, both capital and operating costs should be intrinsically lower. The smaller scale of these processes relative to the BF/BOF, enables location to service regional markets, and the processes are not gas dependent, as is the case with DRI. While it would be possible to supply the product in hot form if located adjacent to an EAF steel shop, with resultant cost savings, the material in cold form provides a high quality, low carbon metallic feed capable of forming up to 70% of an EAF charge, compared to a maximum 30% for cold BF/BOF pig iron, 20% for iron carbide, or up to 50% for Fastmet DRI.

- The Cyclone Converter Furnace is a joint venture between British Steel and Hoogovens was formed to replace the abandoned converted blast furnace concept tested at pilot scale in the early '80s. Process development is now being pursued by Hoogovens and an Italian steelmaker with EEC funding support. The revised smelting reduction concept involves the smelting of the iron ore feed in a water cooled cyclone reactor to produce a mixture of liquid wustite and magnetite. The smelter is fuelled by the off-gases from a direct coupled bath smelting furnace, where the final reduction of the molten ore is completed. Direct coupling of the cyclone smelter to a pneumatic direct smelting liquid bath process is the significant improvement over the original INRED direct smelting process.

Post combustion of 20% in the smaller and up to 80% in the cyclone reactor are claimed to give a coal consumption of approximately 600 kg per tonne of hot metal. Pilot testing of each unit has been completed separately. The partners are currently planning a demonstration plant.

- The Jupiter Process is being jointly developed by IRSID and Thyssen. It is a coal fuelled, fines based fluid bed process that feeds highly metallised material to an EAF for final reduction. The two process stages are uncoupled. Jupiter has its origins in the fluidised bed technology developed for the now abandoned ELRED process developed in Sweden in the late 70s. Significant advances in the fluid bed reduction technology and the application of off-gas scrubbing and recycling offer the potential of very low fuel consumption with this process.

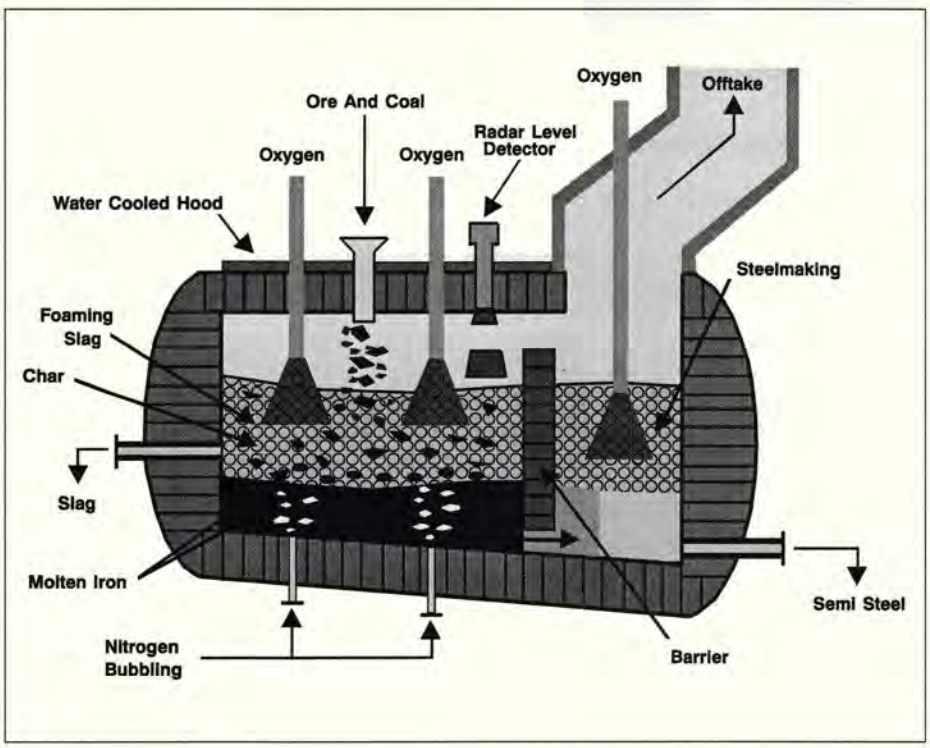


Figure 6: Conceptual AISI direct steelmaking.

The HIsmelt process

At the core of the HIsmelt process is a closed molten-iron bath reactor referred to as the smelt reduction vessel (SRV). Hot prereduced ore, ore fines, coal and fluxes, are injected into the molten iron charge. The coal is 'cracked', releasing carbon into the bath and carbon monoxide and hydrogen into the

top gas space. Post combustion (PC) of the gases releases the energy which sustains the process reactions.

The iron ore injected into the bath is smelted, producing metallic iron and slag, both of which are tapped from the SRV. The effectiveness of the process depends on the efficiency with which the heat of the (PC) reactions is transferred back into the molten bath in terms of the heat transfer efficiency (HTE).

At a cost of over US$100 million, a large-scale pilot plant with a nominal design of 100 000 tonnes per annum has been constructed and commissioned at Kwinana in West Australia. Initial results are encouraging.

At present, the HIsmelt joint venture is the only group pursuing a 'gas continuous top space' based direct smelting technology (as opposed to the deep slag bath-based Japanese DIOS and American AISI processes). The relative merits of the two approaches have yet to be established in a commercial arena. A schematic comparison of the two distinct process technologies can be seen in Figure 8.

Process development

Davy McKee (Stockton) Ltd (DMSL), an internationally recognised engineering and technical consultant to the world steel industry, in joint venture with CRA's wholly owned engineering subsidiary, Minenco Pty Ltd (Minenco), was responsible for the engineering and construction management of the HIsmelt Research and Development Facility (HRDF) which was commissioned at Kwinana in Western Australia late in 1993. The facility is currently undertaking further research and development activities designed to prove up to the process. DMSL also provided engineering services to the HIsmelt project.

Development of the HIsmelt process has had significant involvement by consultants, particularly the Commonwealth Scientific and Industrial Research Organisation Division of Mineral and Process Engineering (CSIRO DMPE).

CSIRO has undertaken work in a number of fundamental research areas related to the process development under a collaborative research agreement with CRA since 1982. Their particular expertise has focused on pyrometallurgical smelting fundamentals involving simulation and modelling of:

- direct reduction processes;
- iron bath processes (steel, direct smelting, coal gasification, etc);
- circulating fluidised bed processing;
- process flowsheeting options;
- injection technology fluid mechanics.

A focused research effort has also involved the characterisation of raw materials for use in new smelting technologies and the development of new instruments targeted at improving process understanding and simplifying process control. Their involvement in the project will continue.

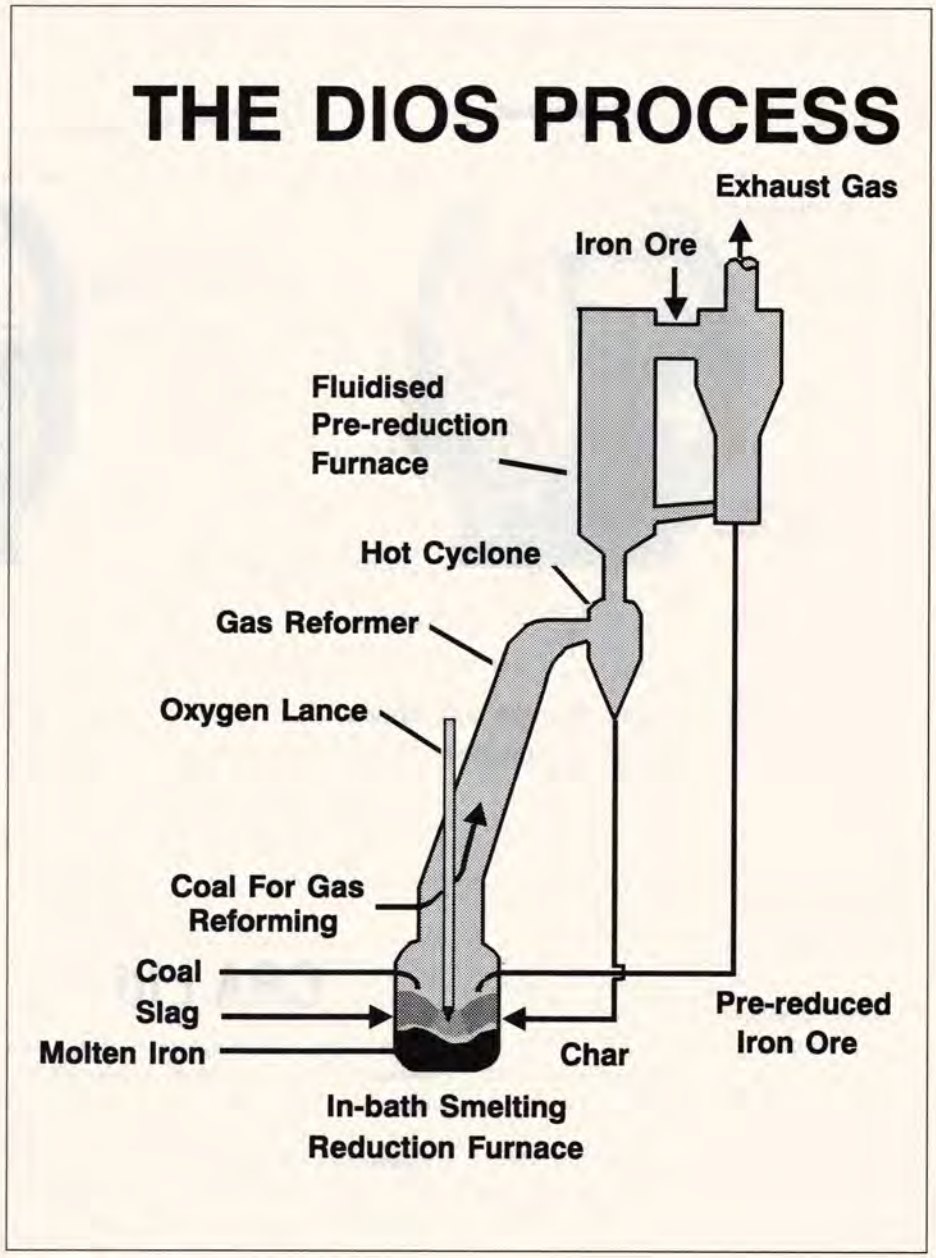


Figure 7: The DIOS process

Other consultants include CHAM Ltd, in the UK, a computational fluid dynamics consulting company contracted by CRA to model the physiochemical phenomena occurring in the top space of the HIsmelt smelt reduction vessel (SRV). This effort commenced in 1983, and has recently been transferred to CRA in Western Australia. UK-based University of Greenwich provide consulting services to the joint venture, and are principally concerned with supervising the modelling work undertaken by both CHAM and CSIRO.

CRA's Advanced Technical Development Division (ATD) is also developing an advanced process control system for the HRDF based on the latest process simulation and advanced control techniques. Facilities to examine the refractory bricks used by HIsmelt have been established at ATD to aid in the interpretation of the highly critical area of refractory performance during the HRDF's operation. The group also provides HIsmelt with computing and laboratory assistance.

HIsmelt has a joint development agreement with A Ahlstrom Corporation, from Finland, to develop a prereduction system for the HIsmelt process based on the original concepts imbedded in Ahlstrom's 'Fluxflow' off-gas cleaning and heat recovery, circulating fluidised bed technology. Ahlstrom is supplying the prereduction system for the HRDF.

CRA's partner in the HIsmelt joint venture,

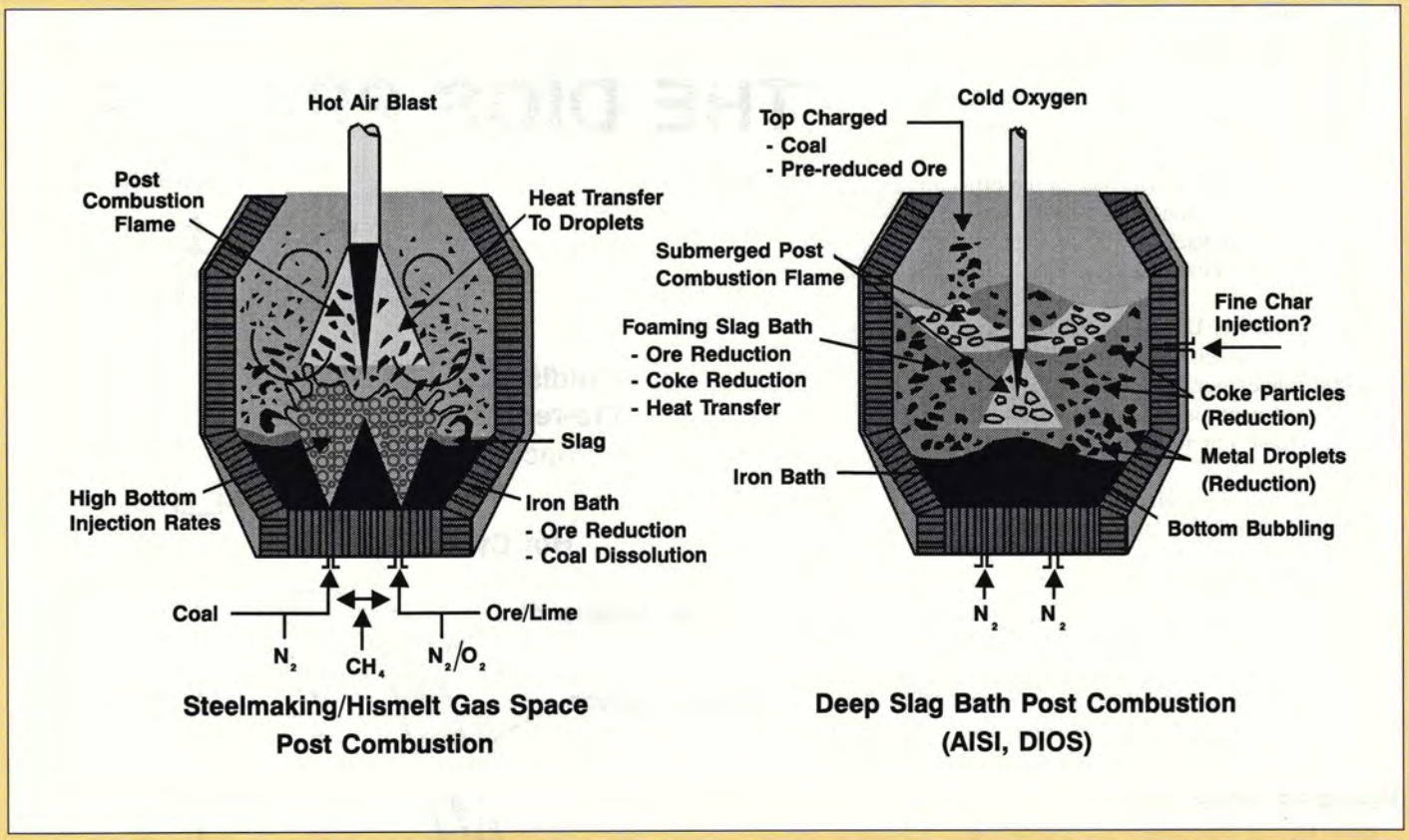


Figure 8: Comparison of direct smelting process technologies.

the Midrex Corporation, has its own technical centre and through its parent company has access to substantial research and development facilities.

The world steelmakers currently produce over 700 million tonnes of crude steel per annum, some 30% or so by EAF technologies, close to 12% by the OHF process which is progressively being closed, and the remainder by the BF/BOF route. The factors that have encouraged the growth of the EAF's are expected to continue. The result will be a strong demand in the near future for additional sources of new iron units.

To meet this demand, a number of government-sponsored initiatives, together with various private sector enterprises around the world are involved in a race to develop the next generation of iron and steelmaking technologies. In addition, the industry is constantly striving to enhance the existing processes in an effort to remain competitive.

It is too early to conclude who will win the race to develop the new generation of iron and steelmaking technologies. At CRA we have confidence that the HIsmelt joint venture will be one of the leading names in the 21st century. ❑

CRA Ltd

CRA, which is majority Australian owned and controlled, is one of the world's leading mining, metals and resource companies. The CRA Group comprises wholly and partly -owned companies with world-scale resources and assets covering many essential minerals and metals.

CRA is a major integrated producer of aluminium through its 67% owned subsidiary, Comalco Ltd, one of the world's largest producers of iron ore and diamonds, and a major producer of steaming coal through its major interests in a number of world class steaming coal mines, including its 71% interest in Coal & Allied Industries Ltd. CRA is also an important producer of salt and has further significant interests in zinc, lead and silver production through its 31%ownership of Pasminco Ltd, and has developed substantial gold resources in Australia and Indonesia. Bougainville Copper Ltd, owned 53.6% by CRA, is the owner of one of the world's major copper and gold mines.

Shares in CRA are held by The RTZ Corporation plc (49%), and by institutional and public shareholders located principally in Australia. The twenty largest shareholders hold around 81% of CRA's issued capital.

The CRA Group originated in 1905 with the formation of The Zinc Corporation Ltd, to treat zinc-bearing residues at Broken Hill in New South Wales. In 1962, Zinc Corporation merged with the Australian interests of The Rio Tinto Company Ltd, of the UK (later renamed The RTZ Corporation).

CRA controls world class resources in minerals, some not yet developed, which offer strong growth potential. CRA has a strong commitment to both exploration and technological development in order to provide further opportunities for growth and to maintain and enhance the international competitivenes of existing operations.

Pioneer in waste heat recovery

by Steve Minett

Stockholm's water company is proving itself a pioneer, not just in water quality standards, but also in environmental protection and waste heat recovery. This article describes three of their projects: waste heat recovery from a treatment plant's discharge water; a district air-conditioning system using pumped lake water, and gas turbines powered by methane from digested sludge.

STOCKHOLM is a city built on a group of islands, between Lake Malaren and the Baltic. Historically it was often characterised as 'the city between the bridges'

Since it was founded in the thirteenth century, the city has used its abundance of surrounding water as a mode of transport, and as a source of water for both domestic and industrial purposes. In addition it was a receptacle for all manner of discharges — sewage, industrial waste water and other effluents. For centuries these were dispatched into the lakes without any form of treatment whatsoever. In early modern times, as the city expanded rapidly, the waters around the city became significantly contaminated. Nevertheless, Stockholm's first drinking water plant was built only 130 years ago, and its first sewage treatment works, 60 years ago.

Now, however, the city water company (which is wholly owned by Stockholm City Council) has established an enviable record, not only for stringent water quality standards in and around the city, but also for its pioneering work with environmental and waste energy recovery projects. This article describes three examples of what Stockholm Water is doing in this field.

Warm discharge water for a heat pump. When water emerges from a treatment plant it is fairly warm: between 14-16°C all year round. The heat comes into the plant in the waste water, already warm, as it comes from indoor environments, and has admixtures of hot water from baths, washing and so on. Ordinarily this warmth is lost to the environment as waste heat.

In the late 1980s, however, Stockholm Water and Stockholm Energi conceived a plan to exploit this source of heat by passing the water through a heat pump at one of the city's district heating systems. A tunnel was going to be built to carry the water discharged by the Bromma treatment plant, on the western side of Stockholm, out to the waters of the Baltic.

The tunnel idea was part of a master plan to ensure that no treated waste water should be discharged into the eastern part of Lake Malaren, which is the inner lake of Stockholm and also the city's major source of drinking water. One tunnel was built to transport the warm water discharged at Bromma directly to a heat pump at the Solna district heating plant. Another tunnel, called the Saltsjo tunnel, takes water from the heating plant to the Saltsjo (Saltsjo is the name of the body of water which stretches from the eastern side of Stockholm to the open Baltic). This tunnel was completed in 1989. It was driven by a full boring machine through solid granite at a depth of about 50m under the city. The sides of the tunnel are smooth and hard enough to allow the water to flow directly through it, without lining pipes. When it reaches the heat pump, the water has a temperature of 12 to 16°C. Having passed through the heat pump, its temperature can go as low as 1°C. The now cold water passes along the rest of the tunnel and out the Baltic, to the east of Stockholm.

It didn't take long before it occurred to the ingenious people at Stockholm Water that this cold water, running conveniently under the city centre, might also have a viable application. Discussions were started with a large company which operates major computer facilities in Stockholm. The cold water could be used to help maintain the correct, constant temperature for their computers. "We were fairly close to signing a contract on this deal," says Brita Forssberg, Head of Information at Stockholm Water, "when the Stockholm Energi company entered the picture. The energy company had heard about this possible single-building, cooling system

The author

Freelance journalist Steve Minett also works as a technical writer, language and press consultant.

A politics graduate from the University of Sussex, he went to Sweden to take his MA at Stockholm University, where he also taught organisation theory for a period of four years. In 1989 he received research grant from a Swedish fund to carry out a study of decision-making in 450 Swedish companies. He published a book, as a result of the study, in 1992.

In the same year Steve founded his own company, Minett Media, forming a network with First Edition Translations and Omega, a design company. The network was contracted to produce IMO AB's international magazine last year.

He is a member of the Society of Authors, and also of the British Association of Industrial Editors.

and suggested a much more sophisticated development of it, on which our two companies could cooperate."

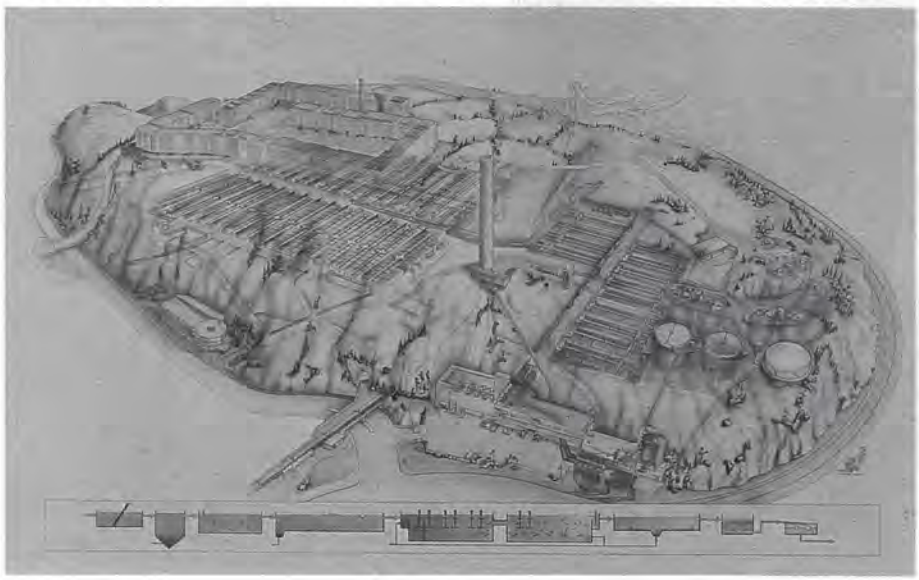
District cooling

Here again, the idea for the project has been made possible by the existence of the Saltsjo tunnel. The concept (which is still only at the planning stage) is to create what might be described as a 'district cooling system'.

A dense population of office buildings in central Stockholm, many directly under the tunnel, could use the cold water to operate their air conditioning systems. If established this would probably be the only cooling system of its kind in the world. There are some other cooling schemes in operation, but they use more conventional air conditioning technology.

The change in technology is one of the key motivations for this project. Legislation is being introduced to restrict the use of freon in air conditioning systems. District cooling could provide a freon-free alternative. This would have both the obvious environmental advantage and also a cost advantage because conversion to district cooling would be cheaper than having to replace all the freon systems with alternative, non-freon air conditioning systems.

A district cooling system for central Stockholm would, however, involve modification of the Saltsjo tunnel system,. The discharge water from the Bromma treatment plant would not be an adequate medium for a cooling system on this scale. It's only used for heat recovery during the cold months of the year. During the summer its temperature can rise to 15 or 16°C. The solution is to pump cold water from the bottom layers of Saltsjo, up into the tunnel. Water from these depths has a constant temperature of 5 to 6°C, even in summer. This water, however, would be travelling in the opposite direction to the Bromma discharge water, so there would have to be a system of pipework in the tunnel to accommodate flows in two directions.



An aerial view of the Henriksdal treatment plant (above). Below a diagram of the same plant.

Stockholm in Sweden.

A third energy-environment project at Stockholm Water is the installation of methane gas turbines at its Henriksdal treatment plant, in south central Stockholm. The methane comes from the plant's sludge digesters. Before the turbines were installed, the gas was burnt in boilers to provide part of the hot water supply for a local district heating system. Now the methane goes straight into the gas turbine to produce electricity.

This new arrangement has two distinct advantages. The first is greater safety. Henriksdal is a very unusual plant in the sense that most of it is located in underground rock caverns, excavated out of solid granite. Storing and/or piping out an explosive gas in such an underground environment obviously involved an element of risk. It's much safer to consume the gas immediately in the plant to produce electricity.

The second advantage is that the new turbines provide an economic (and environmentally friendly) way of generating the extra power which the plant now requires. The additional electricity consumption at Henriksdal is needed for its future nitrogen removal process. This involves an enlarged aeration system, with a significant amount of electricity operated equipment. ❑

● *Article by courtesy of Anglian Water Processes.*

District heating

The district method of heating employs a single, central boiler house to supply hot water, via a network of pipes, to whole communities, often as large as 300 000 people. Heat losses in such systems are low, usually less than 10%. The hot water used is normally metered and each customer is charged accordingly. In the post-war period, district heating has become more and more common in Scandanavia, and Sweden, for example, now supplies heating and hot water to half of the country's residential and commercial properties.

Meeting the environmental challenge

AN ADVANCED water clean-up scheme: the environmental quality improvement project (EQUIP), was opened at the end of June at the Shell Stanlow manufacturing complex at Ellesmere Port in Cheshire.

The complex is the larger of Shell's two UK refineries, and the fifth largest of their 53 refineries worldwide. Stanlow is a combined oil refinery and chemical manufacturing plant, occupying 1800 acres of land alongside the Manchester ship canal. The complex has a crude oil processing capacity of 262 000 barrels per day (bpd).

Costing £35 million, EQUIP represents the largest single UK environmental investment by Shell to date. The custom-designed system will clean thousands of tons of water discharging daily from Stanlow to rivers and streams feeding the River Mersey.

The water in Stanlow's operations consists of cooling, process and surface water. The cooling water is drawn from, and then discharged back into, the Manchester ship canal at a rate of 6250 tons per hour, and stays clean, therefore having no clean up requirement. The process water, however, comes into contact with hydrocarbons, emerging as condensed steam from inside the processing equipment. And surface water (mainly rainwater) picks up traces of oil and dirt from the ground. Surface and process water is discharged at a rate of up to 600 tons per hour (6 million tons per annum).

Shell's biggest UK environmental investment to date was officially opened at the end of June this year. Local MP Andrew Miller has expressed the hope that others will follow Shell's example, and also help to improve pollution levels in the Mersey Basin.

Before the advent of EQUIP, water treatment at the refinery complex consisted of 37 interceptors, skimming off oil and dirt. Any traces that escaped were dealt with by the double boom and skimmer equipment at the main water outfall. Although the overall cleanliness of the water was well within National Rivers Authority (NRA) limits, pollution levels had, on occasion, peaked above the NRA's consent levels. Shell decided this situation was unacceptable.

By 1988, existing equipment was nearing the limit of its capacity, and was not well placed to comply with rising environmental standards in the future. The resultant trace of oil and dirt was not at a consistently low level of oxygen — essential for the bacteria who eliminate any microscopic traces of oil and dirt to thrive.

EQUIP is the culmination of six years research and development by Stanlow engineers, in collaboration with Shell International and Shell Research Ltd. Construction work began in October 1992, and was completed by the end of 1993. Preliminary trials during the first six months of this year have shown that EQUIP removes up to 95% of oil and dirt from discharge waters.

The project began with a major research study of the site's water use, which analysed all potential sources of contamination. Flow measurements, sampling and testing were carried out at all 12 of Stanlow's production units, which had a total of 21 water outfalls — all eventually feeding back into the Mersey. The first stage was to rationalise the number of water outfalls, from 12 to four — achieved by the construction of 20 km of piping and 43 pumps. Six giant oil storage tanks were converted and refurbished to hold contaminated water awaiting treatment, preventing damaging overflows within the system.

The existing 37 interceptor pits were upgraded with new plate racks and better skimmers, for more effective removal of oil and dirt; with two dissolved air floatation (DAF) units to supplement the interceptors, boosting their cleaning and filtering work. DAF units inject millions of tiny air bubbles into the water, which rise to the surface carrying the contaminating droplets of oil and water. These are then skimmed off for incineration. A third DAF unit, the largest, is used for intensive treatment of the process water — traditionally the most difficult to purify.

Incineration facilities at Stanlow have also been upgraded, and destroy all the oil and dirt skimmed off by the interceptors and DAF units. They also provide an energy recovery system: burning the skimmed-off sludge to make steam for use in site processes.

Thornton Brook is one of the streams used

Aerial view of Stanlow Manufacturing Complex, which has a crude oil processing capacity of 262 000 bpd.

Mr Andrew Miller (far right), MP for Ellemere Port and Neston, formally opened EQUIP, by switching on the specially-built fountain, through which clean water will flow as a permanent feature of the site. Also pictured are David Varney, managing director of Shell UK Downsteream Oil (left), and Chris Gillies, manager of the Stanlow Manufacturing Complex.

by Stanlow for discharge of surface and process water. It was this section of the project that won an award for Business and Environment Achievement in October 1993. A special combination of filtering and DAF unit 'bubble-skimming' cuts dirt traces in half and oil traces by up to 90%. Thornton Brook has seen the return of mute swans, teal, mallard, dabchick and fish.

Andrew Millar, MP for Ellesmere Port and Neston, formally opened EQUIP, by switching on a specially-built fountain, through which the clean water will flow as a permanent feature of the site. "The petrochemical industry presents enormous benefits and challenges to this community," said Mr Miller. "I am delighted that Shell are meeting this challenge in such a positive way. Everybody involved int he campaign to clean up the Mersey Basin will welcome this investment. I hope other industries in our community will follow this lead."

EQUIP is fully supported by the National Rivers Authority. Dr Chris Harpley of NRA's North West region said: "We very much welcome this major contribution to cleaner rivers and streams on Merseyside. We are particularly pleased with the high degree of consultation we were able to have with Shell at every stage, and the company's receptiveness to our advice. It has been an important learning experience in managing water quality, and we hope the expertise gained can be spread to similar projects elsewhere."

The EQUIP project is in two phases. Phase one, the major part of the work, was completed on time and to budget. Phase two will consist of a year-long investigation and performance analysis, to help establish whether further refinements, such as a biotreater, can provide any further benefits. An additional £35 million has been earmarked, should any further requirements be identified. ❑

EQUIP has three DAF (dissolved air floatation) units. The largest DAF unit, pictured above, gives particularly intensive treatment to the process water. DAF units inject millions of tiny air bubbles into the water. The bubbles rise to the surface carrying droplets of oil and dirt which are skimmed off for incineration.

A cost effective system for high purity deionised water production

by Roy Bolton and Bill Dearie***

A LICENCE agreement covering the use of the Amberpack® system for deionisation plants has been signed between Thompson Kennicott Ltd, a member of the Rolls-Royce Industrial Power Group, and Rohm and Haas (UK) Ltd.

Thompson Kenicott is a major water treatment company providing a total capability in water treatment engineering, from conceptual design and detail engineering, to supply, installation and commissioning of plant.

The company is based in the West Midlands, and with over 90 years' experience in the field of water treatment, is a market leader in the supply of water and effluent treatment plant, gas generation systems and equipment for the storage, distribution and handling of gases, liquids and liquid gases.

Thompson Kennicott Ltd, part of the Rolls Royce Group, supplies water treatment systems to several large UK power utilities. This article describes their latest developments with Rohm Haas (UK) Ltd.

They specialise in the supply of equipment for the production of high purity water for boiler feed and process purposes and has established and consolidated its reputation as a result of its long association with the power generating, petroleum, electronics, industrial manufacturing and process industries throughout the world.

Rohm and Haas are the largest suppliers of ion exchange resins in the world. They are based in Philadelphia, USA, but have major production plants in Europe, including Jarrow in the UK.

Amberpack is a backwashable, packed bed ion exchange resin system patented by Rohm and Haas, and is particularly suited to the deionisation or softening of water. It combines an efficient mechanical process with a range of ion exchange resins specially manufactured to complement the system.

The concept of reverse flow ion exchange processing with upflow loading and downflow regeneration is now well established. The Amberpack system overcomes many of the shortcomings of earlier processes and permits high efficiency treatment of water by ion exchange or absorption.

Having researched the range of competing reverse flow regeneration systems, Thompson Kennicott opted for the Amberpack technology and the incomparable range of Amberlite® resins to form a cornerstone of their new range of standard process designs.

The Amberpack system is ideally suited for use with the Amberjet® range of uniform bead size resins as well as with other specialised resin grades with low pressure drop, high capacity and calibrated granulometry characteristics.

The uniqueness of Amberpack is that it is backwashable. Traditional counterflow systems using air or water hold-down can also be backwashed but require 50-100% freeboard to accommodate the resin expansion. With packed bed systems this expansion volume is reduced to approximately 5%. The Amberpack system combines this optimisation of unit volume with the lack of need for bed hold-down fluids, whilst allowing for resin backwash when required.

The system consists of a variable number of single of multiple chamber ion exchange columns with an upper and lower collector/distributor and one or two small ancillary columns for resin backwash.

The Amberpack system has all the advan-

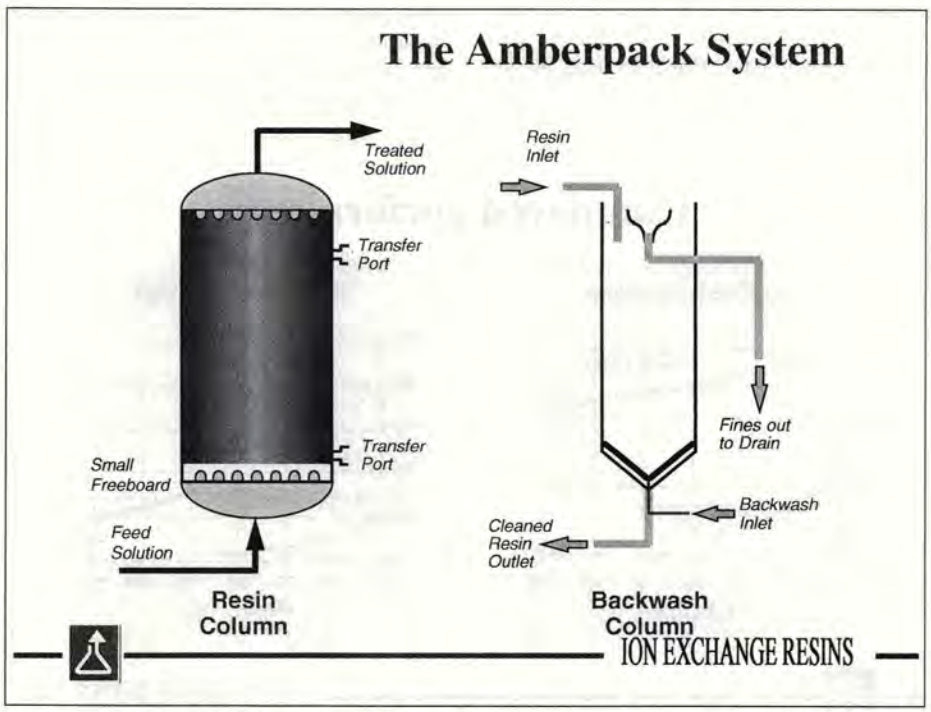


Figure 1: Schematic of the Amberpack system. Amberpack and Amberjet are trademarks of Rohm and Haas Co Philadelphia PA.

*Thompson Kennicott Ltd
** Rohm and Haas (UK)

The authors

Roy Bolton (pictured left) holds a BSc Tech in Chemistry from Manchester University's Faculty of Technology (now UMIST). He has been with Thompson Kennicott for more than 26 years.

His lifelong enthusiasm for water treatment technology was initially acquired during spells with Unilever at their Merseyside power station, and the CEGB at Spondon and Derby power stations, from 1964-68.

Since 1987 he has been technical manager, then business development manager with Thompson Kennicott.

Bill Dearie (pictured right) is sales manager for the ion exchange resin business of Rohm and Haas UK, and has been with the company for over 20 years. He is market manager for the Amberpack systems in Europe and South Africa, and is involved in the licensing and technical support to OEMS and design consultancies for the system. He holds a BSc and PhD from Glasgow University.

tages of packed bed counterflow techniques with upflow loading and downflow regeneration using a stationary compacted resin bed. In addition it permits removal of portions of the resin for mechanical cleaning by backwashing when necessary without interrupting the operating cycle.

The backwash tower is an open vessel of a size designed to handle no more than 400 mm of the resin depth of an individual ion exchanger chamber. It is equipped with facilities for resin backwash and transfer from and to the ion exchange vessel. It can be made from glass fibre reinforced plastic material. Because suspended solids tend to accumulate in the lower portion of the bed and resin fines in the upper portion, only fractional quantities of the resin charges need to be backwashed occasionally.

For complete Amberpack deionisation systems (which may comprise multiple streams), no more than two backwash towers, one for the cation exchange resins, and one for the anion exchange resins, are necessary.

Amberpack resins are tough, durable and do not generate fines in normal operation, hence if the feed water does not contain excessive amounts of suspended solids, then the backwash vessels need not be permanently connected to the ion exchange units. In practice, Amberpack plants can operate for periods of more than 18 months without the need for a backwash.

The ion exchange vessels are of very simple design, requiring only top and bottom distribution systems. Amberpack units can be designed as a multi-chamber system to accommodate weak and strong resins in the same column. Operation is extremely simple and there is no risk of resin mixing. Three-compartment columns are sometimes used when the volume of any single resin exceeds approximately 15m^3. Individual chambers are separated from each other by intermediate nozzle plates. All nozzle plates are designed with respect to the number and type of nozzles to give satisfactory distribution or collection of process fluids during both the loading and regeneration phases, which usually involve significantly different flow rates.

In the Amberpack process regeneration is performed downflow. The resin bed is thus naturally immobilised by gravity and any fluidisation is avoided. Concentration of the regenerant is adjusted to allow for a minimum contact time of 20 minutes.

The regenerant solution is displaced downwards by the rinse water. The difference in specific gravity between the regenerant solution and rinse water reduces mixing at their interface, minimising rinse water consumption. Furthermore, because there is no void space in the column, there is no necessary dilution of the regenerant with the rinse water. This improves regeneration efficiency and further replaces waste.

After downflow regeneration and a normal displacement rinse, the final rinse is carried out upflow in recycle mode, thus saving large amounts of rinse water and decreasing the ionic load on the resin. For systems with-

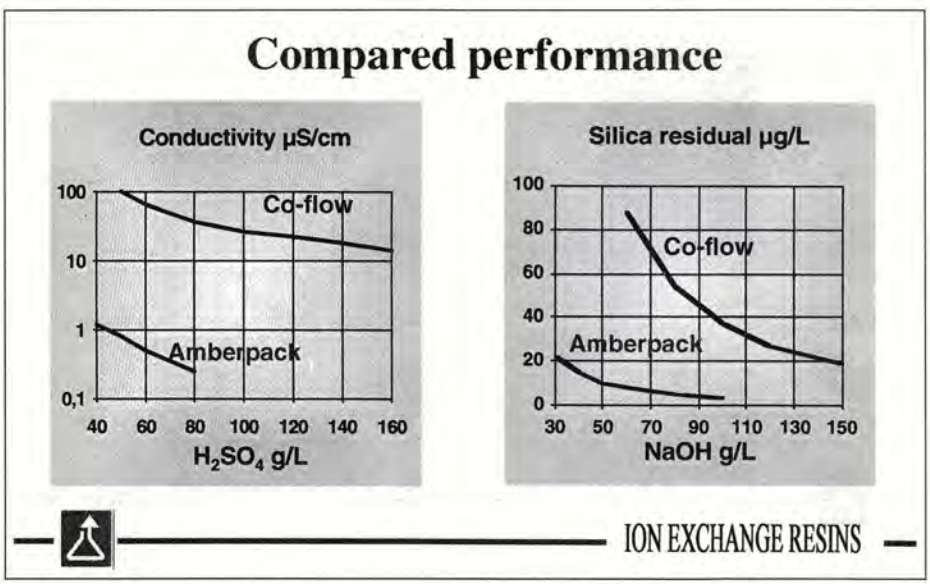
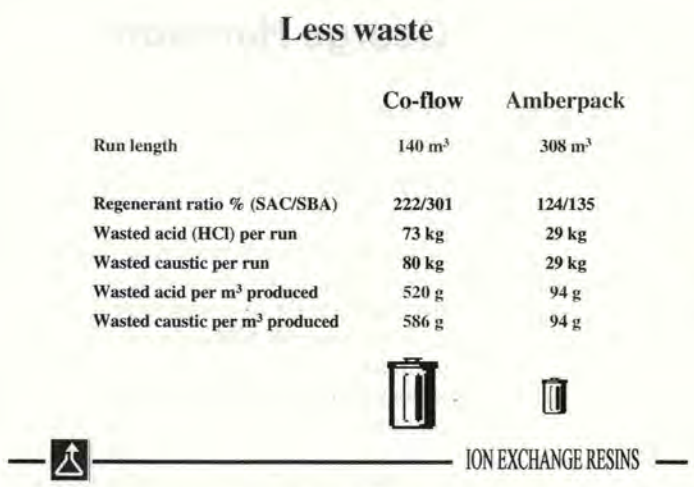


Figure 2: compared performance.



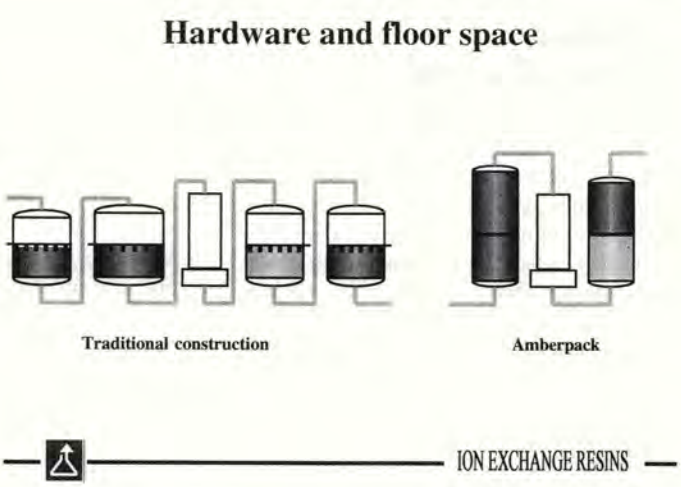


Figure 3: Amberpack results in less waste. (left) Figure 4: Space requirements for Amberpack.(right)

out a degasser, the feed pump can be used for recycling. An Amberpack deionisation system usually delivers treated water with a conductivity below 1S/cm and reactive silica of less than 20 ppb.

Figure 2 corresponds to a given set of conditions, and can vary according to raw water composition and temperature. With hydrochloric acid as a regenerant the conductivity is even lower than with sulphuric acid, and in all usual cases below 1S/cm, independent of the regenerant level and water composition.

The difference in quality is particularly striking when retrofitting a co-flow regenerated plant. The data shown in Figure 3 is taken from an example of a retrofit installation. The resins used during co-flow regeneration were Amberlite IR120 and IRA420, and after conversion these were replaced by Amberjet 1200 Na and Amberjet 4600 Cl. Because the regeneration efficiency of the Amberpack system is very high, almost all of the regenerant is actually utilised.

By contrast in co-flow plants a large excess of regenerate is required to obtain low leakage levels and acceptable capacity values. This excess regenerant is discharged, unused, in the waste system. With multi-chamber units even higher efficiency values are achieved and even less waste is produced. In such cases the regenerant utilisation of a weak/strong resin combination is in the range of 103 to 100%.

Key features of the system include: simple and compact counterflow packed bed design; extremely high regeneration efficiency; very high operating capacity resins; very low leakage values; treated water quality constant and independent of feedwater quality; optimum choice of resin combination to suit the application; resin backwash does not affect treated water quality and is both efficient and simple to operate.

These features combine in operation to produce maximum reliability and operational availability; low service water requirements due to minimum freeboard and optimum resin granulometry; fast and complete displacement of regenerant from the bed assisted by the difference in density between water and regenerant; highest quality water achievable from a two-bed system; low runnings costs, due to reduced resin differential pressures, high chemical utilisation and minimal rinse water requirements; as well as simple and cost effective retrofitting of Amberpack to both co-flow and other counterflow units (Thompson Kennicott and Rohm and Haas provide a joint package for the total conversion of existing systems to the Amberpack system).

The engineering skills and technical innovation of Thompson Kennicott and Rohm Haas have combined to provide a cost effective, compact and highly efficient range of backwashable packed bed ionisation systems, designed to satisfy the present day needs of a wide range of applications and industries. ❑

Obituaries

James Burns

DR JAMES BURNS, CBE GM, Past President and Senior Fellow of the Institute of Energy, was born in Kiltarlity Inverness-Shire, and was educated at the Inverness Royal Academy and later at Aberdeen University, where he graduated with a first class Honours Degree in Chemistry. He was awarded a Carnegie Fellowship, which took him to Kings College Cambridge to continue research in Chemistry. He received his PhD in 1928.

Through the Cambridge Appointments Board, he joined the Gas Light and Coke Co in 1928 as a member of their research team. His research work was varied and fruitful and included a period working on secondment with a team in Germany on the high pressure conversion of tar and tar products to light spirit. At the successful conclusion of his work there he returned to the production side of the Gas Light and Coke Co with a full knowledge, inter alia, of the German language.

Shortly after the outbreak of war, he was given charge of a large production works in the East End of London, in an area which suffered severe enemy bombing attacks from time to time. On 10 May 1941 the works was in, or near, the centre of a particularly heavy attack, in the course of which a high risk explosive mixture was created in a gas tank on the site. If ignited this would have had serious consequences for the surrounding neighbourhood, but recognising the risk, Dr Burns led a group of men, under continued bomb attack, and rendered the position safe.

He was awarded the George Medal for his courage and leadership.

After the war, Dr Burns was appointed deputy chief engineer within the company, with the particular duty of rebuilding the war-ravaged production and distribution plant at the company's stations, visiting several countries, most commonly America, to exchange information and experiences. On nationalisation of the industry in 1949, he became chief engineer of the North Thames Gas Board, in which the Gas Light and Coke Co, and other smaller companies were vested.

In 1954, the industry was given the opportunity of taking part in a joint venture with American interests to carry out a large-scale study of the possibility of making use of the vast amounts of methane gas available in many parts of the world. This study was to include the liquefaction of the gas, its storage and its transportation by ship. Dr Burns was given charge of the British technical team to work in collaboration with the American technical team.

The teams' efforts were successful, and the arrival of the tank ship, the Methane Pioneer, with its cargo of liquid methane at Canvey Island from the Gulf of Mexico in 1959 laid the foundations for the new industry and a new raw material for the gas industry. Dr Burns was later awarded the CBE for his work on this project.

In 1957 he was elected President of the Institution of Gas Engineers. He chose as his theme: the development of centralised gas production and long distance gas transmission, forseeing the potential of a gas pipeline from London to Manchester. His interest in pipe lining was shared by others, and with the objective of providing a platform for the interchange of technical, economic and administrative information, they formed the Pipe Line Industries Guild, of which Dr Burns became the Founder President in 1960. The Guild's success is well recognised in pipe lining circles.

Later in 1961, he was elected President of the then Institute of Fuel, serving for some years on the Council of the International Gas Union. In the course of his duties, he visited most European countries and spent some time in Russia, in collaboration there with authorities on the potential of liquid methane.

A year later Dr Burns was appointed chairman of Northern Gas, with the task of carrying out a reorganisation to bring the administration of the Board into conformity with the Gas Council's preferred systems. He spent a successful five years there, and then, approaching retirement, he was invited to apply his knowledge and experience as Chairman to the operation of the Southern Gas Board, where he stayed until his retirement in 1969.

On his retirement to Canford Cliffs, Dorset, he and his wife Kathleen, who had helped him so much in his professional career, turned their attention to charity work. They founded the Grange Cheshire Home, which was later extended to care for seventeen disabled residents. When it no longer possible to enlarge the Grange, Dr Burns sought — and won — permission from the Cheshire Foundation to buy a piece of land to build a new home on the outskirts of Bournemouth, exclusively designed to meet the needs and accommodate disabled people. The new home was named after him: James Burns House.

Another charity, the MacDougall Trust, also benefited from Dr Burns' work on their behalf.

He took a keen interest in local as well as general conservation matters, and was well known in his area for his support of the local council in curbing an undesirable development in Poole.

Much in demand as a public speaker, he was noted for his clear diction and an ability to memorise long passages without notes.

George Harrison

GEORGE HARRISON, (Fellow), known to all South African members of the Institute as the architect of the South African branch, died in Johannesburg in April after a long, and in the latter weeks, painful fight against cancer.

George was born in Scotland in May 1922, and studied mechanical engineering at Herriott-Watt. He emigrated to South Africa after the war, and held a number of senior positions in engineering companies before joining the General Mining Corporation as a consulting mechanical engineer.

On the formation of the South African Coal Bureau, he became its senior technical manager, and later, when this organisation was absorbed into the Transvaal Coal Owners Association (TCOA) he became their technical consultant.

George's activities in the Institute commenced when he joined the Coal Bureau. Realising the need to gather together the diverse range of people involved in industries associated with fuel, he worked tirelessly to set up a South African branch, which he achieved with great success. For this he was given a special award by the Institute.

After his retirement from the TCOA, he continued consultancy for a number of the major mining houses, and retained his interest in both the coal industry and the Institute to his last weeks.

His great interests outside of his work were bowling and his family. A great family man, George will be sadly missed by his wife, Birthe and their children, Jennifer and Stuart, to whom we offer our deepest sympathy and condolences.

Ted Cole

Birthday Honours

INSTITUTE of Energy Past President, Robert Evans, was made a Knight Bachelor in the Queen's Birthday Honours List. Our congratulations to Sir Robert Evans CBE FEng.

Search for alumni

SOUTH BANK University has relaunched its Alumni Association. They are looking for students who have not joined the Association since it was set up in 1989.

To celebrate the Association's relaunch the University will publish a Who's Who guide, which will act as an essential guide for networking and enable past students to keep in touch.

For further information, contact Elisabeth Gates, Alumni Officer, South Bank University, 103 Borough Road, London SE1 0AA. Tel: 071 815 6717.

New members

Fellow

Santanu Chakrabarti, The Tata Iron & Steel Co, India *(transfer)*
Darius Nikanpour, Canmet-Energy, Canada

Member

Michael John Adams, Intercity (British Rail), Derby
David Ian Anderson, Babcock Energy Ltd, W Sussex
Stanislaw Andrzej Maria Burek, Glasgow Caledonian University
David John Raphe Covell, Torpy & Partners, Bristol
James Elder, British Steel plc, West Glamorgan
Cham Leung Fong, Hong Kong Productivity Council
Keith Johnson, British Gas, Scotland
Antony Gaskell, British Gas, Cheshire
Vladimir Ivic, Quaytron Controls Ltd, Surrey
Kevin Norman Maunder, Babcock Energy Ltd, W Sussex
Paul Duncan Miller, Woodgate Building Services, Middlesex
Alan Roderick Muir, IVQ Energy Ltd, London
Ajit Patnaik, ICI Chemicals & Polymers Ltd, Lancs
John Michael Piggott, AHS-Emstar plc, Middlesex
Andrew John Purnell, British Gas, Wales
Andrew Thorne, N W Hertfordshire Health Authority
Thomas Alexander Tolputt, Ravenheat Manufacturing Ltd, Leeds
Syed MD Saiful Wahid, ICTVTR, Dept of Mech & Chem Eng, Bangladesh

Professional Associate

Malcolm Hugh Robertson, TA Consultancy Service Ltd, Aberdeen

Associate

Anthony William Kelly, Stordy Combustion Engineering, West Midlands

Associate Member

Paul James Brobyn, Associated Heat Engineering plc, Hampshire
Paul Seth Ellen, Land Rover, West Midlands
Stephen Philip Jones, March Consulting Group, Manchester

Graduate

Paul Andrew Cottam, George S Hall Ltd, Hampshire
Grant Mackenzie Ferguson, Highland Health Board, Inverness
James Anthony Goth, NIFES Consulting Group, Hertfordshire
Jonathan Soper, Target Energy Services Ltd, London
Alexander Taylor, Napier University, Edinburgh
James Ferguson Thompson, Short Brothers plc, Belfast

Student

Oladuntan Taiwo Akinola, Middlesex University
Mario Amati, Leeds University
Peter John Anderson, Nene College, Northampton
Matthew James Anslow, Nene College, Northampton
Raymond Kenneth Appleby, Middlesex University
Moazzam Ali Bakhshov, Middlesex University
Clair Louise Bassindale, Nene College, Northampton
Chris David Benning, Nene College, Northampton
Richard Bentley, Leeds University
Rachel Louis Booth, Leeds University
Rebecca Nina Bourton, Nene College, Northampton
Jeremy Paul Bullock, Coventry University
Matthew Jonathan Clarke, Coventry University
Constantinos Constantinou, Middlesex University
Delphine Gabrielle Cluze, Leeds University
Adrian Mark Cunliffe, Leeds University
Christina Davies, Leeds University
Steven William Davis, Leeds University
Shanti Brata Dhar, Middlesex University
Alastair Ian Paul Dodd, Leeds University
Kejun Dong, University of Westminster
Mehmet Murat Erdil, Middlesex University
Michael Houston, Napier University, Edinburgh
Rolf Phillip Charles Hudson, Cranfield University, Bedfordshire
Jody Ellis, Leeds University
Brian James Fitzpatrick, Napier University, Edinburgh
Robert John Fiddik, Middlesex University
Mohammad Javad Gazerj, Middlesex University
Richard Gordon, Newcastle upon Tyne University
Simon Mark Gossling, Leeds University
Catherine Annick Grincourt, Leeds University
Edward James Harford, Leeds University
John James Hart, Leeds University
Andrew David Hawke, Leeds University
Michael Heath, Middlesex University
Joel Francis Hope-Bell, Leeds University
Graeme Iain Johnstone, Newcastle University
Mehran Kamkarfar, Middlesex University
Vincent Lawrence Kehana, Leeds University
James Robert Kennedy, Leeds University
Noel David Kelly, North Trafford College
Peter David Lawton, Newcastle upon Tyne University
Eugene Lehane, Cranfield University
Sanda Sin Tak Leung, Leeds University
Clare Ann Lillywhite, Nene College, Northampton
Neil Simon Lowry, Leeds University
Alexander Lynch, Middlesex University
Justin Lee McCann, Coventry University
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Andrew Robin Merricks, Nene College, Northampton
Roger Neil Millis, Leeds University
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Thierry Morel, Cranfield University
Rachel Alexandra Morrell, Leeds University
Michelle Suzanne Morris, Nene College, Northampton
Julian Myers, Leeds University
Ian Alexander Newman, Leeds University
Angela Dawn Nicholls, Nene College, Northampton
Kwame Oduro-Yeboah, Middlesex University
Aidan Paul O'Dwyer, Soth Bank University
Olsen Herfinn, Cranfield University, Bedfordshire
Carys Owen, Leeds University
Katrina Fleur Owen, Leeds University
Giles Lewis Payne, Leeds University
Sarah Parry, Leeds University
Anil Kumar Patel, Leeds University
Richard Howard Percival, Coventry University
Alexander Rak, North Trafford College
Catriona Reeby, Cranfield University, Beds
Aziz Roohj, Middlesex University
Andrew James Reid-Thomas, Newcastle upon Tyne University
Claire Amanda Shrewsbury, Cranfield University, Beds
Emi Sakai, Leeds University
Kamaljit Singh, Bradford City Architects
Robert David Smith, Coventry University
Liani Ahmed Soboi, Leeds University
John Andrelo Stickland, Nene College, Northampton
Stoker Darren Mark, Newcastle University
Martyn Henry Street, Coventry University
Esther Tang, Leeds University
Suk-Kung To, Leeds University
Fatai Olufemi Tobun, Middlesex University
Janet Thompson, Coventry University
Martin Thmoas Treacy, Coventry University
Harriet Walton, Nene College, Northampton.

Based on experience

'Industrial Energy Management: Principles and Applications' by Giovanni Petrecca
Published by Kluwer Academic Publishers, Boston/Dordrecht/ London, 1993, 430 pp, H/B.

'Back to basics' can mean different things to the politician, but all engineers will know exactly where they are when they read the first paragraph of the author's preface: 'After many years of researching, teaching and consulting I am firmly convinced that all problems, in order to be solved, must first be reduced to their essentials.' He then goes on to say what he expects from the reader: 'Readers are assumed to have a basic knowledge of thermodynamics, heat and mass transfer, electric systems and power electronics, as well as computer programming.' The book has therefore been written both as a university engineering textbook and as a reference source for energy management professionals.

There are twenty-one chapters, ranging in length from a few pages to by far the longest, 47 pages on boiler plants. The first group of four chapters covers the general principles of energy transformation and management, with a brief overview of some renewable sources theory. Electrical substations, internal electric networks, boiler plant and thermal fluid distribution systems are then covered before a whole group of specific applications including pumps and fans, air compressors, HVAC systems, some economics and the role of education in energy management.

There are some 30 main references cited and there is a good index. A feature of the text is the use of boxes to place emphasis on useful sections of basic theory. The line diagrams are clear, and there are over twenty case studies. The text is based on the author's experience in Pavia, where he works in the Faculty of Engineering at the University, and would be a useful addition to the course reading list in many UK engineering degree courses. For the busy energy professional whose background in some topics may be a bit rusty, this fresh approach to basics should have a special appeal.

Dr J C McVeigh

Sound papers

'Influence of Man on Climate III' Proceedings of the VDI-GET conference, Dusseldorf, Germany 1992. Published in English by Multi-Science Publishing Co Ltd, Brentwood, 177 pp, £65.00.

IT IS often the case that papers presented at symposiums and conferences are often difficult to track down only a few years after the conference date. So more permanent publication, such as the hard-backed books produced by the Institute of Energy, are to be welcomed. This particular publication gives an excellent English translation of the papers, originally published in German.

Inevitably the papers are of uneven quality. The paper on population growth makes several interesting points. The worry by Malthus was not so much the problem of feeding the rapidly increasing population, but that the most rapid increase was among those of low intelligence and ability, thus reducing the human race's capabilities at a time when important decisions have to be made. Some have used this argument to oppose aid to developing countries. Although clearly the rapid increase in population has environmental — and energy — implications, the paper's main point is the contrast between the industrial West and the third world in age structure. In Europe we are familiar with the problem of an aging population being supported by a decreasing working population. In contrast in the developing world, the age structure is reversed, with a preponderance of young people, often with little chance of finding work, and no welfare state provision.

Other papers cover ozone depletion, CO_2 reduction strategies, retention and disposal of CO_2. There is an analysis of methane emissions with both German and world estimates. It would be interesting to compare the data in this paper with those of the Watt Committee on Energy report on methane emissions, due to be published later this year.

Germany's views on emissions are important, both because Germany is by far the largest industrial power in Europe, but also because German governments are more active in taking steps to control emissions than the UK.

This book is not comprehensive, but does provide sound technical and political papers on a range of important topics.

Norman Worley

Convenient format

'GWC International Steam Coal Qualities' Published by George Waterhouse Consultants Ltd, Bridge House, Bainton Road, Tallington, Lincs PE9 4RT. £130.00.

AFTER the turmoil which has engulfed the British coal mining industry in the past two years, coal sellers and buyers have found their market places turned upside down. It is a situation which strained the abilities of many who had for years settled into comfortable grooves, handling the same familiar coals from traditional sources that had satisfied most of the demands of their customers.

Now all that has changed. Pits which produced the same reliable qualities for half a century or more no longer exist. Customers with very closely defined requirements are having to be offered quite unfamiliar blends made up from several sources, often from overseas. The traps for the unwary are many and complex. For many coal handlers it may mean going back to the drawing board, scratching their heads to recall facts they learned many years ago, but rarely use.

And then along comes George Waterhouse with his slim volume to refresh the memories with specifications for best performance in power generation, iron and steel, cement and other specialist industries.

The fundamental value of the book lies in the painstaking and meticulous assembling of basic facts and data. In seven tightly-packed chapters it ranges across the intricacies of sampling, the essential elements of coal analysis, the complexities of qualities required for power generation and the importance of the correct balance of ash, sulphur, nitrogen and chlorine. The special requirements of coal used in cement manufacture are unique, and have to be observed with precision; the steam coals used in the iron and steel industries (as distinct from coking coal) require their own chapter; and the wide ranging needs of general industry in terms of stokers, feeders and spreaders, are covered in the kind of detail usually only found in major textbooks.

Produced in a very convenient hard-back format, which can be slipped into a briefcase without adding too much to the carrier's burden, *International Steam Coal Qualities* is one of those rare portable reference works that can get its owner out of difficulties even when miles from the office.

'GWC Coal Handbook' Publisher as above, £21.00.

A pocket-sized volume, a real companion to the major volume, reviewed above, the *GWC Coal Handbook* contains tables of coal statistics and data, resources and reserves of competing fuels and comparative specifications, conversion tables for everything from calorific value, through heat flux and heat transfer coefficient, down to volume rate flow, traffic fuel consumption conversions, and tyre pressures. A little book to dip into and marvel at the important things you thought you had forgotten, but will come in handy one day.

Peter Heap

CAT prize for windmill winners

Fifteen-year-old James Jarman of Cardinal Hinsley School took third place with his colourful windmill.

Pictured top left is the winning team, from Copthill School, Mill Hill in north west London. Team members are Aisha Razik, Jaime Hart, Hema Mistry, Farrah Gangji, Li Ming Soong, Sarmini Ghosh and Stephanie Boodha, all aged 14. Above left are entrants from Cardinal Hinsley RC School, also in north west London. And above right are winners of the fourth prize, placed second in the inner London section, from Lady Margaret School, Parsons Green, south west London.

A TEAM of eight 14-year-old girls from Copthall School, Mill Hill, won first prize for building the best windmill in a competition judged at City University, London, in July.

Second place went to a team of boys from Quintin Kynaston School, Marlborough Hill. Both teams have won a trip to the Centre for Alternative Technology (CAT) at Machynlleth in Powys.

75 finalists from ten London schools were judged on the windmills they had built to generate electricity from a standard kit of parts supplied by their Neighbourhood Engineer — the Engineering Council's scheme to link professional engineers with their local schools.

The windmills were placed in a wind tunnel and judged on efficiency, elegance and cost of construction. The competition was devised by City University in conjunction with Neighbourhood Engineers.

The aim of the competition, sponsored by BT and Sir John Cass's Foundation, was to introduce pupils to the concepts of engineering design and problem solving in the context of the economic, environmental and efficiency aspects of power generation by wind energy.

James Jarman, 15, from Cardinal Hinsley RC School won third prize: a t-shirt and a book: *Where the wind blows* — an introduction to wind power. A fourth prize of t-shirts went to a team of four girls, all aged 15, from Lady Margaret School, Parsons Green

Quintin Kynaston School, Marlborough Hill, and Lady Margaret School, Parsons Green, won special prizes of £200 and £100 respectively from Sir John Cass's Foundation for the best windmills entered by inner London Schools.

September 1994

Reliability assessment
AEA training course, 5-7 September, Warrington, UK. Details from Dr L Fairman, AEA Technology, Consultancy Services, Thomson House, Risley, Warrington WA3 6AT. Tel: 0925 254345; fax: 0925 254569.

Control of electroheat processes
Short course, 5-9 September, Hatfield, UK. Details from BNCE, 30 Millbank, London SW1P 4RD. Tel: 071 344 5917; fax: 071 344 5996.

19th annual Uranium Institute symposium
7-9 September, London. Details from Concorde Services Ltd, 10 Wendell Road, London W12 9RT. Tel: 081 743 3106; fax: 081 743 1010.

North Sun '94
International conference, 7-9 September, Glasgow. Details from North Sun '94, Mackintosh School of Architecture, Glasgow School of Art, 177 Renfrew Street, Glasgow G3 6RQ. Tel: 041 332 9797; fax: 041 353 0995.

World renewable energy congress
11-16 September, Reading, UK.

Wastemanagementlicensing
Conference, 12 September, Edinburgh. Details from Christine Rickards, IBC Legal Studies & Services Ltd. Tel: 071 637 4383; fax: 071 631 3214.

Briquetting, pelletising, extrusion and fluid bed/ spray granulation
Short course, 12-14 September, Amsterdam. Details from The Center for Professional Advancement, Oudezijids Voorburgwal 316A, 1012 GM Amsterdam, The Netherlands. Tel: +(31) 20 638 2806; fax: +(31) 20 620 2136.

11th international Pittsburgh coal conference
12-16 September, Pittsburgh, USA. Details from Ann McDonald, Conference Secretary, The Pittsburgh Coal Conference, University of Pittsburgh 1140 Benedum Hall, Pittsburgh PA 15261. Tel: 412 624 7440; fax: 412 624 1480.

Emerging technologies in advanced robotics
Conference, 14-15 September, Windermere, UK. Details from Sarah Ashmore, IBC Technical Services Ltd, Tel: 071 637 4383; fax: 071 631 3214.

The nuclear industry — into the 21st century
Conference, 14-15 September, London. Details from Financial Times Conferences, 102-108 Clerkenwell Road, London EC1M 5SA. Tel: 071 814 9770; fax: 071 873 3969/3975.

Hydrocyclones
Short course, 14-16 September, Bradford, UK. Details from Dr Ing J Svarovska, Course Director, Fine Particle Software, 8 Carlton Drive, Bradford, W Yorks BD9 4DL. Tel/fax: 0274 546276.

Energy efficiency accreditation
Free seminar and lunch, 15 September, Runcorn; 30 September, London. Details from ETSA, Conference Registrations, PO Box 16, Stroud, Glos GL6 9YB. Tel: 0453 886776; fax: 0453 885226.

The competitive edge
12th national natural gas vehicle conference & exhibition, 18-21 September, Atlanta, Georgia, USA. Details from American Gas Association, Meeting Services Department, 1515 Wilson Blvd, Arlington, VA 22209. Tel: (703) 841 8444; fax: (703) 841 8692.

Natural gas: the commercial challenges
Seminar/workshop, 18-23 September, Oxford, UK. Details from Anita Gardiner, The Alphatania Group, London, tel: 071 613 0087; fax: 071 613 0094

Incineration of municipal waste with energy recovery
Short course, 19-20 September, Leeds. Details from Miss Julie Charlton, Dept of Fuel & Energy, University of Leeds, Leeds LS2 9JT. Tel: 0532 332494; fax: 0532 332511/ 440572.

3rd European Congress on Thermal Plasma Processes
19-21 September, Aachen, Germany. Details from VDI-W, Graf-Recke-Str 84, D-40239 Dusseldorf, Germany.

70th anniversary of Russian district heating
International conference, 19-23 September 1994, St Petersburg, Russia. Details from Mr Chistovich, Director VNIIGS, St Petersburg, fax: 010 7 812 567 88 49.

Compressor & steam turbine technology
Short course, 20-23 September, Amsterdam. Details from The Center for Professional Advancement, Oudezijids Voorburgwal 316A, 1012 GM Amsterdam, The Netherlands. Tel: +(31) 20 638 2806; fax: +(31) 20 620 2136.

Solid-liquid separation
Short course, 20-23 September, Bradford, UK. Details from Dr Ing J Svarovska, Course Director, Fine Particle Software, 8 Carlton Drive, Bradford, W Yorks BD9 4DL. Tel/fax: 0274 546276.

Regulating the utilities in a changing marketplace
Conference, 21 September, London. Details from Christine Rickards, IBC Legal Studies & Services Ltd. Tel: 071 637 4383; fax: 071 631 3214.

Advanced concepts & techniques in thermal modelling
Eurotherm seminar N36, 21-23 September, Poitiers, France. Details from Dr D Lemonnier, LET-ENSMA, Site du Futuroscope - BP 109, 86960 FUTUROSCOPE Cedex. Tel: (+33) 49 49 81 00; fax: (+33) 49 49 81 01.

Transducer design & simulation using computers
Colloquium, 22 September, Southampton. Details from Laura Brown, USITT, University of Southampton, Highfield, Southampton SO17 1BJ. Tel: 0703 593534; fax: 0703 592738.

SAVE conference on energy efficiency
26 September, London. Details from Alex Smeets, EEMD, ETSU, B156 Harwell, Oxon OX11 0RA. Tel: 0235 433235.

New techniques in CHP generation
Conference, 26-27 September, Prague, Czech Republic. Details from VDI-Gesellschaft Energietechnik, Postfach 10 11 39, 40002 Dusseldorf, Germany. Tel: *211 6214 219 363; fax: 0211 6214 161.

13th CERI international oil and gas markets conference
26-27 September, Alberta, Canada. Details from CERI Conference Division, tel: (403) 282 1231; fax: (403) 289 2344.

COMADEM '94
International condition monitoring & diagnostic engineering management, 26-29 September, Ashok Hotel, New Delhi, India. Details from Prof B K N Rao (Birmingham, UK) Tel: 021 472 2338.

Combustion fundamentals
Course, 26-30 September, London. Details from Continuing Education Centre, 558 Sherfield Building, Imperial College, London SW7 2AZ. Tel: 071 594 6881; fax: 071 594 6883.

Electricity distribution review & new regulatory developments
Conference, 28-29 September, London. Details from IIR Ltd, tel: 071 412 0141; fax: 071 412 0145.

DEGREE DAYS: MAY 1994

Source: **Degree days direct**

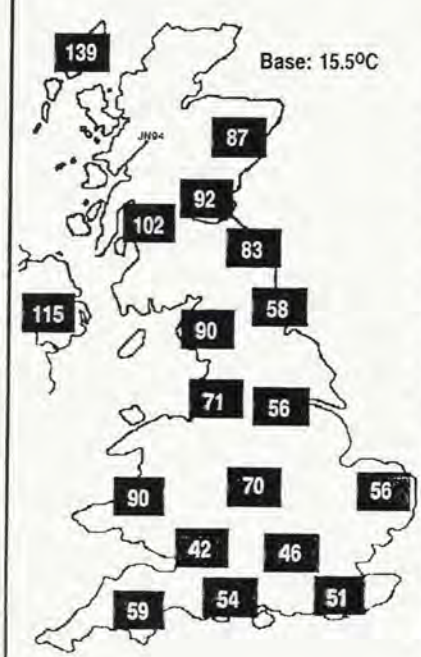
These regional figures, calculated from daily outside air temperatures, provide an index of demand for space heating over the month and thus enable excessive consumption to be detected.

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

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

DEGREE DAYS: JUNE 1994

Source: **Degree days direct**



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INSTITUTE OF ENERGY
CONFERENCES

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

1 December 1994
The Cafe Royal, London.
Internationalisation — Power & Energy Services
The Business Opportunities

Conference Subjects for 1995

- ❑ Coal Bed Methane
- ❑ Performance of Large Gas Turbines
- ❑ Energy From Waste II
- ❑ Renewables for Power Generation
- ❑ *2nd International Conference on* Combustion & Emissions Control
- ❑ Fuels for Power Generation - Investment Opportunities

Events Co-Sponsored by The Institute of Energy

From September 1994 (4 CEA regional conferences on)
Steam — The Cost Effective Solution
Contact: CEA Conference Office Tel 0444 458080

12-13 October, 1994, CEA, Leicestershire
The Future of Incineration for Waste Destruction
Contact: CEA Conference Office, Tel 0444 458080

29 November, 1994, CEA, London
Natural Gas Vehicles - On the Road Today
Contact: CEA Conference Office, Tel. 0444 458080

26-29 November 1994, New Delhi, India.
COMADEM 94 (Condition Monitoring & Diagnostic Engineering Management - 7th International Congress & Exhibition)
Contact: Prof Rao Telephone (Birmingham) 021 472 2338

8 November, 1994, IMechE, London
Thermal Processing of Biomass and Small Scale Power Production
Contact: Philip George at the IMechE on 071 973 1312

9-10 November, 1994, IMechE, London
Managing Wastes - Integrated Pollution Control
Contact: IMechE on Telephone 071 222 7899

14-15 November, 1994, AIC, London
Competition in the UK Gas Industry
Contact: AIC Conferences on Telephone 071 329 4445

CALL FOR PAPERS

THE INSTITUTE OF ENERGY'S
2ND INTERNATIONAL CONFERENCE ON
COMBUSTION & EMISSIONS CONTROL

3 - 5 December 1995, London, UK.

Following the success of the *Institute of Energy's first International Conference on Combustion & Emissions Control* held at the University of Wales, College of Cardiff in September 1993. We are pleased to announce that the next conference on this subject will be held in London in December 1995 at the Commonwealth Conference and Events Centre, Kensington High Street.

CALL FOR PAPERS
We are pleased to invite the submission of abstracts (in English) of a maximum of 250 words on the following subject areas:

- ◆ High temperature processes
- ◆ Advanced power generation
- ◆ Energy from waste & biofuels
- ◆ Emissions reduction
- ◆ Plant performance
- ◆ The role of consultants/technology transfer
- ◆ Combustion of Residues
- ◆ CHP, Industrial Furnaces & Process Heaters
- ◆ Fuel Cells — Efficiency & Emissions

For a leaflet and further information please contact Judith Mackenzie at The Institute of Energy on 071 580 0008 or Fax 071 580 4420.