# ENERGY WORLD

The magazine of The Institute of Energy

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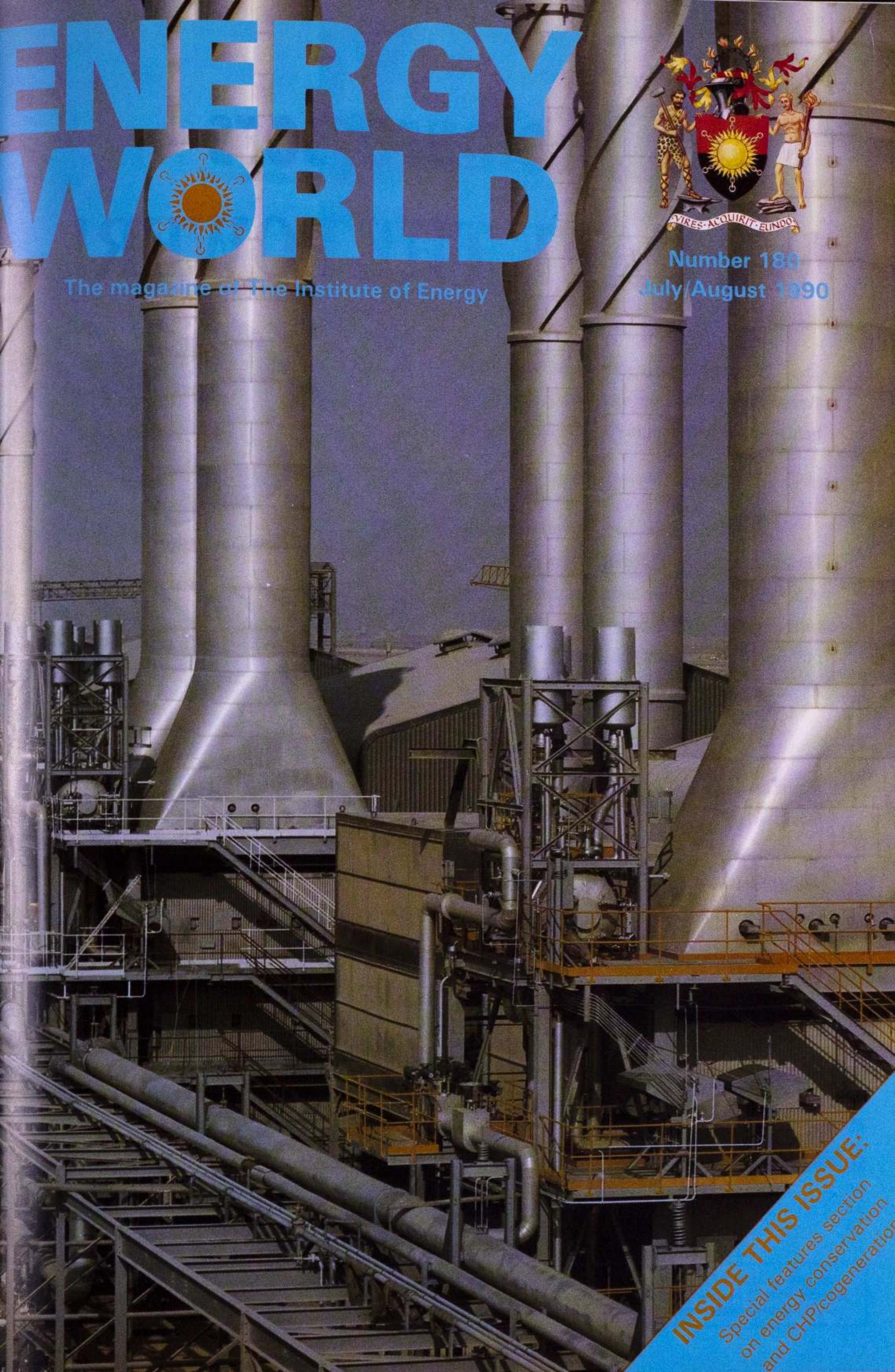
Number 180

July/August 1990



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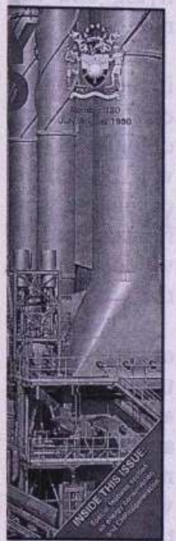

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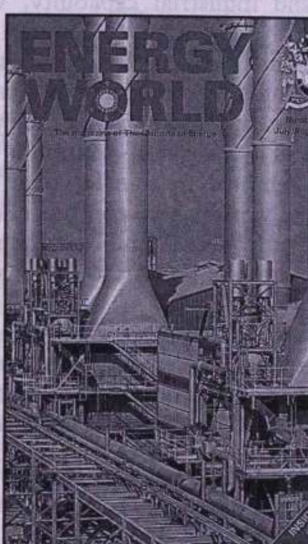
## COVER STORY



Our cover photograph shows the new gas turbine power and water station at Jebel Ali, Dubai, providing power for an aluminium smelter and also utilising waste heat from the gas turbines' exhaust gases to service one of the world's principal sea water desalination plants. The plant's gas turbine waste heat recovery boilers were built by Foster Wheeler Power Products Limited.

Constructed for the British Smelter Corporation, the Dubai Aluminium Smelter Power and Water Station is among the largest of its kind outside North America. Situated on the coast 30 km from Dubai city, the complex is now in full operation.

Foster Wheeler Power Products Limited, now the Power Division of Senior Thermal Engineering Limited, was responsible for the design, manufacture and erection of 13 waste heat boilers, comprising eight GE FR-5 and five GE FR-9 turbogenerators, together giving a total rating of 700MWe.

The waste heat recovery boilers harness the heat from the turbine exhaust gas (TEG) to supply 1390 tonnes of steam per hour to the sea water desalination plant. The desalination plant provides 43 million gallons of fresh water per day — enough to meet the Emirate's industrial and domestic water needs.

The contract awarded to FWPPL, valued at £30 million, also called for the engineering, delivery and erection — the latter in temperatures of up to 55°C — of all associated ancillary equipment, including six auxiliary boilers, two deaerators, feed tanks, and water treatment plant.

## CONTENTS



**TERMS OF CONTROL** **Energy World is circulated free of charge to all paid up members of The Institute of Energy. To libraries, organisations and persons not in membership it is available on a single subscription of £45 for 10 issues. Energy World is also available with the Journal of The Institute of Energy (quarterly) at a combined annual subscription of £140.**

# How much pain?

POLLUTION of the environment is now everyone's concern. The greenhouse effect is uppermost of all the considerations, and consequently it is vital that the information on this subject is correctly interpreted.

At the present time the only real data available are the temperature records over the last 100 years, and the interpolation of these records. Analysis of this data suggests that 1/2 degree C warming occurred over the last 100 year period. Extrapolation of the data must be extremely tenuous and so it behoves the scientific community, the politicians and the media to be highly responsible in their predictions, otherwise the world could be thrown into chaos by ill founded conclusions. In spite of the fact that the weight of scientific opinion concludes that global warming is taking place, surely the Institute is right in faciliating other voices to be heard, even those that do not conform with the majority view.

Research must be intensified to resolve our present dilemma and in the meantime all sections of society should be encouraged to economise in energy use. It has been said that there must be some sharing of the pain between the developed and the developing world. The question is, how can the problems be kept to a minimum?

The most obvious action is to increase the efficiency with which we use our energy. This may be dull and uninteresting, but it is vital, and the maximum publicity is needed. It is significant that it is possible to buy in a supermarket in Portugal, high efficiency fluorescent tubes that replace normal light bulbs when such products are practically unavailable in Britain.

In the UK electricity industry the drive for economy, perhaps brought about by privatisation, seems to have convinced the generators to build gas fired combined cycle plants. Generation cost is less, pollution is lowered and efficiency is increased. It is clear that this plant is being built because it is more economic, and technology has advanced to such a stage that it has become possible to increase the efficiency of the cycle. It would be encouraging if the financial position were equally attractive for renewable energy, whether it be windmills, tidal power or any other technically capable source. Regretfully, without changes to the underlying financial requirements, this is not the case.

Large gas finds have reduced the commercial pressures to develop other energy sources, so there is a need to ensure that we take steps now to help future generations by reinvesting some of our present day profits into future equipment associated with energy efficient products and environmentally sound plant.

The need to perfect the clean use of coal is paramount and research must be put into this field covering fluidised bed combustion and coal gasification. One of the main sources of energy throughout the world is still coal and much of the world will use it for many years to come, indeed for as long as it is available. It is essential therefore that it should be used in an efficient and environmentally acceptable manner.

The other main source of energy is nuclear and it is prudent that this is developed, but in such a way that it is seen to be environmentally acceptable, which must carry with it the need for satisfactory disposal of the waste. The UK's delay in reaching a solution can only be regretted.

If the best steps are taken, then we can reduce significantly environmental pollution without reducing our standard of living and industrial capability, with the added bonus of reducing the amount of fuel used.

If taxation is to be used to reduce the use of carbon fuel, then it should only be considered as a last ditch method as against efficient use of energy and development of the best methodologies. The danger of taxation is that big business interests will be tempted to transfer their operations to the underdeveloped world where controls may be understandably more relaxed, and where an industrial presence would be more than welcome, maybe leading to less environmental control rather than more.

So in my view the potential to create pain caused by the cost of protecting the environment and a more equitable distribution of the world's available energy need not be as severe as is sometimes suggested. If the wealthy nations use their skills and resources to ensure that all sources of energy are used in the most effective and efficient manner to the benefit of mankind, with the minimum impact on the environment; and if they lead the way by efficient energy use, and adopting financial policies that encourage all rational development in the energy field, then the world will stand a chance of overcoming its pollution and energy supply problems. Otherwise I suspect we are in for hard times.

**C E Pugh CBE**
*Past president*

## Anglo-American power consortium

TWO major Anglo-American companies have formed a unique partnership to build a new generation of power stations.

TBV Power was launched in London on 25 June as a venture between UK building giant, Tarmac Construction, and the leading power plant engineers and construction managers, Black and Veatch, based in the United States.

The new operation has been formed to take advantage of opportunities for new power stations following Government plans to privatise the electricity industry this autumn.

Tarmac Construction chief executive Mr Neville Simms said: "We believe there will be a market worth many millions of pounds and we are determined to win a large share of the new work with a partnership that is second to none in the world."

Tarmac Construction, using considerable project management and construction skills, undertake a diverse range of large scale and complex projects worldwide. Black and Veatch, a large multi-disciplinary practice, based in Kansas City, are one of the world's leading power plant engineers and construction managers.

TBV Power will offer complete project services from design, construction and commissioning through to full turnkey and on to build, own and operate. A wide range of projects can be undertaken in both the UK and overseas.

## Major refuse incineration plant

AS A result of a wide-ranging international bid contest under the European Community's 1992 preferred rules of competition, the Amsterdam city authorities have placed an order with W+E Umwelttechnik, Zurich, a company in the ABB Group, for one of the largest household refuse incineration plants in the world. The contract is worth about SFr 100 million (£42 million) and the plant is scheduled to be completed by 1993.

## Energy efficiency 'a double benefit' to Eastern Europe

"THERE ARE huge opportunities for energy efficiency both in and for Eastern Europe," Peter Morrison, former Energy Minister, said in London on 11 July.

Mr Morrison was opening the seminar arranged by the Department of Energy's Energy Efficiency Office to assist the exchange of expertise between the UK energy efficiency industry and the markets opening up in Eastern Europe. The audience heard contributions from a representative of the Embassy of the Polish Republic, Department of Trade and Industry, the Foreign and Commonwealth Office, WS Atkins, the National Industrial Fuel Efficiency Service, March Consulting Group, and Barclays Bank.

Mr Morrison added: "Energy efficiency will help the newly democratised nations of Eastern Europe face the challenges of improving their national economies through reduced energy costs.

"We know from our own experience in the United Kingdom just what impact energy efficiency can make. Over the last ten years our gross domestic product has increased by 25 per cent while our energy consumption is slightly lower than in 1979. This is in large part due to major improvements in energy efficiency in the last decade and demonstrates the wide range of expertise we have in the UK which we are keen to share.

"The UK energy efficiency industry can make a significant contribution to the economy and the environment of Eastern Europe, and I hope that the new opportunities for developing trade links will be seized."

## Gas turbine aboard space station

BY UTILISING 30-year-old gas turbine technology for a space station's complex power generation needs, more than $3 billion dollars will be saved over the project's 30-year life span.

According to a paper presented at a conference jointly sponsored by the International Gas Turbine Institute of the ASME, "the use of solar dynamic power conversion utilising aircraft gas turbine technology will have a major impact on the overall life cycle cost of the space station."

The space station *Freedom*, when launched in 1997, will present designers with an array of new technical obstacles, including power generation, for designers because of its long-term use in space.

Although initial electric power for the space station will be provided by photovoltaic arrays (essentially solar-powered batteries), significant additional power will be required to take advantage of the unique, technical environment that space station provides. This additional power will be supplied by aircraft gas turbine technology developed 30 years ago.

For the space station's electric power generation needs, the National Space and Aeronautics Administration (NASA) has selected a series of solar dynamic power generating modules. In these modules, sunlight is captured and focused into a solar receiver. The receiver then performs two functions: it is a heat exchanger which transfers the incoming solar heat to a gas for power generation, and an energy storage device which stores solar energy during the daylight portion of the orbit for use during eclipse periods.

The heart of this system is the power conversion unit, or heat engine. A relative of the aircraft gas turbine, it consists of a turbo-alternator compressor and a recuperator. The recuperator recovers energy from the turbine exhaust and returns it to the cycle, thus enhancing the overall efficiency of the system.

## Siberian gas strike

A POWERFUL jet of gas condensate has been struck near the settlement of Samburg, Tyumen region, in Western Siberia. The daily yield is estimated at half a million cubic metres of gas.

The deposit, found at a depth of four kilometres, attests to the region's huge fuel potential. The area already accounts for more than half the Soviet Union's natural gas production.

## British Gas invests in environment

BRITISH GAS is the lead corporate investor in a fund set up to help finance emerging European companies involved in environmental protection and waste management.

The TR Ecotec Environmental Fund will specialise in providing development capital for emerging growth companies in the European environmental protection and waste management industry. BG Corporate Ventures Ltd (a wholly owned subsidiary of British Gas plc) is investing £1 million in the environmental services fund and will have a seat on its advisory committee.

"British Gas has a strong commitment to the protection of the environment. This investment, which should help develop the European environmental services business, will give British Gas early knowledge of technological developments in this industry," said Frank Corrigan, British Gas' Venture Capital manager.

## World 'first' at French factory

A WORLD 'first' has been achieved by the French company Framatome in its heavy nuclear components factory at Chalon St Marcel: the forming of a forged single-piece steam generator head for a 900 MWe PWR unit.

In their latest design, these steam generators have an outer envelope consisting of forged shell rings, which are welded together. Their upper head is made from a blank, also forged, having a diameter of nearly 5.6 meters, a thickness of 100 mm, and a weight of over 25 tonnes. As its centre of the outside, this disk has a protuberance which, after machining, will form the steam outlet nozzle, and, on the other side, a ring from which the SG internals will be suspended by welding.

It is this large part, of complex shape, which, after having been heated to about 1000°C, was formed by hot spinning, somewhat like the way in which a potter shapes a vase, to obtain a SG head of the desired dimensions.

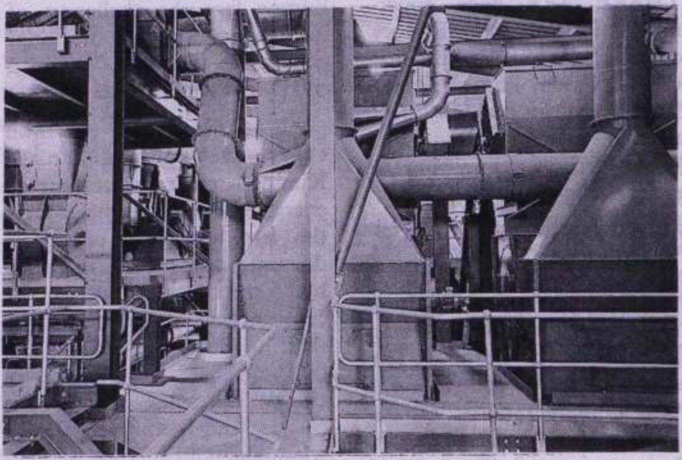
# New waste derived fuel production plant opens at Hastings

A NEW plant that produces a type of pelleted fuel manufactured from municipal waste, was opened at Pebsham, Hastings on 9 May by David Trippier MP, the Minister for the Environment and Countryside,

It is expected that the fuel will be mainly used in industrial process heating plant, although negotiations to supply some of the plant's output for use in power station boilers are also taking place.

The new plant was designed and constructed by East Sussex Enterprises Ltd (ESEL), a company created by East Sussex County Council in 1984. It is only the second plant of its kind in Britain. The first, on the Isle of White, was also designed and constructed by ESEL last year.

The Hastings plant is capable of processing 85,000 tonnes of domestic waste plus 10,000 tonnes of selected trade waste each year. Its output is expected to be 28,800 tonnes of fuel pellets, 40,000 tonnes of fine screenings (to be further treated to produce methane for electricity generation, 4,300 tonnes of ferrous metal for recycling, plus 21,000 tonnes/annum of rejected waste, from which further material recovery is planned.



**Inside the fuel plant at Pebsham, near Hastings, East Sussex.**

The plant, as constructed, is only the first stage of the ultimate process. The recovery process for aluminium, heavy plastic and glass will be added later, as will the processing of 40,000 tonnes of fine screenings which can be treated to produce methane. These processes will reduce the volume of rejected waste to 15 per cent of the total input.

Successful trials have been undertaken by a number of large national companies, including trials in two of the CEGB's coal-fired power stations. Currently, trials are running in a number of Home Office prisons and at a brick factory owned by Redland Bricks Ltd. ESEL, who are marketing their fuel under the trade name *Easiburn* claim that the fuel can be used in industry, commerce, farming and horticulture.

In the fuel manufacturing process, the waste is screened, to ensure that only suitable products for burning remain, and then dried and shredded before being made into the final product.

# Climate forecasts 'unreliable'

CLIMATE forecasts for the next century are at present so unreliable that they are useless to policy makers. That is a warning given on 13 June by the George C Marshall Institute, of Washington DC, one of America's most respect scientific educational organisations.

At a briefing for the British media organised by The Institute of Energy in London, Professor William Nierenberg and Mr James Frelk, directors of the Marshall Institute, said that while new results are coming in more and more rapidly as climatic researchers focus on the greenhouse effect, there remains an overwhelming amount of research to be undertaken before conclusions can be reached which will be reliable enough for sound policy making.

In a new study published in July, the Marshall Institute concurs with a view expressed in *Nature* magazine that attempts to predict temperature changes in the next century on the basis of current data would be 'foolhardy'.

The study also finds:

- On the basis of current greenhouse forecasts the 1980s should have seen a substantial rise in global temperatures. But NASA satellite measurements showed no significant change in that decade.
- Earlier predictions of global warming by the UK Meteorological Office forecast a rise of 5.2°C in the next century, but recently that has been reduced to 1.9°C. Other experts believe the answer will prove eventually to be less than 1°C.
- Predictions of catastrophic increases in sea levels seem to have been similarly exaggerated: in 1980 a rise of 25 feet was forecast, by 1985 that had been reduced to three feet, and in 1989 it was further cut to 12 inches.

The delegates from the Marshall Institute went on to meet Members of Parliament at Westminster on the afternoon following the press briefing.

# Rating launch

FOLLOWING its creation in February, the National Energy Foundation (NEL) launched their National Home Energy Rating scheme on 18 June.

The rating will be managed by the NEF and is an accurate indicator of the standard fuel running cost of a property on a scale of 0-10 with 10 being the most efficient. A home built to the new 1990 Building Regulations would score around six.

Using the rating, homeowners, prospective buyers and housebuilders will now be able to gain a reliable indication of the energy running costs of new and existing homes. The computer programs which calculate the rating also highlight the most cost effective ways to save energy in the home.

The calculation of the home energy rating will be done by qualified assessors, and take into account the location, design and construction of the home, its heating system and controls, fuel used, lighting systems and appliances.

# Richborough wind turbine inaugurated

"THE GOVERNMENT believes that renewable sources of energy, wind energy in particular, have a vital role to play in the electricity supply industry," said Peter Morrison, Energy Minister, on 10 July.

Mr Morrison was in Richborough, Kent, to inaugurate the 1MW wind turbine that is to be operated by PowerGen plc. Built at a cost of £3.2m by the Department of Energy, the Central Electricity Generating Board (as it was), the European Commission and James Howden Limited, it will provide power to meet the needs of 600 homes.

# Gas prices fall

BRITISH GAS has announced reductions averaging 5 per cent in gas prices for its long period interruptible customers in industry and commerce.

A reduction of 1p per therm will apply to all volume bands in the long period interruptible price schedules with effect from the first meter reading at the customer's premises after 1 July 1990.

Gas prices in these schedules are market related and this reduction follows the earlier falls in oil prices.

# Citigen formed to provide CHP

A NEW company — Citigen Limited — has been set up by British Gas and Utilicom Holdings Ltd to build and operate major combined heat and power (CHP) plants particularly where these are associated with district heating in city centres.

British Gas and Utilicom will share equally in the equity participation and the initial investment will be in the region of £20 million or more per project.

Citigen Ltd will undertake all forms of contract energy management and aims to take a lead in designing, constructing and operating city-wide CHP schemes. Cities will be specially targeted where there is a balance between the demand for heat and power and where local authorities are keenest to co-operate in encouraging energy savings and improving the environment.

## Esso award for InstE members

TWO British Gas engineers from the Midlands Research Station at Solihull, both Institute members, have won the prestigious 1990 Royal Society Esso Energy Award in recognition of work they have carried out in a new approach to improving the efficiency and performance of metal reheating furnaces in industry.

Mr Kevin Pomfret and Mr John Waddington will be presented with the Award at the Royal Society in November this year for the development and exploitation of gas fired rapid heating furnaces. They will receive a gold medal and a cheque between them for £2,000.

The Royal Society Esso Energy Award is given for outstanding contributions to the advancement of science, engineering or technology leading to the more efficient mobilisation, use or conservation of energy resources.

British Gas is the only company to have won this award twice since it was first established in 1974.

## New President takes office

**The Institute's President for 1990/91, Doug Willis BSc, CEng, FInstE, receiving the President's badge from the retiring President, Professor Brian Brinkworth. The installation of the new President took place at the annual general meeting, held in Scarborough on 19 May. It is believed that this is the first occasion on which the AGM has been held in a venue outside London.**

## British Steel prize

THE INSTITUTE of Energy wishes to award an annual prize for the best final year project on Energy and the Environment. Entries, which will be welcomed from any tertiary education establishment, and should be received by 1 November.

The prize, which is being funded by British Steel, will be up to the value of £500.

Entries should be sent to The Education Secretary, The Institute of Energy, 18 Devonshire Street, London W1N 2AU.

## Call for papers

PAPERS are invited for the 2nd International Symposium on Coal Combustion, to be held in Beijing, China in October 1991.

The symposium covers all aspects of coal combustion and gasification.

1,200 word abstracts of proposed papers, which must be previously unpublished work, should be sent to The Secretary of The Institute of Energy, not later than 30 October 1990.

# Message from the President

FROM time to time it is necessary to obtain views from members on matters affecting the well being of the Institute. The comments may be requested in answer to a 'Viewpoint' article, they may be in answer to a questionnaire contained in *Energy World*, or they may be the result of a direct mailing to members.

It is helpful to me and to officers of the Institute when members take the trouble to reply and I do my best to acknowledge individual letters written to me.

It is not easy to keep in touch with the membership, and yet it is extremely important that the Council and the Executive Committee have the benefit of members' views as they seek to make changes designed to improve the Institute and in particular to provide a better service to its members.

During the year there will be several occasions when I shall be asking for your help, and I thought that a few words would help to explain the reasons for the specific requests.

In this edition of *Energy World* there is a questionnaire which relates to the Institute Diploma in Energy Management and the one in Energy Technology that can be part of the Incorporated Engineer qualification. The Institute is aware that this has been a very neglected area, and it has commissioned a study of courses available in this field so that its own requirements can be updated to meet a number of needs, including those for IEng registration. This qualification would be very suitable for certain energy managers where there is a great need for a recognised career structure. The Institute hopes, together with the Department of Energy and the National Energy Efficiency Association, to develop clearly defined qualification criteria, and your response to this questionnaire will help in this. New possibilities for IEng qualification are also opening up as a result of privatisation of major energy organisations and a change in the internal training facilities offered by such organisations.

An additional questionnaire will appear in a future issue of *Energy World* and this will be designed to enable the Institute to further improve its services to members.

I hope that readers have noted and approved of the changes in *Energy World*, which are already attracting improved reader response as well as more advertising. It is our modest intention to make *Energy World* the leading magazine in the energy business, and with the enthusiastic support of our members it is entirely possible to achieve this aim.

We also hope during the year to update the register of members' interests. This was started in 1986, but unfortunately changes in Institute staff and pre-occupation with other priorities have meant that this has lapsed. This register is extremely useful at Headquarters as we are quite frankly asked at quite short notice to provide names of members who can be approached to serve committees or provide expert opinion on a specific area of interest. Now that an information officer has been appointed we hope to be able to improve our capability of providing information or conducting projects for such bodies as the Department of Energy, the EEC and the World Bank.

I also expect to be able next spring to put before members some alternative future scenarios for the future of the Institute. This will bring to a head the discussions which have taken place over the last two years or so, and hopefully will set the Institute firmly on a positive path of expansion for the future.

Let me emphasise again: the question is not whether the Institute can survive, it can and will. The question is rather, 'in what form can the Institute best achieve the aims and objectives as set out in our Charter?'

**D M Willis** *(President)*

## Dr Roland Jackson at 80

WHEN after many years' service as secretary of the then Institute of Fuel, R W Reynolds-Davies retired, many in the Institute found it difficult to imagine how the Institute could survive his departure. However, Dr Donald Townend, Past President, produced a former colleague Dr Roland Jackson, who was willing to tackle this formidable task.

In April, at the village of Blackheath, near Wonersh where Roland and Grace Jackson now live, a large company celebrated Roland Jackson's 80th birthday, although he is not now in the best of health.

Those invited could imagine they were back at 18 Devonshire Street all those years ago. Among the guests was Miss Margaret Brown, who was for so many years the *eminence grise* behind the Institute Secretary.

Also present were Mr Jack Eames, former Institute Finance Officer, and Mrs Eames; Mr and Mrs Christopher Payne and Miss Joan Deakin.

The party included Roland's son, daughter-in-law and two grandsons, and many members of the Institute, including three Past Presidents: G J Gollin, C A Roast and Dr G G Thurlow.

*G J Gollin*

## Services to the Institute recognised with award

**Norman Worley, the outgoing Chairman of the Publications and Conferences Committee, receiving his Recognition of Services Award from the new President at the AGM. Mr Worley served the Institute as its Chairman of Publications and Conferences Committee for a full five-year term from 1985-90.**

## British Gas Scholarships

BRITISH GAS is looking for 12 ambitious graduates to take up three-year PhD Research Scholarships on science and engineering projects awarded to universities and polytechnics around the country.

The company's scholarships are boosted by an increase in the annual maintenance grant of £1,000 this year. A scholar not living at home can expect to receive £6,345 a year (£7,310 a year in London), plus possible additional allowances geared to experience and dependents. Other benefits include travel and book allowances, as well as a technical visit abroad.

Candidates should normally be UK citizens and hold, or be expecting to obtain, a first or upper second class honours degree in a suitable discipline from a British university.

For a list of projects and Colleges, please write to: David Reay, British Gas, Research & Technology, 148 Grosvenor Road, London SW1V 3JL.

## Eur Ing title for Fellow

GEORGE C Widdup (*Fellow*) has been awarded the title of European Engineer (Eur Ing) by the Fédération Européene d'Association Nationales d'Ingénieurs (FEANI).

Mr Widdup has been a member of The Institute of Energy since 1944.

## Appointment

PAUL JOHNSTONE (*Member*) has been appointed manager of European and International Standards Division at the British Gas Watson House Research Station.

Previously principal scientist/engineer of the Controls Division at BG's Midlands Research Station, Mr Johnstone entered the gas industry in 1969. He took up his new post in February this year.

Mr Johnstone has been a member of the Institute since 1980.

## Birthday honours

FORMER Melchett Medallist, Sir George Porter was awarded the title of Baron in the Queen's Birthday Honours list in June.

Sir Robert Haslam, British Coal chairman, was also elevated to the peerage as Baron.

## Trade missions

THE ENGINEERING Industries Association (EIA) is organising trade missions to East Germany in November, and the Gulf States in October of this year. Both trade missions have the support of the DTI.

Applications for places on the East German mission must be with EIA by 17 August 1990, applications for the Gulf States mission must reach EIA by 6 July 1990.

For further details contact Anna Small, Export Director, EIA, 16 Dartmouth Street, London SW1H 9BL.

## New president for IPlantE

THE INSTITUTION of Plant Engineers has installed its new president, Richard James Wyatt, IEng HonFIPlantE MRSH, following their AGN in May.

Mr Wyatt joined the Institution in 1953. For the last six years he has held the posts of Honorary Administrator and Chairman of the IPlantE's management committee.

## Consultancy and training provision

THE LANCASTER District Chamber of Commerce, Trade and Industry with North Lancashire Local Employer Network are preparing a guide on consultants and training providers serving companies in North Lancashire and South Cumbria.

The publication is being prepared at the request of a number of companies who have stated their need for such a guide to give ready reference to consultants and training providers who could meet particular needs of companies.

The guide will be issued in the autumn and will be sold to companies for a nominal sum. Those who would like to participate in this guide, please contact Nigel Carruthers (0524 39467) for more details.

## BG director new IM president

DR LES MERCER, HQ director, gas research at British Gas was installed as president of The Institute of Metals at their AGM in London in May.

Dr Mercer chose the link between energy and materials as the theme of his presidential address, entitled 'Materials and Gas — A Natural Link.'

# CHP — powering the 1990s

*by David Green MBE**

**CHP is a method of power generation whose time has come argues David Green, a leading proponent and Director of the CHPA. In the following article he reviews current prospects for the increasing utilisation of CHP systems in the UK, and considers the export potential of UK-pioneered small-scale CHP schemes.**

COMBINED heat and power is the technology of the 1990s — that's the clear message from leading opinion formers in the world of energy policy and its business offshoots.

Opportunities for the CHP promoter could now be better than ever before — and that's good news for energy consumers, industry and commerce. Yet why is this? What has suddenly accelerated interest in CHP as the prime means of co-generating both heat and power?

Essentially a unique set of circumstances has created an underlying momentum for the development of CHP. This momentum has been influenced by five key factors:

- The dramatic reduction in input fuel prices for large industrial consumers.
- The growth in competitive pressures in the energy market has added to the potential for a new approach to power generation — particularly by the wider use of gas, and advanced clean coal technology.
- The considerable advances in the efficiency and cost effectiveness of gas turbines, combined cycle plant and advanced coal technology has enabled the wider use of this advanced technology in industry and elsewhere.
- The impact of considerable fresh thinking in the electricity industry brought about by the restructuring of the industry may well give CHP a unique opportunity to move into action for the benefit of industry and others.
- The nation's rediscovered concern with the environment may well enhance the prospects for CHP, as the UK looks for new ways of meeting the global requirement to constrain the growth in world greenhouse gas emissions.

These underlying factors have created a surge of growth in the CHP industry, as the record level of attendances achieved by the Combined Heat and Power Association (CHPA) at its events in the last year indicates. How far this will result in new schemes is going to be highly influenced by price and other competitive tension created by the Government in their setting of terms for the new electricity 'market'.

Meanwhile, the CHPA is not the only agency to recognise the significant potential for growth in the use of CHP. The Government's Energy Efficiency Office has estimated that by building upon the three per cent of UK electricity supply currently being met from CHP sources, a doubling of CHP capacity to some 6 GWe of installed capacity could be achieved in the 1990s. Much of this would be in the industrial and commercial sectors. Indeed, the Department of Energy has, on a wider basis, estimated that installed CHP capacity could reach 30 GWe by the year 2020.

So, which energy users could be thinking about a switch to CHP?

The following are the sorts of users, and sectors, where CHP could well be relevant:

- larger chemical and other process sites;
- agricultural sites with a quick heat and electricity requirement;
- petrochemical sites;
- the textile industry;
- the paper and board industry;
- urban areas with a captive heat, and electricity requirement.

For smaller scale or packaged CHP systems:

- hospitals and other health service sites;
- larger hotels and other leisure facilities;
- telephone exchanges, office buildings, and, of course by converting boiler houses to CHP for community heating networks.

Energy users interested in these opportunities can get practical case studies from either the Energy Technology Support Unit or, of course, the CHPA.

Yet as the energy user gets to grips with how they could use CHP — perhaps with the advice of a specialist consultant who is a member of the CHPA — then it will be important to understand the new legislative framework that influences the use and application of CHP.

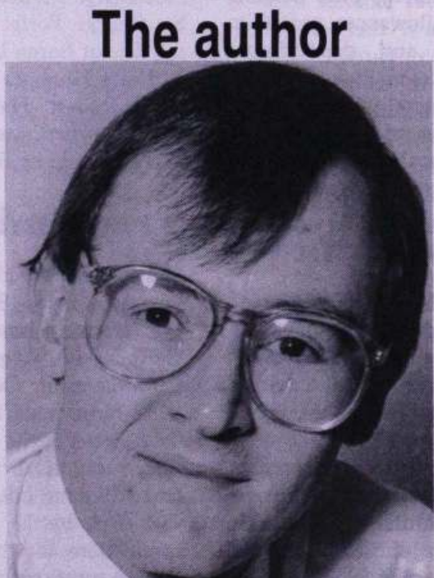
Here it is important to recognise that from now on *anyone* generating electricity in the UK will need a licence to do so, *unless* they fall into an exempted category. For CHP users, this probably means you don't need a licence if at least one of the following criteria is met:

- aggregate generation output is less than 500 kWe;
- use is purely 'on-site' and the electricity exports don't exceed 49 per cent of the declared net capacity;
- power is only exported to a so-called 'primary' licence holder (eg, an area electricity company).

However, anyone wanting to check the precise position would be advised to contact the Office of Electricity Regulation (OFFER), which is the regulatory authority responsible for overseeing the privatised electricity industry.

Clearly, as the Government gets to grips with the challenge of global climate change, then the UK's support for CHP is likely to undergo further development, as it is already clear that

## The author



**David Green is Director of the Combined Heat and Power Association. Prior to this he worked as energy adviser to Newcastle upon Tyne City Council and the Association of Metropolitan Authorities. During this time he co-founded and launched the national charity Neighbourhood Energy Action, which now delivers energy conservation services to low income households. He was awarded the MBE in 1987.**

**Mr Green has also worked as a consultant on energy issues to the State Government in Victoria, Australia, The Conservation Council of the State of New Brunswick in Canada and the New Zealand Government. In the UK he initiated the country's first local home insulation project for lower income households in Durham in 1975.**

**Since joining the CHPA he has worked not only to develop the potential use of CHP, but also to revitalise the association in order to enable industry to respond to the environmental and economic challenges of the 1990's.**

**Director, Combined Heat and Power Association (CHPA)*

there is a growing understanding of the benefits of combined heat and power to the environment. Indeed, the Government's evidence to the international panel of scientists spearheading the global response to climate change clearly indicates that by 2020 CHP could have reduced greenhouse gas emissions by at least 15 per cent.

Moreover, as UK Environment Secretary, Chris Patten MP, has already made clear to his European colleagues, much of this could be achieved by the wider use of gas in power generation. When tied into CHP then clearly the environmental gains become significant. Whether Chris Patten is able to persuade his European colleagues to respond to this challenge remains to be seen.

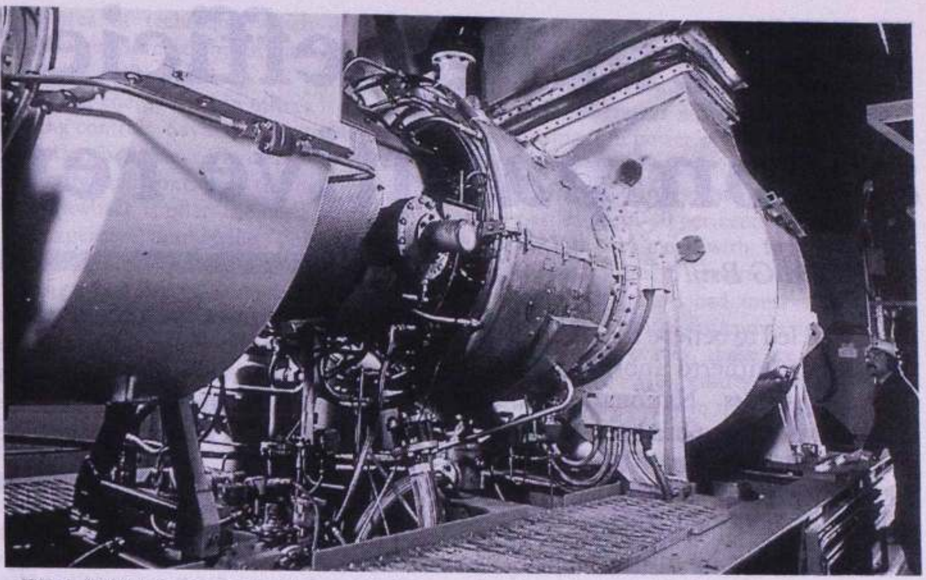
However, the UK approach to CHP is unique in Europe. Whilst other countries have concentrated on the so-called 'big city' CHP schemes — Britain has pioneered the development of small scale or packaged CHP schemes. Much of this gives the UK a unique export potential, which could be of considerable relevance when future technology transfer protocols are drafted for third world countries concerned about their own greenhouse gas emissions.

These developments have been achieved with the full and active support of the Government's Energy Efficiency Office, underlining the role of the EEO in support of the UK energy efficiency industry. For its part, the CHPA also plays an active part in promoting the use of CHP in the UK.

Indeed, the CHPA's recent annual general meeting urged the Government to back a five point action plan for the development of CHP. This calls for: effective action to promote CHP in the form of a pro-active CHP campaign, maintained by the industry and reinforced by government. This could be achieved through enhancing the role for the Energy Efficiency Office; through the DTI's Business and the Environment Programme; through the Department of the Environment and its associated bodies, such as Urban Development Corporations; English Estates; the Housing Corporation; Property Services Agency and so on, and through the Department of Health to the Health Authorities.

In addition they recommended that encouragement should be given to local authorities to actively promote and use CHP technology. An Environmental Action Survey Scheme should be launched to enable industry and the public sector to gain effective guidance on what they should do.

The second point of the plan was to 'meet the institutional challenge'. The Office of Electricity Regulation (OFFER) should act swiftly and effectively to ensure that the competitive development of on-site CHP schemes can be achieved. The Government should build on its new guidelines for the use of contract energy management schemes in its own buildings by ending the residual blockages to the use of energy service companies and 'third party finance' in the health and other public services. It was further recommended that the Department of the Environment should act to ensure wider application of energy efficiency measures and technologies in the housing



**The 5.8MW Ruston gas turbine, part of a cogeneration scheme at Allied Colloides Group plc, Bradford.**

sector through revitalising the energy dimension to Estates Action, Inner City Initiatives and so on.

The third point was to secure the economic benefits of CHP. When required, firm, effective and prompt action should be taken by OFFER to ensure any un-competitive practices to restrict the growth of CHP applications are resolved. Wider recognition by the new electricity industry of the economic benefits to their businesses of small scale CHP should be promoted, was also called for.

The fourth point was to balance any action to 'make the polluter pay' through Government backed economic instruments, and to stress the environmental benefits of CHP. Measures should be taken to secure corporation tax benefits for companies investing in CHP plants; and corporation, or other related tax benefits to facilitate the installation of heat grids related to CHP plants.

Targeted capital control relaxations should be introduced to enable local authorities, housing associations and the health service to invest more rapidly in a range of energy efficiency measures including building-based CHP schemes.

The final point of the action plan was to aid adequate technical improvement in the industry. Whilst the CHP industry will continue to undertake market based technical innovation other actions are also required. The Department of Environment should enable emission guidelines for all CHP plant down to 1 MWe to be introduced, in order to facilitate a greater degree of consistency in local approaches to emission and stack height requirements. Further partnerships for technical innovation should be developed to enable long term research and development to be undertaken.

The CHPA will be working to ensure Government and Opposition parties respond appropriately to this agenda. Indeed, the Labour Party's recently published policy review pledges their full backing for the development of CHP.

Indeed, at this stage it would be helpful to describe the current work of the CHPA itself, following the major revitalisation of the association which took place some two years ago.

Essentially, the association brings together all the major players in the UK CHP market, and in this way has a unique capacity to reflect the CHP interests of, not only major fuel and power suppliers, but also public authorities, manufacturers, installers and the new generation of energy service companies. New users are now set to play a bigger role in the association as more systems come on stream.

It is from this basis that the CHPA has been able to launch its major Power Plus '90 campaign and attract the keen support of National Power plc, PowerGen plc, British Gas plc and British Coal, together with a number of other leading companies in the industry. With the support of Government and Opposition alike, at least 14 major events are being staged to bring home to industry the full benefits of CHP. Indeed this pathfinding approach to getting the message over to leading energy users is one which already others are looking to build upon in other industries.

So as more and more businesses and public authorities look for ways to respond to the environmental imperative, CHP can not only help us all act in the interests of a better environment, but also improve energy efficiency and cut costs. Those who do take this route will be following Trust House Forte; British Telecom; Slough Estates; Newcastle City Council; Hull Health Authority and the many others operating the UK's 500 CHP systems at present. Indeed, British Gas, now a major force in the CHP market, is itself setting a clear example, as its own North Western offices have a CHP plant to meet its power, heating and cooling needs. Moreover British Coal already supplies some 60 MWe major CHP schemes.

CHP is therefore a technology already at work. It brings benefits to business, benefits to the consumer and benefits to the environment. The challenge before policy formers and decision makers is to sustain the translation of these benefits into action. □

# UK energy efficiency— a comparative review

*by Michael G Brill**

**Michael Brill draws upon his long term experience of the UK energy efficiency industry to review the progress, or lack of it, that has been made during the last 10 years. The current situation is not one that he feels inspires optimism, and Mr Brill calls for a major change to our 'hidebound' attitudes if we are to avoid being put to shame by our European competitors.**

WE ARE led to believe that in the UK at least, the hitherto unbreakable link between Gross National Product (GNP) and energy has been smashed. Over the last 10 years GNP has risen by 25 per cent, whilst energy consumption has remained static. I hope I may be forgiven by my colleagues for some scepticism, but after 15 years' experience in the energy efficiency industry I see no room for self congratulation, and certainly no excuse for satisfaction in these figures. You will all have heard of lies, damn lies and statistics. Whosoever thought up this wonderful set is suffering a bad dose of the statistical equivalent of Montezuma's revenge.

In trying to relate energy (unit consumption) to product (cash income) someone has surely forgotten that the value of money changes whilst engineering units remain the same. Quite apart from the fact that much of our GNP is now accounted for by 'invisibles' and oil revenues, instead of energy intensive industrial output, so that energy use should have actually fallen by natural wastage, monetary inflation would have accounted for at least 63 per cent rise in GNP, even if the annual rate averaged only five per cent.

It is my view that we have in fact suffered a loss against the energy yardstick of at least 40 per cent, and until we admit that our economy is ailing because we ourselves suffer from the 'wasting disease' we will not even begin to redress that balance. Personal experience of every day 'hands on' energy management leads me to disbelieve anyone who attempts to show energy efficiency is nationally effective. This is not to say that individual concerns have not made considerable strides. There are plenty of companies that have made vast inroads into their energy overheads, and who have stolen the edge on their competitors, but the vast majority still simply do not care.

Why should we be surprised at this attitude? The investment record in the UK has made us the laughing stock of Europe if not the world.

Just look at the number of world beating ideas that have made millions for our foreign competitors, because funding could not be found at home. Unfortunately energy efficiency needs investment to work. Perhaps there is some excuse for failing to support risk capital, but investment in energy efficiency techniques bears no significant risk! In this country we have an energy efficiency supply industry second to none: pacesetters from traditional to state of the art. Yet we are unable to give it any real support. Eventually when it has atrophied to the current state of the car industry and our market is full of foreign products we will beat our breasts and shed our hair. VAT is about to be imposed upon non-domestic energy users for the first time and many consumers including schools, hospitals, insurance companies and others who are liable to pay but not charge VAT seem to have little realisation that their energy bills are about to rise by 15 per cent. Most still exhibit large doses of the complacency that got us where we are today.

A customer of mine recently revealed that their programme was prompted, not by the boss, but a demand from the shop floor that the company become much more energy conscious and reduce waste. Luckily the boss was no slouch either and realised that with the workforce behind him, saving money would be a lot easier. Have we been looking for help from the wrong end of the ladder all this time? Maybe the answer to the introduction of energy awareness lies in convincing the workers, its their world too. I find that even after Monergy '86 and all the effort that has since gone into promoting the cause, that as many as 60 per cent of the companies I talk to have either tried to economise on energy and have made mistakes which put them off trying again, or they would like to try but are worried that they will be ripped off. A further 30 per cent have never heard of the problem and one in 10 just don't want to know. Not one I have spoken to in six months has been running an effective campaign against energy waste.

## Energy management

Among those who have tried, not one had implemented an effective strategy. A number were using an expensive BMS as a monitoring tool, spewing out miles of hard copy and not knowing what to do with it. A few have implemented targets, but with only one exception, none had any scientific basis for considering that they might achieve those goals. Monitoring and targeting are not just ideas but real practical tools and no-one can say they have a strategy if they are missing or poorly implemented.

Again experience tells me that there are a lot of good energy managers who learned this lesson long ago, and who are saving their companies millions of pounds in otherwise lost profit. But I find that they only represent a very small percentage of the total, national energy spend. 'If you can't measure it you can't manage it' is an adage that applies to any discipline, but especially so to energy efficiency.

## The author

**Mike Brill began his career with GEC where he trained as a mechanical engineer before going on to work in the nuclear power generation sector. Later he gained further experience in the petro-chemical industry before moving into the heating, ventilating & air conditioning sector with Haden Young.**

**In 1974, he went into partnership to form an energy consultancy and in 1978 he joined another consultancy to specialise in work projects in the Middle East, mainly air conditioning.**

**In 1983, he joined Selfridges on a secondment to lead an air conditioning design project and then continued for a further two years as the project manager. In 1986, he was invited to become energy manager for the group's central London store. He remained in this post for more than three years, during which time he became chairman of the Central London Energy Management Group and founding chairman of the National Energy Efficiency Association.**

**Earlier this year, Mr Brill resumed consultancy work on his own account, specialising in advising companies on energy efficiency strategy.**

**Chairman, National Energy Efficiency Association (NEEA).*

Let's not forget the man or the woman at the helm. They have to be effective too. Often it seems that top management are happy to create a sideways move for some favourite who has passed their level of competence, or as a barrier to stop the company rep's getting through. They need no training because they have no power to do anything. This attitude is simply not good enough, but it will remain all the while energy managers fail to take the initiative and join a representative body that can ensure that there is a standard to which all who practice the discipline can aspire.

## Lighting

In most commercial concerns much of the energy consumed is electricity, yet one still finds enormous effort going into reduction of the gas or oil bills which may represent less than 10 per cent of the total energy spend. Within the electricity bill, 60 per cent or more is often consumed by lighting and yet rarely do we see designers consulting anyone about the technical performance of the lamp involved.

Aesthetics are important. Particularly in the retail trade where the customers' vision of the product for sale is everything, and poor lighting can lose more sales than shoddy workmanship. In the selling environment colour rendering and intensity are crucial. Too often, cost cutting imposes limits on the quality of the fittings used, compromising lamp life and reliability.

Ignorance by most interior designers of all but the basics of lighting and energy science leads to poor building performance and control. It is common to see short life lamps in almost inaccessible locations making maintenance impossible and causing lamp manufacturers to be vilified without due cause. A case in point is that the Dichroic lamp which is ideally used in a well ventilated fitting with a stable voltage and used for displaying food, fine fabrics or jewellery, but a disaster when used as a general illumination lamp, and the owner is faced with colossal bills and an angry maintenance manager who can no longer contain replacement costs.

How often to do you see cold (4,000 deg K) lighting from Metal Halides lighting up summery scenes when warm (3,000 deg K) is readily available? Regularly ignorance of the fact that fluorescent tubes are available in many different shades is displayed by those who should know better. Just look up when you are next in a shop to see warm and cold shades mixed in a haphazard fashion. Lighting is available in effiencies between six and 160 lumens per watt, so the choice should be easy in favour of the most efficient lamp.

Unfortunately, the more efficient the light source, the greater its defects in other areas. Strangely 'life' is not one of the problems with really efficient types, but colour stability can be, as can expense, reliability and colour rendering. Lighting is a minefield, and clearly an area for experts of whom the energy manager is but one. Why does it so often get left to the interior designer, whose choice is often based upon the danger of overrun on cost coming out of his fee. This is a particularly weak area of technique which desperately needs to be addressed by all those concerned.

Another effective way of reducing the amount of energy used in offices is the use of lighting controls. Savings of up to 60 per cent may often be achieved by a system of central and individual control of the lighting times. The drawback is often the need for extensive (and expensive) hardwiring. This is overcome in some systems by mains signalling, but there is a big reliability question mark in this area which must still be resolved if this method of signal communication is to be widely accepted. One final method is based upon time circuit interruption. The number of switched zones is limited to three, but the system is at least reliable and low cost.

Although not confined to commercial use, high efficiency lighting in the form of HF electronic ballasts should by now surely be *de rigueur*. Far from it! Wire wound ballasts are as popular as ever and even low loss types are rarely chosen. High efficiency fittings are also widely available but expensive, although there are now just coming onto the market a combination of replacement reflectors and new bodies which are efficient and relatively cheap, so they should take the market by storm. Long fluorescent tubes are economic but become progressively less so as length decreases. The incorporation of longer miniature fluorescents (up to 600 mm) can considerably improve performance.

Finally, before becoming obsessed with lighting I must not fail to mention power saving devices. These vary from small individual electronic gear that is fitted to every lamp, to large equipment that sits as close as possible to the main incomer, reducing energy consumed by 20 per cent. The only problem with individual gear is that they are relatively labour intensive to install and once in place there is no way of knowing whether they are functioning.

Many commercial applications now call for air conditioning, where power is consumed both in the generation of cooling and the movement of media by pumps and fans. I have still seen no proof that any 'bolt on' device improves chiller operation, other than marginally, and I certainly would not risk damaging expensive chillers without consulting the manufacturers first. Pumps and fans however are very different. Traditionally, economies of 25 per cent are regularly made by power savers and variable speed drives will often save 50 per cent plus. Such devices often incorporate soft starters which help to reduce maximum demand as well as reduce wear and tear on drive transmissions. Even escalators are excellent candidates for this type of economy.

## Giant step

Thermal storage is a technique that should not be ignored. More accurately ice storage. This technique seems to me to be a future winner and where space can be found in conjunction with a cheap source of heat and/or electricity (CHP?) could well be a 'giant step for mankind'. I am investigating such a project with a client at the moment but anyone out there with any ideas — let me know.

The last major use of electricity in commerce is in the area of catering. It seems likely that the electricity generators will be forced to waste gas by using it in power stations to keep down greenhouse emissions. It makes nonsense of energy efficiency to use gas to generate electricity at less than 40 per cent efficiency, and then use it to cook meals with. Induction hobs are the best form of electric hob available however, and I have had most satisfactory results. Along with fan/convection/steamer ovens and microwaves, these are set to take cooking into the 21st century. Cooling has an important role to play in the kitchen. Fridges use electricity 24 hours a day, seven days a week, and in the same way as lighting and motors referred to earlier can use power savers to vastly reduce their energy consumption. Dishwashers are notorious energy wasters. They are now available to recycle both heat and water at a price.

Commercial premises can be designed to gain all their heating from lights and people, but until that sub-Utopian aim is reached we must continue to use boilers powered by gas or oil to provide both heating and hot water. Hot water can almost always be generated by some better method, ie, waste heat retrieval or decentralised local generation. If boilers are over 10 years old it is unlikely that they will be efficient to modern standards. However this is no reason to reject them out of hand. It may be possible to refurbish them with modern controls and fittings to give a substantial saving over a new installation. Much over 20 years old and you will almost certainly be looking at trading in old Betty, Tessie and Liza and giving the boilerman a new love in his life (Tina, Ginna and Kylie perhaps?).

Wherever possible go for dual fuel capability, although transparent pricing has reduced the advantage of this policy. Condensing boilers and steam generators both have their place in a complex and highly professional area of the discipline, great care must be exercised.

I have great reservations when considering the motivations of buying a Building Management System. In this country we have some of the best BMS companies available, but its a minefield, and the only area other than boilers where I currently feel expert advice is a must (thermal storage and CHP are others but they are still, in my opinion, tomorrow's technology, although tomorrow may be almost upon us). Space precludes the necessarily lengthy discussion needed to make any sense of the subject, but selection of a BMS must be done with great care. Computerised systems are available from simple regression and tariff analysis tools to full blown expert systems, which will cover just about everything you could ever want from monitoring and control. Make sure you know what you want first.

Analysing tariffs is perhaps the first area to be tackled, although I have left it to this stage because it is simple to do and much advice already exists, perhaps too much. One-off savings are to be made, sometimes of considerable value, and new STOD type arrangements are useful to some people, but unfortunately rarely to the retail trade.

## Motivation

As I have mentioned before, staff motivation is a considerable help when running an energy efficiency programme. Motivational techniques are therefore both relevant and important. Unfortunately the results are not often quantifiable and the opportunity missed by those who need the reassurance of exact paybacks before they dare move. This is an area where expertise may not be necessary for simple exercises, but we are talking psychology here, and specialists become essential quite rapidly in this field.

To quantify the value of a project we need to know its true value over a period of time. Unfortunately few, even financial directors seem to understand Nett Present Values, Discounted Cash Flows or Internal Rates of Return. So we are stuck with straight paybacks as a singularly inappropriate technique of measurement, since it represents the value of one or two of the important financial factors to be considered when deciding the viability of a project.

One of the strangest lessons I have had to learn in this business is that while millions are willing to believe in global warming, ozone depletion, resource starvation, acid rain, and clouds on the planetary horizons, (we wait to discover which will strike first), few are willing to invest in the means of prevention which is mostly common to all.

Even when energy saving projects offer paybacks in mere months they are often turned down because some other area of petty expenditure rates a higher priority. If a project has a payback within one year it requires no capital to fund it. That money is already in the revenue budget, but hidebound views of accounting procedure prevent investment being made from revenue. The world is at stake here, and we quibble about accounting niceties!

More common is the case where a £12,000 project repaid over three years requires only £8,000 of capital, the balance funded from revenue. Payback requirements are ridiculously short, in line with an idealised view on product investment, where a line may last for no more than five years. Like the building that houses it, most energy saving equipment will still be going in 20 years or more. No one expects a heating or air conditioning system to amortise in three years (if ever). Why then a system to economise on the energy used? Unless we can shake ourselves free of this hidebound thinking the battle is already lost.

Paradoxically in this country we levy no tax on wasted fuel whilst we charge it on the equipment to save it. Recent competition amongst electricity suppliers has meant larger companies have had an effective 15 per cent reduction in their unit cost, putting many energy efficiency projects in jeopardy. Few other countries in the developed world allow their energy industry to struggle in this way. Our Government is more concerned about regulating dog ownership than regulating energy waste. Most other developed nations give a boost to energy efficiency, not ours.

The USA has a policy of least cost options and some European states give energy saving lamps to their households free of charge to encourage the right attitudes. We have no regulatory guidelines, no energy policy and are destined once more to slip back as followers when we have the capability to lead. Once again we will experience that mixture of contempt and disgust from our erstwhile partners that has become so common over the last few decades.

Despite what I say I am an optimist, and will continue to fight for this essential cause as will my colleagues in NEEA and elsewhere. We will be on hand when the axe falls, but whether we will be able to soften its blow depends upon people like you. □

## Correction

Two typographical errors appeared on page 14 of the April issue of *Energy World* (No. 177). In column 1, penultimate paragraph, final line, the word 'units' should have appeared as 'watts', and in column 2, under the sub heading *Efficiency*, the second line of the first paragraph, the word 'stations' should have appeared as 'systems'. We apologise for these errors.

# Go cogenerate!

*by Fred Nash, CEng, FInstE, FIMechE**

**Increasing pressure upon industry to conserve energy through greater efficiency has led to a reappraisal of combined heat and power (CHP) by governments and industry alike. In June this year a government-backed initiative — Power Plus 90 — was launched throughout the country to encourage the uptake of CHP systems in both the public and private sectors. In his article, Fred Nash examines the different forms of cogeneration, and looks forward with optimism to the future of CHP in the UK.**

COMBINED Heat and Power (CHP) is not a new technique for conserving energy and costs. Users have adopted it for many years, both to their benefit and the nation's. However, positive encouragements such as availability of tax incentives, grants, and other forms of advantageous legislation to encourage CHP (cogeneration), as provided for in more enlightened countries has been lacking in the UK, and its usage declined during the 1970s and early 1980s.

In 1983 the Energy Act was introduced which aimed to help private generators, but this time also saw the commencement of positive action by the Electrical Supply Industry (ESI) to transfer costs from avoidable to non-avoidable classification, modifying the electricity tariffs to the disadvantage of cogeneration. Notwithstanding considerable political activity, including a Select Committee report in 1986, there has been little actual change in the Government's position. This still included 50 per cent funding up to 1988 for extended surveys for CHP applications, and for supporting installations judged to be sufficiently innovative and reproducible to justify classification as 'demonstration projects'.

However, all of these factors have been overshadowed by the greatly increased differential between primary fuel and electricity costs, caused by the world glut of oil which resulted from the OPEC-inspired general recession, and users switching to other fuels, recognition of which finally became unavoidable in 1985. In consequence, interest in local generation of electricity with high efficiency, by taking advantage of concurrent heat demands (cogeneration), has increased dramatically in the UK, as elsewhere. It shows all the signs of bubbling into a mass of installations, a trend the prospect of a privatised electricity industry should reinforce, but with the dropping of the requirement for private utility companies to adopt and support CHP, may not do so. Now is therefore an appropriate time to review the overall situation and factors affecting the future prospects of cogeneration.

## Definition of terms

Cogeneration is one of those descriptive American words written into their legislature under PURPA in the late 1970s which has, as often happens, become common usage worldwide. Fundamentally it covers the production of power (electricity) as high efficiency — lower limit 42.6 per cent. The most common way of achieving such overall efficiencies is, of course, by combined heat and power where, in a fully exploited industrial installation, overall conversion efficiencies will average over 70 per cent. It is also achievable with combined cycle plant with only minimal thermal output.

Most USA schemes are industrially or commercially based and perhaps, in its common generic usage, cogeneration should be restricted and differently driven (social and environmental as much as economic) district heating applications to be categorised as CHP/DH.

## Cogeneration systems

Cogeneration systems of the combined heat and power type fall into five basic categories as indicated in Figure 1.

Figure 1(a) shows the classical industrial CHP system, still the most widely used today, but which is more and more being restricted to large process industries. It has the advantage of being able to use any fuel but, unfortunately, the prime cost of the boiler is almost always inversely proportionate to the quality (and hence cost) of the fuel burnt, because low cost

**Group Director, McLellan and Partners Ltd*

## The author

**Fred Nash completed an apprenticeship with Yorkshire Imperial Metals and obtained a Higher National Diploma in Mechanical and Production Engineering before commencing his subsequent career-long involvement with power systems and utility services in general. The change of direction was precipitated by a period as a seagoing engineer on steam turbine and turbo-electric driven tankers with Shell Tankers Limited.**

**There followed four years' research and development work on large steam turbines with C A Parsons Ltd before joining McLellan and Partners in 1965. He remained with McLellan, progressing from a project to a principal engineer assessing energy usage and implementing services and power projects in a wide range of industries including the chemical, brewing and steel, in which he led teams to engineer and build cogeneration power stations.**

**In 1980 he joined NEI (APE) Ltd as manager, Special Projects Group, during which time he was responsible for the implementation of energy conservation measures, including energy management systems in the Group's five works; as well as all waste heat and combined cycle projects undertaken by the Group's Companies. In addition he led the development of the diesel engine/boost fired boiler cogeneration system and was responsible for the system design of its first commercial application at Cynamid (UK).**

**In October 1988 Mr Nash rejoined consultants, McLellan and Partners Ltd, as Group Director to control an engineering group specialising in generation, energy and utility services projects. Current projects include power generation from landfill gas, a small district heating system, improvement of emissions from power generation plant, large combined cycle power generation and cogeneration systems in a number of widely differing industrial and commercial situations.**

fuel usually means more expensive boiler plant.

Another weakness of the system is that its design will be optimised not only against some fixed heat-to-power ratio, usually between 5:1 for large systems and 25+:1 for very small systems, but also against given demands, ie 10MW electrical and 100MW thermal outputs. Any decrease in the thermal demand, say to 60MWt in the example above will reduce the power output by a greater than corresponding proportion to, say, 5.2MWe. The system therefore loses both in efficiency and in value of output on turn down.

Turbines can be designed with a bypass provision to feed inlet-pressure steam into the second and third stages of blading which enables the turbine to absorb peaks of thermal demand and to optimise performance at a lower output, down to probably 85 per cent MCR. However, this allows alteration of one aspect of the system performance characteristic against 'known' variations in design, rather than providing true flexibility.

Figure 1(b) shows the standard method of providing flexibility to the fired-boiler steam turbine system by equipping the turbine with a condensing exhaust end. Hence, the heat-to-power ratio achievable is variable between all the steam to the turbine being extracted, less back-end cooling flow, which will typically give a heat-to-power ratio of 8:1, or all the steam going through to the condenser, giving a heat-to-power ratio of 0:1.

Any combination of power and thermal output is possible within the operational limitations of the turbine. Unfortunately, the conversion efficiency to useful output is normally very low for steam passing to the condenser, possibly as low as 25 per cent, which is worse than that achieved in a standard utility power station. The resultant economics are such that, today, this type of installation is only initiated under special circumstances. An example is a turbine-driven compressor, where the driving power to the compressor must be available regardless of the extraction steam (process thermal) demand at any particular instant.

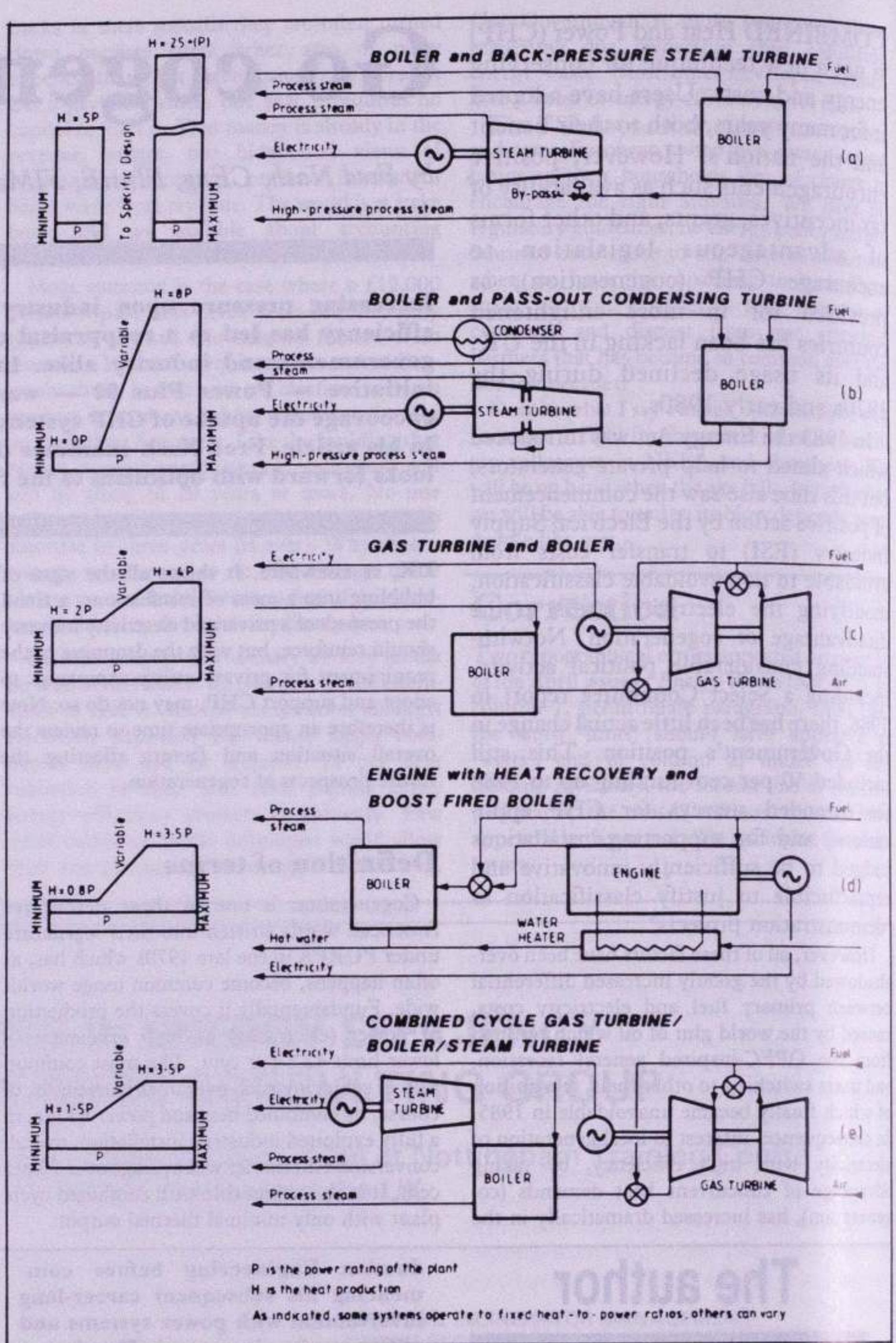



**Fig 1: Types of cogeneration systems.**

## Gas turbine and boiler

Figure 1(c) indicates what is currently regarded as the system with most potential: an alternator driven by a gas turbine with exhaust gas waste heat recovery boiler, with or without supplementary firing.

Industrial gas turbines have proved very acceptable for commercial and industrial applications based on their aviation pedigree of high power-to-size ratio, low vibration levels, known acoustic treatment, high reliability, developed control systems; monitoring systems which minimise operator demands; and, most importantly, high availability through a quick unit exchange or major part replacement capability by the manufacturers. Experience with first-generation gas turbines, with efficiencies typically up to 23 per cent, show that, on premium fuel, ie, natural gas and uncontaminated air (which is not always as good in industrial situations as it is in the depths of Russia, Alaska or at 40,000 feet) maintenance costs are low.

The scope of activity defined as 'maintenance' can vary from site to site, as can operational and accounting practices, making it almost impossible to obtain maintenance figures on a common basis. However, a figure of 0.2p/kWhe is reasonable.

Whether this will hold true for the most sophisticated second-generation gas turbines now available, with efficiencies up to 37 per cent, but which operate at higher combustion pressures and temperatures, only the next few years in general service with show.

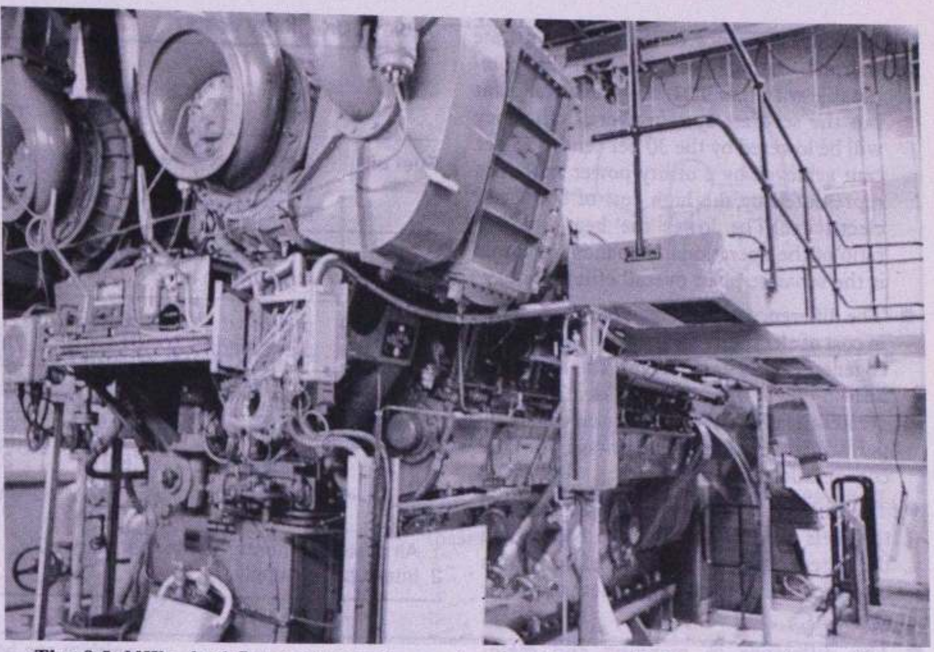
Under design (MCR) conditions, gas turbine and waste heat recovery boiler systems will typically operate with heat-to-power ratios between 1.5:1 to 2.5:1, dependent on the prime mover selected, that is with an efficiency to power conversion of around 30 per cent to 23 per cent respectively.

The efficiency of gas turbines reduces quite quickly on turn down. It is normally uneconomic to operate them at below MCR conditions in cogeneration schemes.

There is considerable free oxygen in the turbine exhaust gases and supplementary firing (boost firing) is possible which, theoretically, can achieve heat-to-power ratios up to 17 to 1. However, the physical size and cost of associated ducting, combined with the gas turbine's sensitivity to increased exhaust back-pressure, and a change in waste heat boiler type required to incorporate a radiant section, usually limits supplementary firing to a 4:1 heat-to-power ratio in practice.

With supplementary firing, thermal output can be fully varied between basic waste heat recovery and maximum steam output by simply changing the amount of boost fuel input. Heat-to-power ratios below waste heat recovery output can also be achieved by by-passing part of the exhaust gas flow, but this of course had a detrimental effect on overall system efficiency and economics.

Perhaps the most significant recent development is the steam injection cycle. This can provide gas turbines with the flexibility to operate from the normal 4:1 heat-to-power ratio, to one with full steam injection of 0:1, where the power is in fact increased by 60 per cent (0:1.6 ratio), with, at the same time, an improvement in the efficiency of conversion power of 18 per cent, 41 per cent rather than 35 per cent. Theoretically an improvement in the order of 30 per cent is possible in efficiency, so there is scope for even further increase. These charactertistics match those of large commercial buildings which have significant computer facilities, and also light process industries using refrigeration techniques. With both, electrical load increases in summer periods when there is a reduced call for heat.



**The 3.5 MWe dual-fire reciprocating engine that is part of the cogeneration project at Cyanamid (GB) Ltd at Gosport.**

## Engine systems

Figure 1(d) indicates the same basic type of system and facilities as Fig 1(c) but utilises a reciprocating diesel type engine as the prime-mover. This, in fact, changes the characteristics of the system through 180 degrees in almost every aspect. Engine systems have higher power generation efficiencies than gas turbines, and this is retained over a wide load range. They also have good fuel flexibility but present more problems as regards acoustic treatment, vibration and system complication compared with gas turbines.

Large reciprocating engines currently do not have the same acceptability to industry as gas turbines. Generally gas turbines are preferred because, rightly or wrongly, it is considered that they can be started up and forgotten about. Reciprocating engines require regular inspection and attention, and maintenance involves in situ work rather than total exchange. However, given that routine actions are not neglected, through-life maintenance costs of large dual-fuel engines may be comparable with those of gas turbines.

In order to match gas turbine availability engine manufacturers will have to provide a 'national'/'international' scale 'maintenance contract'/'service organisations', such that on annual shutdown a team of men with appropriate replacement subassemblies and components are on site ready to strip, rebuild and return the unit to operation in the minimum time.

Small systems, using automotive type spark-ignition engines, are used successfully at swimming pools and in other public buildings. Their economic viability is largely dependent on relatively low capital costs. Maintenance requirements are high, costing perhaps 0.7p/kWhe or more, but they have limited application in industry and larger commercial installations.

It is interesting to note that perhaps only the navies of the world have extensive comparable experience with both diesel engines and gas turbines, the latest trend is to use gas turbines for 'dash' operations and 'cruise' on diesels. Gas turbines, although tried, have made no headway at all into the highly cost-competitive world of the Merchant Marine. This may be due more to the diesel engine's ability to operate on a variety of fuels at higher conversion to power only efficiencies, typically 36 per cent to 45 per cent, as to reliability, availability and maintenance factors in the cost comparison. These same factors are of course important in cogeneration applications, especially fuel flexibility. Today, base load type medium speed engines are available to operate on gaseous fuels from low calorific process to natural gas and liquids, from premium diesel to the worst residual heavy oils available.

In the past engine systems have operated with waste heat recovery only where an overall heat-to-power ratio of around 0.8:1 will normally be easily achieved but at two levels, ie 0.5:1 as steam (high quality) and 0.3:1 as 80°C hot water (low quality). It is not always easy to find a use for the latter. Variations in thermal demand above the 0.8:1 ratio level required operation in parallel of a standard fired boiler. Spark ignition engines in micro systems generally produce heat-to-power ratios of 2 to 2.5:1 often with all thermal output as 65°C water.

The development of boost firing to utilise the free oxygen in a diesel engine or dual-fuel engine exhaust, and to extend the system's capability to heat-to-power ratios of 3.5:1 with total flexibility, is very important to reciprocating engine cogeneration prospects. Much will rest on the experience obtained from the UK Department of Energy's demonstration project at Cyanamid (GB) Ltd Gosport site, where a 3.5 MWe dual-fire engine driven alternator is coupled to a 30,000 lb/h boost-fired boiler.

This installation was put to work in September 1988 at an overall cost of £2.2m, and in its first year of operation achieved an annual saving of £516,000. Furthermore, whilst tests have yet to be completed, it is expected that the phased combustion of this installation will result in improved $NO_X$, CO and hydrocarbon emission levels being achieved.

## Combined cycle

The most common form of a combined cycle system (Figure 1(e)), consists of a gas turbine with waste heat recovery boiler, which produces steam to drive a steam turbine. For best operational efficiency the steam turbine should be of the back-pressure type. Fixed heat-to-power ratios in the range between 1:1 and 3.5:1 are typical with a back-pressure turbine. For ratios between 0:1 and 3:1 a condensing steam turbine is required. Both systems incorporate supplementary firing of the exhaust gas boilers, without which the upper limits are around 1.5:1 fixed and 1.2:1 variable, respectively. Sometimes exhaust gases from two gas turbines produce steam for one steam turbine, but this does not affect the ratios.

The combined cycle system extends gas turbine capability to lower heat-to-power ratios than if operating alone, and can also provide flexibility which can be important if meeting thermal loads which incorporate a large annual environmental element, whether for heating in winter or absorption chiller air conditioning in the summer. Unfortunately, it is an expensive system and tends to be economic only at larger sizes, unless some retrofit is involved. For example, where a gas turbine is installed to replace the standard force-draught fan of a large fired boiler already serving steam turbines.

## Economics

The fundamental economics of cogeneration are well known. However, in practice, as always, there are some complications. There are five major factors affecting the economics of cogeneration systems:

- the increase in overall conversion efficiency achieved by the cogeneration plant as compared with that of separate plant.

Here the efficiency of the on-site separate thermal output producer will be comparable with that of the cogeneration plant but the separate system overall efficiency will be lowered by the 30 per cent to 35 per cent achieved by a utility power station as represented by the high cost of bought-in electricity. The lower the heat-to-power ratio of the operational demands the lower is the separate plant overall efficiency.

- The difference in price between the bought-in cost of electricity and the fuel used by the cogeneration system. Again, the lower the heat-to-power ratio of the demands the greater the effect of this factor on economic performance to the advantage of the cogeneration system.
- The difference in price between the cost of the fuels used by the separate boilers and the cogeneration system. The effect of this increases with the ratio of the heat-to-power demands.
- The difference in manning and maintenance cost of the cogeneration and on-site separate plant.
- The difference in capital cost of the cogeneration and the on-site separate plant.

Table 1 shows energy cost information on the basis of what a smaller industrial user could typically expect to pay for his energy supplies, as indicated by current prices published by The Energy Information Centre at that time.

Using the figures recorded in Table 1, and assuming an electrical output of around 5MW, Table 2 computes the effects of cycle efficiency and relative energy costs for a number of systems. It also indicates the operating cost of the cogeneration and separate plant for the years 1984 when fuel costs peaked, 1986 when they collapsed, and December 1989, typical of today, which appears more consistent with a logical future when fuel prices relate to fuel quality, ie inversely to the ease of using and lack of environmental effect.

It must be recognised that the relative costs as calculated are at best only indicative since in practice:

- the heat and power demands on the plant will vary;
- the cycle efficiency of all plants varies with changes in heat and power output;
- interaction of electricity tariffs with load demand must be taken into account, also the extent of electrical cost that is non-avoidable;
- the performance of one gas turbine or reciprocating engine to another as power producers are different, also the effect they and other items of equipment have on system characteristics and these will differ again at both design and part load conditions;
- operating and maintenance costs, of course, vary from one type of equipment and system to the next, but this is far from the whole story as they can also vary considerably from one installation to the next, sometimes for reasons not strictly within the control of the plant supplier.

**Table 1: UK energy costs**

| | | § year of peak consumption | | | | | |
|---|---|---|---|---|---|---|---|
| | | § 1973 | 1981 | 1983 | July 1984 | May 1986 | Dec 1989 |
| **Fuel oil** | £ per tonne (includes tax) | 12.80 | 108.20 | 125.90 | 151.00 | 60.0 | 65.7 |
| | p per therm | 3.11 | 26.65 | 31.00 | 37.20 | 16.3 | 17.8 |
| **Coal** | £ per tonne | 8.90 | 39.90 | 49.60 | 49.80 | 55.0 | 41.0 |
| | p per therm | 3.40 | 15.52 | 19.07 | 19.10 | 22.0 | 16.4 |
| **Electricity** | p/kWh | 0.74 | 2.71 | 2.94 | 2.69 | 3.0 | 3.1 |
| | p per therm | 21.68 | 79.29 | 85.09 | 77.85 | 88.9 | 94.8 |
| **Gas** | p per therm* | 3.07 | 21.59 | 24.06 | 26.27 | 21.0 | 22.0 |
| **Ratio of cost:** | | | | | | | |
| | Elect/oil | 6.97 | 2.97 | 2.74 | 2.09 | 5.5 | 5.3 |
| | Elect/coal | 6.38 | 5.11 | 4.45 | 4.10 | 4.1 | 5.8 |
| | Elect/gas | 7.06 | 3.67 | 3.53 | 2.96 | 4.2 | 4.3 |

1 All costs per therm refer to therms net CV.
2 Interruptible supply.*

## Market potential

In 1986 the UK Department of Energy (DOE) published a report, *Combined Heat and Power and Electricity Generation in British Industry 1983-1988*, which examined the potential for cogeneration in the traditional user industries. Pre-privatisation, this indi-

**Table 2: Economic comparison of cogenerating systems**

| CHP system | Heat/power ratio | System Electricity | Fuel used | December 1984 Fuel cost index (elect 4) | December 1984 Relative operating costs CHP basic | May 1986 Fuel cost index (elect 4.1) | May 1986 Relative operating costs CHP basic 2 | December 1989 Fuel cost index (elect 5.8) | December 1989 Relative operating costs CHP basic 3 | Relative cost CHP plant |
|---|---|---|---|---|---|---|---|---|---|---|
| Steam boiler/ turbine | 8/1 | 84% | Coal | 1 | 0.50 | 1 (HFO = 0.74) | 0.94 (0.70) | 1 | 0.58 | 2.5 |
| Diesel engine/ boost fired boiler | 3.6/1 | 84% | Heavy fuel | 1.8 | 0.83 | 0.74 | 0.55 | 1.1 | 0.52 | 1 |
| Dual fuel eng/ boost fired boiler | 3.6/1 | 86% | Diesel (8%) NG | 2.4 1.3 | 0.61 | 1.25 0.95 | 0.70 | 1.5 1.3 | 0.65 | 1.3 |
| Gas turbine/ fired WHR boiler | 2/1 | 79% | Natural gas | 1.3 | 0.59 | 0.95 | 0.61 | 1.3 | 0.57 | 1 |
| Dual fuel eng/ fired WHR boiler | 2/1 | 81% | Diesel (8%) NG | 2.4 1.3 | 0.60 | 1.25 0.95 | 0.73 | 1.5 1.3 | 0.58 | 1.2 |

Basic energy provision – purchased electricity + heat from low pressure boilers
1 Basic operating cost December 1984 based on Electricity Cost Index 4 and HFO used in LP Boilers.
2 Basic operating cost May 1986 based on Electricity Cost Index 4 and HFO used in LP Boilers.
3 Basic operating cost December 1989 based on Electicity Cost Index 5.8 and gas used in LP Boilers.

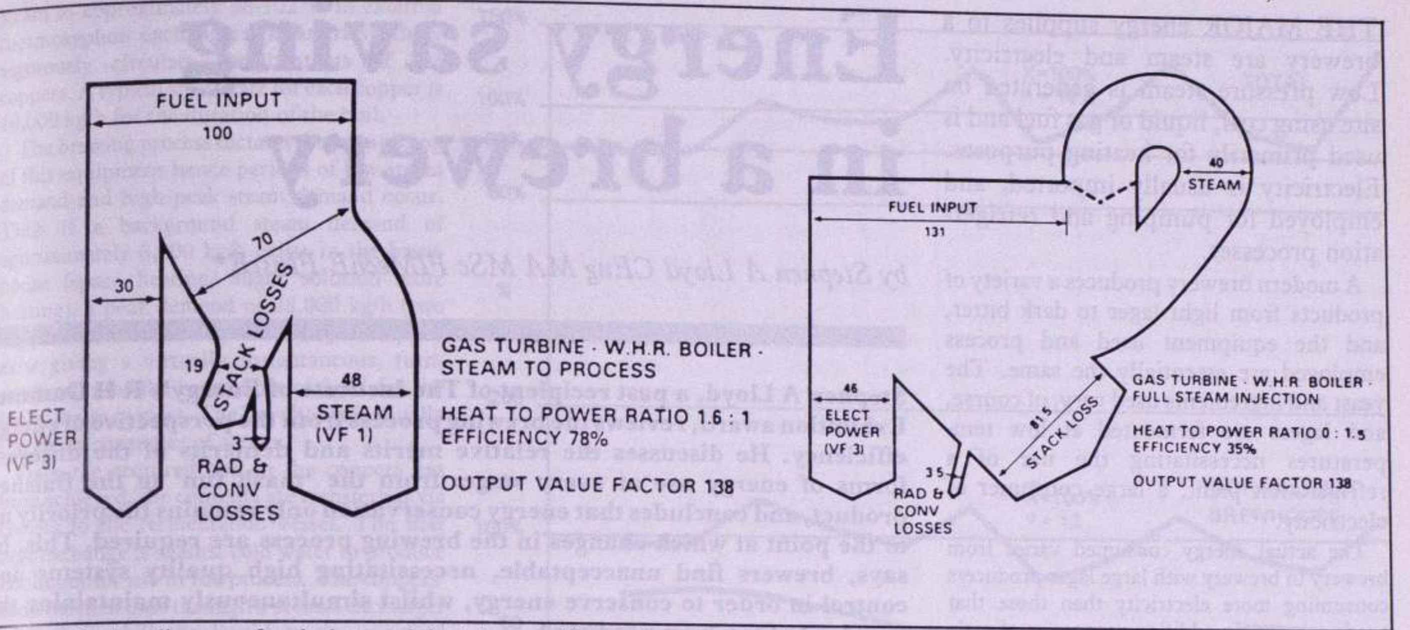



**Fig 2: Sankey diagram of typical steam injected gas turbine.**

cated an overall reduction in industrial electricity production arising from the decommissioning of old oversized boiler/steam turbine plants, but, at the same time, a switch to gas turbine and reciprocating engine systems involving the installation of 360MWe of new equipment of this type.

The latter has not yet happened, but it is more likely that the time scale was wrong rather than the prognosis itself. At the same time as this report, another report was commissioned from a consultant by the DOE to assess CHP (cogeneration) potential in non-traditional user industries (which really meant those whose thermal demand is too small or inconsistent to be met by the traditional boiler/steam turbine system). Publication of this latter report was held until late 1988, and it indicates a potential of 150MWe to 300MWe. However, it is believed than when originally drafted in 1986 the estimated potential, based on a five year acceptable payback, was around 1200MWe. Because the report was originally offered in the midst of the Sizewell enquiry, with a government committed to nuclear energy, it is not surprising it was not published as, from a DOE point of view, it would have been akin to blowing a leg off rather than merely an accidental shot through the foot.

In fact a 1000MWe actual potential does not seem unrealistic. However, the capital, time, equipment and expertise availability logistics may limit the rate of installation to a maximum of 75MWe per year at an investment cost to industry of around £45m per year.

Then there is PRIVATISATION!

## The future

The Government imposed price increases for electricity in 1989, some cynics suggested to 'fatten' the industry up for privatisation, improved the economics of cogeneration. However, this has now been negated since supplying electricity to industry has been chosen by the established generating companies as the marginal battle area for market share and contract prices below 1989 levels in money, never mind real values, are available.

Whilst the UK electricity market is expanding, it is not doing so rapidly and demands certainly will not expand infinitely. Therefore, the new generators that privatisation is aimed at encouraging are going to impinge, not only on the established utility companies, but also on the distribution boards who will suffer prime demand loss as private generating companies contract to supply industrial consumers direct.

Then again a number of Boards are indicating an intention to generate some of their electricity sales themselves, and in the future a private board may be more aggressively protective of its own generation operation than the ESI has been for many years. The rules of regulation will hold the key and be critical for the success or otherwise of the large electrical generation/cogeneration schemes.

Because of their very high operating efficiencies and much to the credit of the DOE, the further advantage of being exempt from the fossil fuel levy (which is in fact a tax to subsidise the high cost of nuclear power), smaller cogeneration schemes, where at least 51 per cent of the power generated is for self use on an industrial or commercial site, can and will be able to stand on economic advantage alone. This will become more evident as the electricity market settles, since on two counts it is doubtful that the very advantageous electricity prices being offered to industry today can be sustained: firstly as shareholder demands on generator companies swing some emphasis from market share to profit margins; and secondly, on the basis that it would be unacceptable to the Government if an accusation could be made that they have set up a system where domestic sales of electricity are subsidising supplies to big business.

For true 'on site' cogeneration, gas turbine plants, possibly with steam injection, will be predominant where the size of scheme and availability of reasonably priced natural gas allows. Fired boilers and steam turbines will be utilised, where low-grade low-cost waste fuels are available, and reciprocating engine systems using residual heavy fuel oil, where neither waste fuel nor low cost natural gas is available.

The energy crisis of 1973 and 1979 are over, and today there is sufficient nuclear and coal utility generating plant installed worldwide to control the price of any fuel through normal market reaction, especially as gas and coal join oil as internationally traded dollar commodities. There is also greater confidence in those companies in the UK who have survived the 'shake out' years of the early 1980s, such that investments showing a return of 35 to 20 per cent in simple terms with a probable life of 15 to 25 years make sense.

The Germans and Japanese have clearly demonstrated that maximising operating efficiency is a major factor in the long term survival of companies, hence technical directors should today be reminding their financial colleagues that maximising short term advantage is not an end in itself — the medium term is tomorrow, long term only the day after — and be leaning on them to reinforce the trend already embraced by many go-ahead companies to look ahead and to 'go cogenerate'.

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# Energy saving in a brewery

*by Stephen A Lloyd CEng MA MSc FIMechE FInstE**

**Stephen A Lloyd, a past recipient of The Institute of Energy's R H Gummer Exhibition award, reviews the brewing process from the perspective of energy efficiency. He discusses the relative merits and demerits of the different forms of energy use at every stage: from the 'mash tun' to the finished product, and concludes that energy conservation only remains the priority up to the point at which changes in the brewing process are required. This, he says, brewers find unacceptable, necessitating high quality systems and control in order to conserve energy, whilst simultaneously maintaining the standard of the beer produced.**

THE MAJOR energy supplies to a brewery are steam and electricity. Low pressure steam is generated on site using coal, liquid or gas fuel and is used primarily for heating purposes. Electricity is usually imported, and employed for pumping and refrigeration processes.

A modern brewery produces a variety of products from light lager to dark bitter, and the equipment used and process employed are essentially the same. The yeast and ingredients used vary, of course, and lagers are fermented at low temperatures necessitating the use of a refrigeration plant: a large consumer of electricity.

The actual energy consumed varies from brewery to brewery with large lager producers consuming more electricity than those that produce none. In addition economies of scale exist.

Typical statistics for a million barrel a year mixed brewery is that energy costs approximately £1 per barrel split roughly 50:50 between fossil fuel (steam) and electricity. For a brewery without a substantial refrigeration load, the electrical costs will be reduced and energy costs of roughly half of the above value will ideally exist.

For one particular brewery producing annually somewhat in excess of one million barrels of beer, its steam consumption was annualised at approximately 20,000 kg/h with very high peak rates in excess of 30,000 kg/h occurring. Of this steam, 62 per cent was consumed in the brewhouse, 16 per cent in the container plant, eight per cent in the canning plant, six per cent in the cask plant with the remaining nine per cent used for bottle store, space heating, and so on.

The steam consumption was not constant throughout the year and varied markedly with throughput. Apart from the space heating load, the steam consumption on a normalised basis did not vary greatly with the time of the year. Figure 1 gives the percentage steam consumption for any given time period (each period is approximately four weeks but does not coincide precisely with the calendar months). The variation and standard deviation about a mean for the total plant wide consumption, the brewhouse, container plant and canning plant are also presented here.

The brewery process is also very expensive in terms of water consumption: six to eight litres of water are required to produce one litre of beer.

Economies of scale exist with breweries in a similar fashion to any other process plant, and the tendency is for fewer yet larger breweries. This economy also applies to the energy side of brewing with the larger breweries employing sophisticated forms of energy saving using hot water (liquor) as the heat recovery media. The energy consumed in a brewery is usually at low temperature hence the waste energy is frequently low grade heat. This article describes the basic brewing process and some areas where energy saving can be achieved.

## Brewing process

A typical brew process proceeds in the following sequence. It is characterised as a series of batch steps of various time durations. The nature of the batch process impacts both the consumption of steam and on the ability to recover energy.

The whole essence of brewing is the extraction of 'sugars' from the malt and its subsequent conversion into alcohol. The malt is received and stored in silos. From there, is it weighed and ground and transferred via feed hoppers to the mash tun. Hot water (called in breweries 'liquor') is added together with calcium chloride and the whole batch is steam heated by sparging to 75°C and maintained at these conditions for several hours. A typical steam sparge rate of 8,000 kg/h will exist for the duration of the sparge only. In this step, the sugar and flavours are extracted from the malt and a weak sugar solution results.

The liquid (wort) from the mash tun proceeds to the 'coppers' where hops and other ingredients are added and the mixture is boiled for 60-75 minutes. Approximately 10 per cent of the liquid evaporates here thus concentrating the sugar solution as well as adding flavour. The liquid in the coppers is heated by

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steam to approximately 98-102°C in external thermosyphon exchangers (kalandrias): these vigorously circulate the contents of the coppers. A typical steam rate for each copper is 10,000 kg/h for the duration of the boil.

The brewing process dictates the sequencing of this equipment hence periods of low steam demand and high peak steam demand occur. Thus if a background steam demand of approximately 8,000 kg/h exists in the brewhouse (space heating, sugar solution store heating), a peak demand of 28,000 kg/h (two copper + one mash tun and background) can exist giving a virtually instantaneous, turndown ratio for the brewhouse of 3.5:1 for the boiler house to meet. The brewhouse is usually the major consumer of steam.

Once the required boil in the coppers has been achieved, the contents are transferred via coolers to the fermentation vessel. The first heat exchange is against cold water to produce hot liquor for use in the process. The coppers' contents then pass through a second exchanger (chiller) to chill the liquid to the required temperature for fermentation. Typical fermentation temperature for beers is 15/20°C whereas that for lagers is 4°C. Presently refrigeration plant is generally used for the chilling process, though heat pumps may be introduced here, rejecting their heat to hot water (liquor).

The residence time in the fermentation vessel is from three to seven days depending on the brew. The fermentation vessel is itself chilled and the temperature reduction/final temperature of the vessel's contents is tightly controlled. Yeast is added to the fermentation vessel so that the sugar solution previously generated is turned into alcohol. Carbon dioxide is evolved here and can be recovered for subsequent reuse. After the requisite time interval, the yeast contents of the fermentation vessel are removed: the yeast is separated, treated and reused.

The liquid product from the fermentation vessel passes via a filter to the conditioning tank where it resides for two to five days and thence via further ultra filtration steps (Kieselguhr, and so on) to the storage tank. Carbon dioxide is added to the beer before final storage.

The main energy consumers in the brewing process itself are steam in the mash tuns and coppers, and electricity in the chilling steps. Other users previously identified include energy consumed in the canning and final storage/transports steps, which are not considered here.

The main technique for minimising the consumption of steam is to preheat all water used in the process. Water (liquor) is softened for the process and stored in cold storage tanks. The liquor is heated via the wort coolers which cool the contents from the copper prior to passing to the fermentation vessel.

The use of heat pumps in the chilling process should achieve a good coefficient of performance thereby saving steam (for liquid heating) and electricity. In addition, this should offer a physically compact layout, thereby minimising the capital cost.

Another potential source of waste heat recovery is to install a heat exchanger in the vapour line above the coppers. The 10 per cent boil off from the coppers would condense in these exchangers and produce additional hot liquor. This has the additional benefit of reducing atmospheric pollution as the condensed products (which contain trace organic vapours as well as steam) can be directed to an effluent water treatment plant, rather than released as vapour to the atmosphere.

The production process is a batch process hence, the generation of hot water is also a batch process. Since the production of hot water does not always coincide with its consumption, hot water (liquor) storage vessels are required. These are large well insulated tanks with sufficient capacity to hold the hot water generated until it is required for use.

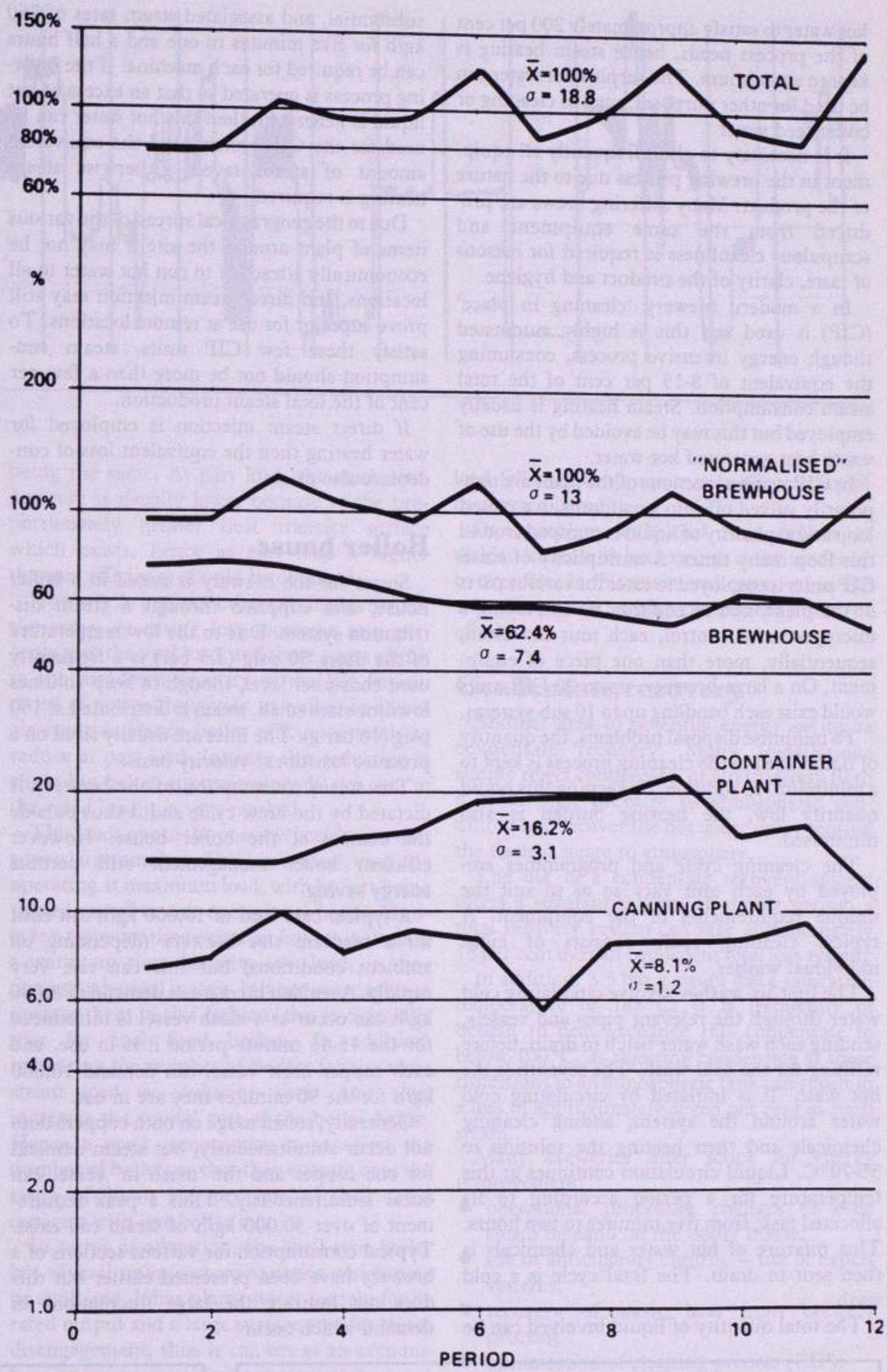


**Fig 1: Annual variation of steam consumption.**

As the process is a multiple batch process, hot water is not produced at the same temperature from all sources. The water in these tanks is frequently at a mean temperature, not always as high as required, and some steam heating is frequently necessary even though certain sources may produce hot water. In addition, brewing in the UK is frequently a five day process and cooldown of the hot water tank occurs over weekends necessitating reheating before use. Hence several hot liquor tanks are usually employed and the management of the liquor to these tanks must be carefully controlled if steam consumption is to be minimised.

By employing the maximum energy recovery techniques it is possible to produce sufficient hot water to satisfy approximately 200 per cent of the process needs, hence steam heating is kept to a minimum. The surplus hot water can be used for other purposes, such as cleaning or boiler feed water

It is necessary to clean frequently all equipment in the brewing process due to the nature of the product. Many differing brews are produced from the same equipment and scrupulous cleanliness is required for reasons of taste, clarity of the product and hygiene.

In a modern brewery 'cleaning in place' (CIP) is used and this is highly automated though energy intensive process, consuming the equivalent of 8-15 per cent of the total steam consumption. Steam heating is usually employed but this may be avoided by the use of waste heat generated hot water.

In CIP, various sections of the plant are temporarily valved off into small units in a closed loop and a quantity of liquid is pumped around this loop many times. A multiplicity of small CIP units is employed to cater for various parts of the plant, and in addition by employing a microprocessor control, each unit can clean, sequentially, more than one piece of equipment. On a large brewery, up to 20 CIP units would exist each handling up to 10 sub-systems.

To minimise disposal problems, the quantity of liquid used in the cleaning process is kept to a minimum. In addition, by keeping this liquid quantity low, the heating burden is also minimised.

The cleaning cycle and programmes employed by each unit vary so as to suit the unique requirements of the equipment. A typical cleaning cycle consists of eight individual washes.

The first six washes involve circulating cold water through the relevant pipes and vessels, sending each wash water batch to drain, before refilling for the next wash. The seventh is the hot wash. It is initiated by circulating cold water around the system, adding cleaning chemicals and then heating the solution to 55-70°C. Liquid circulation continues at this temperature for a period according to its allocated task, from five minutes to two hours. This mixture of hot water and chemicals is then sent to drain. The final cycle is a cold wash.

The total quantity of liquid involved can be substantial, and associated steam rates of 750 kg/h for five minutes to one and a half hours can be required for each machine. If the brewing process is operated so that an excess of hot liquid is generated, then this hot water can be used for the CIP system, and the equivalent amount of steam saved. Otherwise steam heating is required.

Due to the geographical spread of the various items of plant around the site it may not be economically attractive to run hot water to all locations, and direct steam injection may still prove superior for use at remote locations. To satisfy these few CIP units, steam consumption should not be more than a few per cent of the total steam production.

If direct steam injection is employed for water heating then the equivalent loss of condensate also exists.

## Boiler house

Steam for the brewery is raised in a boiler house, and supplied through a steam distribution system. Due to the low temperature of the users 50 psig (3.5 bar) is a frequently used consumer level, though to keep volumes low/line sizes small, steam is distributed at 150 psig (10 bar g). The lines are usually sized on a pressure loss/linear velocity basis.

The steam consumption of the brewery is dictated by the brew cycle and is thus outside the control of the boiler house. However efficient boiler management still permits energy saving.

A typical base load of 10,000 kg/h can exist for a medium size brewery (depending on ambient conditions) but this can rise very rapidly. A sudden increase in demand of 8,000 kg/h can occur as a mash vessel is introduced for the 15-45 minute period it is in use, and each copper brew vessel can demand 10,000 kg/h for the 90 minutes they are in use.

Generally, steam usage on both coppers does not occur simultaneously, but steam demand for one copper and the 'mash in' vessel can occur simultaneously. Thus a peak requirement of over 30,000 kg/h of steam can exist. Typical consumption for various sections of a brewery have been presented earlier but this does not indicate the large fluctuations in demand which occur.

To meet this demand it is customary to employ several shell boilers operating in parallel: shell boilers have very low capital cost in this size range.

Fuel consumption from a boiler can be reduced to the lowest level by keeping the stack temperature low, and by tight control of the excess air. The lower stack exit temperature and the closer the combustion air is to its stoichiometric value, the higher its thermal efficiency. The stack temperature limit it set by the design of the boiler and considers such items as the use of an economiser, the dew point of the flue gases (which in turn depends on the sulphur level of the fuel) and indeed the fuel itself. The fuel selected and operating mode also influence the excess air levels that can in practice be achieved, as zero excess air is not practicable whilst maintaining good combustion control.

With a good boiler design, a thermal efficiency in excess of 80 per cent based on the GCV of the fuel should be achieved. In practice, a value close to 60 per cent is frequently obtained due to lack of control of the excess air level during plant demand changes.

With gaseous fuels, 15 per cent excess air level should be the target, but maintaining 20-40 per cent excess air over the full operating range is more realistic. To achieve this, a good combustion control system is mandatory.

Coal is a lower cost fuel than gas and is frequently employed. Chain grate coal fired boilers inherently require higher excess air levels for combustion than their gas fired counterparts. A nominal design value of 30-50 per cent is frequently employed to ensure that minimum coal carryover in the ash and incombustibles in the stack gases exist. Superimpose on this the difficulties of a slow moving chain grate system to respond to rapidly changing steam loads, and it is inevitable that at part loads very high excess air levels occur. Rectifying this problem is not as simple as that for gas/oil fired boilers in terms of combustion control equipment.

One solution is to employ fluidised bed boilers. These are very flexible and respond rapidly to load changes, but severe problems have frequently manifested themselves with the smaller sizes of FBC boilers.

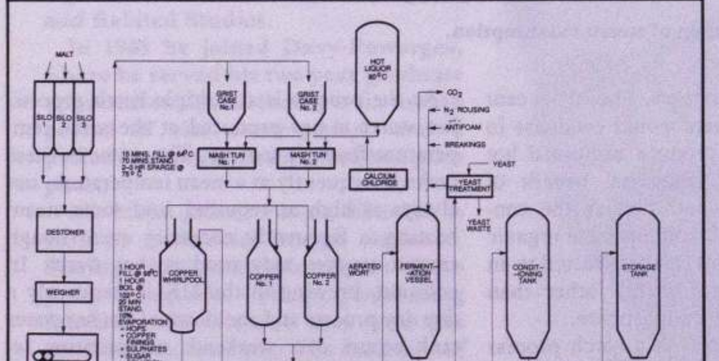


**Fig 2: Typical brewing schematic diagram.**

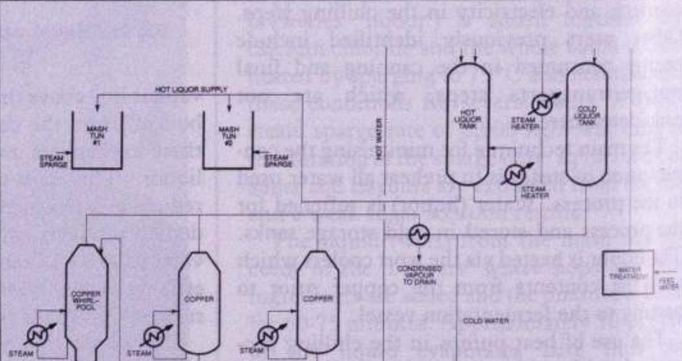


**Fig 3: Liquor circuit.**

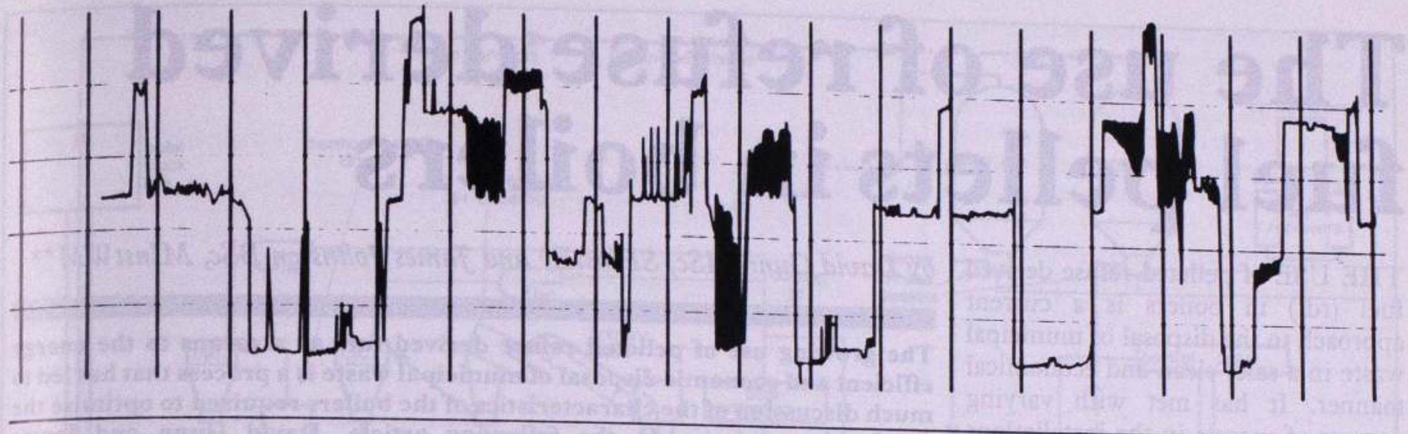

**Fig 4: Typical steam demand in a brewhouse.**

Another approach is to use intelligent control equipment so that demand from the brewhouse can be anticipated by the boiler house and the necessary boilers prepared for use.

At this point several potentially conflicting philosophies concerning the number, size and operation of multiple boilers may be discussed.

The total quantity or steam raising capacity of the boiler house must be sufficient to meet the peak steam demand under the most adverse conditions, unless for certain conditions a reduction in brewing capacity is acceptable. In addition multiple boilers must be employed so that any individual boiler can be taken off line, either inadvertently due to malfunction or for the annual maintenance period. Except for the most critical applications, the planned loss of one boiler is assumed to occur at times of off-peak demand hence this loss should not influence the total installed capacity, only the number of boilers.

Typically, boiler efficiencies are quoted at full rated output, and for specific operating conditions such as steam pressure. In operation, stack temperature is used as a means of indicating relative efficiency: other conditions, such as flue gas $CO_2$, $O_2$ and radiation losses

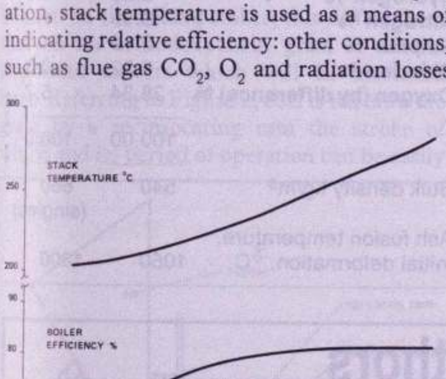


**Fig 5: Stack temperature and boiler efficiency vs per cent load.**

being the same. At part load, the stack temperature is usually lower because of the proportionately greater heat transfer surface which exists, hence at part load a higher thermal efficiency should be obtained.

However in practice other conditions are not the same, eg casing loss increases as a percentage of the total load, and there exists a limit to the turndown capacity of the FD fans in terms of power absorption as well as in excess air control. Hence boiler efficiency tends to reduce at part load. Initially this reduction is slight but below approximately 40 per cent of the rated load it is very marked.

This leads one to the possible conclusion that a very large number of boilers is ideal, each one operating at maximum load, with boilers being turned on/off to suit operational needs. However a response time exists for boilers including a warm up time for very low load, ie they possess a thermal inertia. It is not practicable to operate them in this fashion: this is especially true for coal fired boilers. In addition, increasing the number of boilers for the same steam load (ie reducing their unit size) increases the capital cost of the boiler house. Hence a good compromise is to select the number of boilers so that they operate over the range of 40 to 100 per cent of their rated capacity with one boiler out.

In terms of operation, the shell type boiler has several unique characteristics which may be exploited. It has a large water content for its rated output and a large surface area for steam disengagement, thus it can act as an accumulator to meet excessive short term peaks.

Having selected the number of boilers, the policy as to whether to have all boilers follow the plant load, or whether to base load the majority at optimum efficiency and allow one boiler to swing highly inefficiently depends on many factors.

Generally it is better to have all boilers floating. In this event, a given load change is a smaller percentage variation of each boiler's rated output, and it is easier for the control system to respond.

Where mixed fuel firing is employed, eg coal and gas, it is usually better to have the majority of the coal fired boilers base loaded, with the gas fuel boiler following the load change using sequencing units.

Depending on the relative economies of coal and gas, the maximum number of boilers should however be on line unless their average load falls below approximately 40 per cent of their rated capacity.

One problem with coal fired boilers at sudden increase in load swings is the tendency to over fire. In this event coal carryover in the ash can occur with consequent loss of efficiency.

## Condensate recovery

Another area of potential energy saving is condensate recovery. Many installations simply reject condensate, or alternatively flash it from high pressure to atmospheric conditions and recover the hot water only, venting the flashed steam to atmosphere.

The use of a condensate recovery system offers a substantial form of energy saving: a total recovery system can save approximately 18 per cent over an equivalent total loss system.

In addition, 3.5 bar g steam has a saturation temperature of 148°C. It is frequently of benefit to heat exchange this condensate to below 100°C, as rejecting condensate at these conditions to an atmospheric tank can result in a loss of approximately seven per cent as flash steam.

Many breweries offer scope for energy improvement:

- operational procedure changes to even steam demand on the boiler house;
- use of anticipatory control — use of expert systems;
- recovery of waste heat from brewery process;
- optimisation of cleaning process (CIP);
- condensate recovery;
- heat pumps in the chilling process.

Even modern breweries which have been designed on an energy conscious basis may benefit from the first three steps. However the main characteristic of any brewery is the final product: the beer, and changes which potentially impact beer quality need very careful evaluation. Many brewers will not consider the use of heat exchangers to recover heat from the copper vapours for this reason, and modifications of the brew programme to suit energy conservation is usually totally unacceptable.

Hence for many installations the application of expert systems and anticipatory control will be the route to maximise energy recovery, by enabling all utilities to respond promptly and efficiently to the needs of the brew programme. □

# The use of refuse derived fuel pellets in boilers

*by David Gunn MSc, SFInstE* and James Johnston BSc, MInstWM***

**The growing use of pelleted refuse derived fuel as a means to the energy efficient and economic disposal of municipal waste is a process that has led to much discussion of the characteristics of the boilers required to optimise the combustion process. In the following article, David Gunn and James Johnstone review the features of the typical types of boilers that have been used to combust this material, and in particular they assess the characteristics of the hydrid stoker, which combines the advantages of the chain grate and coking stoker, leading to its first application at the Polmadie waste disposal plant, Glasgow.**

THE USE of pelleted refuse derived fuel (rdf) in boilers is a current approach to the disposal of municipal waste in a safe, clean and economical manner. It has met with varying degrees of success in the installations so far studied but it has now become clear that one of the earlier types of firing appliance, the chain grate, invented by Jückes in 1841, has proved to be very suitable for this new fuel.

Since the late 1940s this type of grate has also proved reliable and effective for firing small coal of varying quality in shell boilers; its use in larger water tube boilers for power generation was established long before then.

Another type of stoker for shell boilers is the so called coking stoker which uses reciprocating bars to move the coal along the grate. This was invented by Vicars in about 1875 and has proved successful on graded coals, especially those with moderate and low coking properties.

The Polmadie refuse collection works of the City of Glasgow Cleansing Department has been equipped with a modern shell boiler rated at 3.41MW with a working pressure of 150 psig. It was fitted with a coking stoker and tested on both coal and rdf. With the latter, fuel difficulties were immediately encountered with the formation of large, often unmanageable clinkers which destroyed the viability of the plant. Coal does not present this problem as it is by nature much harder and with a lower ash content and higher ash fusion temperature.

The results of the experimental work leading to this conclusion have been published (*Energy Recovery from Waste Combustion*, Elsevier Applied Science 1988, p302 to 305) and show that the cause of the clinker formation was essentially the action of the reciprocating bars of the grate. On their return strokes these bars compress the fuel bed against the front part of the stoker. The nature of the fuel, relatively soft pellets, a high ash content (circa 14 per cent) and a low ash fusion temperature (circa 1050°C IDT) combined to form fused masses which inhibited the movement of the fuel on the grate and which were often too large to pass through the ash discharge tube at the bottom of the boiler. It was decided to remove the grate bars and replace them with a chain grate which, being unidirectional, avoids the compression of the fuel bed and thus the formation of massive clinkers.

The work described in this article forms part of a programme sponsored by the Energy Technology Support Unit (ETSU) acting on behalf of the Department of Energy.

## The fuel

Figure 1 shows diagrammatically the process used at the Govan works of Glasgow City Council to manufacture the pellets. After initial screening to remove much of the incombustible material the refuse is pulverised and then passed through a pelleting mill to produce pellets nominally 19mm in diameter and of length up to 50mm. Typical analyses are given in Table 1.

It will be seen that although rdf and coal are both solid fuels their properties differ widely. In particular the fixed carbon content of rdf is much lower than that of coal and the volatile content much higher. This means that less underfire and more overfire air is required for combustion.

It is likely that a boiler plant intended to burn rdf may, at times, be called upon to burn

**Table 1: Typical Analyses of RDF Pellets and Coal**

| | *RDF* | *Coal* |
|---|---|---|
| *Proximate Analysis (as received)* | | |
| **Total moisture %** | 6.9 | 10.0 |
| **Ash %** | 14.0 | 10.0 |
| **Volatile matter %** | 67.3 | 29.0 |
| **Fixed carbon %** | 11.8 | 51.0 |
| | 100.0 | 100.0 |
| Gross calorific value kJ/kg | 17,980 | 27,000 |
| *Ultimate Analysis (as received)* | | |
| **Total moisture %** | 6.87 | 10.0 |
| **Ash %** | 14.02 | 10.0 |
| **Carbon %** | 43.42 | 67.4 |
| **Hydrogen %** | 6.38 | 4.0 |
| **Nitrogen %** | 0.55 | 1.5 |
| **Sulphur %** | 0.10 | 1.1 |
| **Chlorine %** | 0.32 | 0.3 |
| **Oxygen (by difference) %** | 28.34 | 5.7 |
| | 100.00 | 100.0 |
| Bulk density kg/m$^3$ | 540 | 660 (singles) |
| Ash fusion temperature, initial deformation, °C | 1050 | 1300 |

**Director, Energy Projects, White Young Prentice Royle, Leeds, UK.*
***Waste Disposal Manager, Glasgow District Council.*

## The authors

**David Gunn, a Senior Fellow of The Institute of Energy, is Director of Energy Projects in the consultancy practice of White Young Prentice Royle, Leeds.**

**Formerly he was Director of Research for John Thompson Cochran (now NEI Cochran), before which he was a Deputy Director of the British Coal Utilisation Research Association. His earlier days were in the gas industry specialising in the industrial use of gas.**

**He has a Bachelors degree in Engineering (London) and a Masters degree in Gas Engineering (Leeds). He is also a member of the Institution of Gas Engineers and a Vice President of the Combustion Engineering Association.**

**James Johnstone graduated from Glasgow University in 1973 with a BSc in Electrical Engineering and a BSc in Mechanical Engineering. He joined Motherwell Bridge & Engineering Co Ltd, working for the Construction and Project Division. This division specialised in waste treatment turnkey projects involving rolling grate incinerators, pulverisation plants, and waste water treatment.**

**He joined Glasgow District Council as Waste Disposal Manager with responsibility for processing at four treatment plants and landfilling the 320,000 tonnes of refuse generated within the city boundary each year. He is a member of the Institute of Waste Management.**

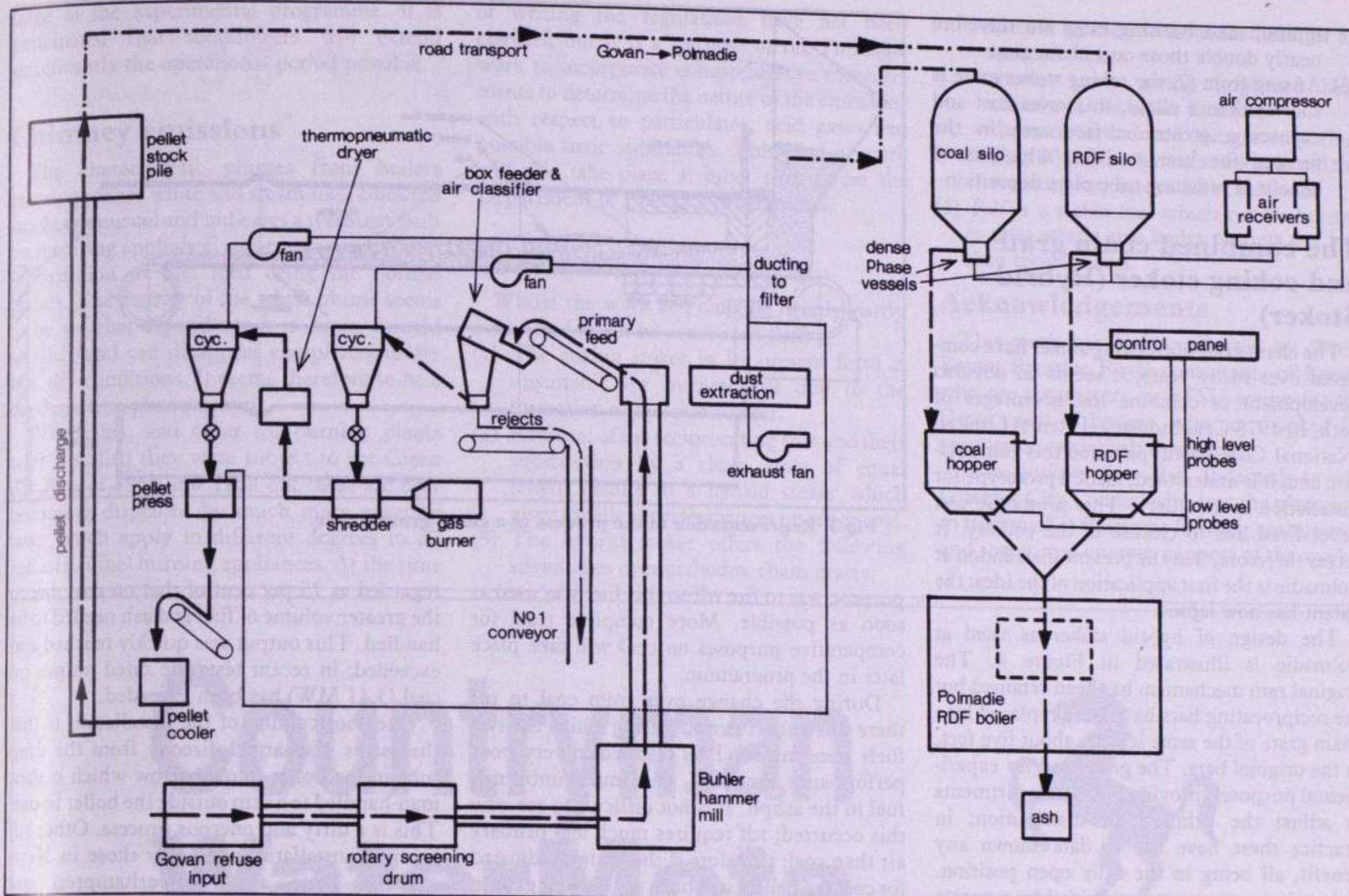


**Fig 1: Cycle of processes in the Govan pellet preparation plant.**

coal if rdf is not available; the change needed to the combustion settings must therefore be borne in mind. In practice this has not proved difficult.

## The coking stoker

Figure 2 illustrates the principle of combustion on the coking stoker; this differs from that on an orthodox chain grate in several important aspects which will be discussed later. Referring to Figure 2, coal is fed onto the grate by a reciprocating ram the stroke of which and its period of operation can be easily adjusted. Air is supplied by induced draught only, and enters through the grate bars and (horizontally) through ports (poke holes) in the front casting of the stoker. The fuel at the front end of the grate is ignited by any convenient means. Combustion is established within minutes, after which fresh fuel is fed on top of the ignited fuel and is itself ignited; this is fundamentally different from the process on a chain grate (see Figure 3) where the fresh fuel is ignited by radiation only from the ignition arch which will take much longer to become sufficiently hot.

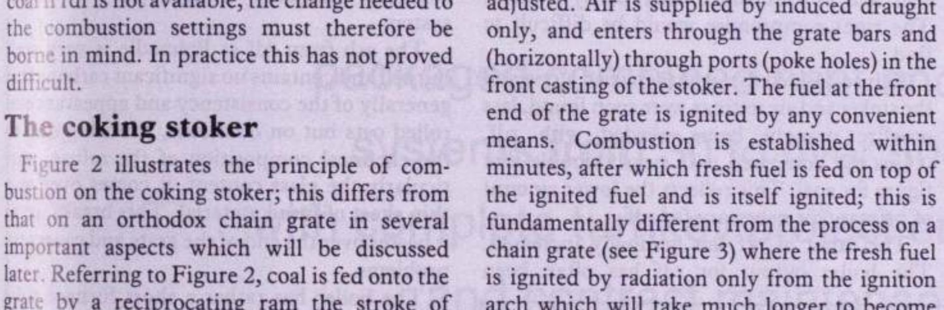


**Fig 2: Diagrammatic representation of the firing process in a coking stoker.**

When ignition is established on the coking stoker the fresh fuel is heated not only by convected hot gases from the already ignited fuel onto which it is fed but also by back-radiation from the luminous flame now stabilised in the furnace. The ignition rate on the coking stoker is therefore roughly double that on a chain grate, the fuel being heated by both radiation and convention. In consequence of this the overall burning rate is much higher and therefore the grate can be shorter; a coking stoker is about 5/8 that of a chain.

It is a feature of the coking stoker that it is provided with an overfire steam jet (or jets) at the front end; it is the purpose of this jet to create a turbulent low pressure zone over the front end of the fire where most of the combustible gases are evolved. The action causes air from the rear and sides of the grate to be recirculated to the front and to be mixed intensively with the combustibles. It should be remembered that both the chain grate and coking stoker were originally developed for coal; arrangements for the provision of additional overfire air for rdf must be provided. There are many ways by which this can be done, both by induced draught only and by forced draught.

The essential differences between coking and chain grates are:

(1) The draughting on a coking stoker is by induced draught only, simpler and easier to control than by both forced and induced draught on an orthodox chain grate.

(2) Ignition on a coking stoker is by convection and radiation compared with radiation only on a chain grate. The

ignition and burning rates are therefore nearly double those on a chain grate.

(3) Arising from (2) the coking stoker grate is shorter than a chain, this saves cost and exposes a greater surface area in the furnace for heat transfer, which is of benefit in reducing tube plate deposition.

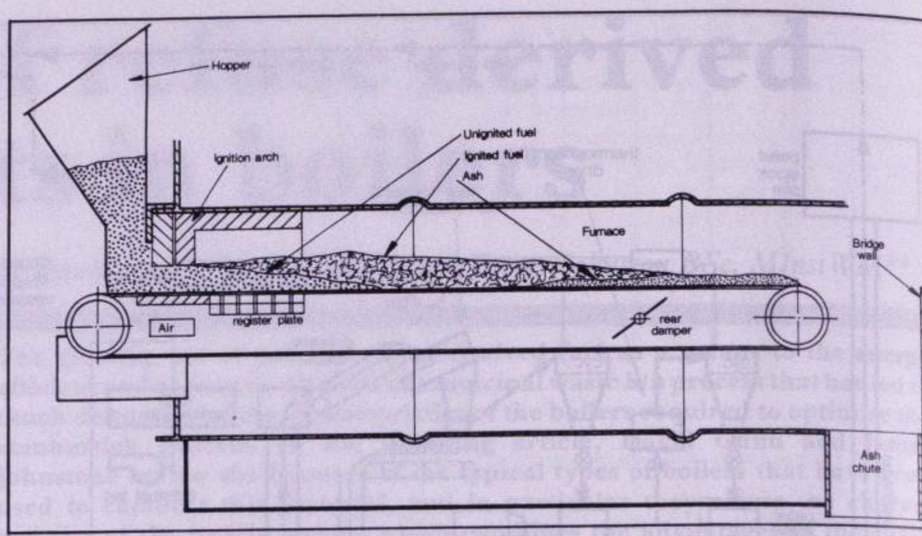


**Fig 3: Representation of the process in a chain grate stoker.**

## The combined chain grate and coking stoker (Hybrid Stoker)

The chain grate and coking stoker have competed over many years; it seems an obvious development to combine the advantages of both. In 1978 Coal Industry (Patents) Limited (National Coal Board) patented this combination and, it is understood, made a prototype for installation at a colliery. This prototype was never fired due to closure of the colliery. It seems therefore, that the present installation at Polmadie is the first application of the idea; the patent has now lapsed.

The design of hybrid stoker as used at Polmadie is illustrated in Figure 4. The original ram mechanism has been retained but the reciprocating bars have been replaced by a chain grate of the same length, about five feet, as the original bars. The grate was, for experimental purposes, provided with compartments to adjust the primary air distribution; in practice these have not to date shown any benefit, all being in the fully open position. Induced secondary air is provided by separate longitudinal compartments at the sides of the grate chassis, the flow being controlled by a damper at each side. There are four overfire steam jets, as provided on the original coking stoker.

## Performance

The stoker was successfully commissioned on singles coal. The boiler behaved well with complete burn off of the coal and no smoke at $CO_2$ levels of around 12%. The tests on coal however were not exhaustive because the main purpose was to fire rdf so this fuel was used as soon as possible. More complete tests for comparative purposes on coal will take place later in the programme.

During the change over from coal to rdf there was a short period during which the two fuels were mixed. This resulted in very poor performance, low $CO_2$ and much unburned fuel in the ashpit. It is not difficult to see why this occurred; rdf requires much less primary air than coal; therefore if the grate is adjusted for coal the pellets will burn out leaving gaps in the fuel bed which allows air to pass through unreacted with the coal. If adjusted for rdf the coal will be discharged only partly burned. The right compromise would be difficult to find.

Refuse derived fuel was then used alone and the stoker and air settings were soon found, less overfire draught being needed with rdf, 0.4ins wg, compared with nearly double that figure for coal. This reflects the lower amount of primary air necessary for rdf.

The input of rdf was gradually increased. The boiler output for rdf has often been regarded as 75 per cent of that on coal due to the greater volume of fuel and ash needed to be handled. This output was quickly reached and exceeded; in recent tests the rated output on coal (3.41 MW) has been exceeded.

One shortcoming of the installation is that the ash is discharged directly from the drop tube in the boiler into a barrow which is then man-handled to a skip outside the boiler house. This is a dirty and onerous process. Other rdf burning installations, notably those in Newcastle-on-Tyne and Wolverhampton use enclosed continuous ash discharge systems which are far more satisfactory. It is hoped that Polmadie will shortly be equipped with such a system.

The ash from rdf at Polmadie is very well burned and contains no significant carbon. It is generally of the consistency and appearance of rolled oats but on occasions, probably due to the chemical composition of the refuse, particularly the glass content, it comes over as a thin sheet of fused material. This breaks up as it passes over the end of the grate and causes no problems.

The boiler has rather a short furnace tube (10 ft) and hence a short first pass of tubes. The exit gas temperature from the boiler would therefore be somewhat higher than that of a boiler with a longer furnace. When the boiler is clean, the exit temperature is about 225°C, which at a $CO_2$ level of 12.5 per cent corresponds with an efficiency of 78 per cent based on the gross calorific value of the fuel. During operation the fly ash, which with rdf is very fine, settles on the surfaces of the boiler and retards heat transfer. Over a period of about three weeks the exit temperature rises to 325°C with a consequent loss of some five efficiency points.

The inlets to the first pass of tubes are very vulnerable to deposition, the fly ash sinters, eventually blocking the tubes so that the ID fan power becomes inadequate. This also occurs in about three weeks, when the boiler has to be laid off and cleaned. The boiler is fitted with front and rear sootblowers, these have not yet been used as it was considered desirable to establish the duration of operation possible without their use in order to determine their effectiveness quantitatively. This is the next

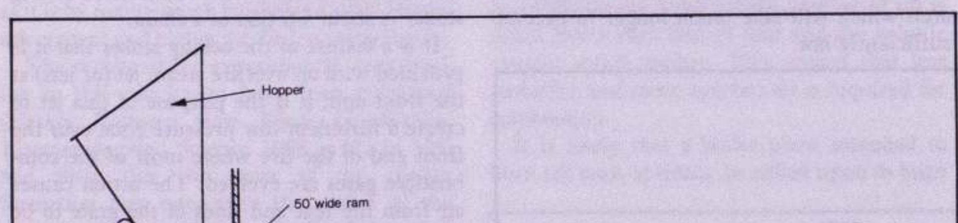


**Fig 4: Hybrid coking chain grate stoker.**

stage of the experimental programme. It is anticipated that sootblowers will extend significantly the operational period possible.

### Chimney emissions

The characteristic plumes from boilers burning rdf are white and steam-like, coloured smoke is unusual and indicates a transient fault on the firing appliance, incorrect settings or an interruption in fuel feed being the normal causes. The density of the white plume seems to be weather-dependent; it is dense in cold weather and can disappear completely under hot, dry conditions. It seems therefore to be a condensation phenomenon.

When this, and other rdf burning plants were installed they were subject to the Clean Air Acts of 1956 and 1968 but these are now becoming displaced by much more exacting laws which apply in different degrees to all industrial fuel burning appliances. At the time of writing the regulations have not been clarified but it is a purpose of the Polmadie work to incorporate comprehensive measurements to determine the nature of the emissions with respect to particulates, acid gases and possible toxic substances. This kind of work will also take place at other sites under the Department of Energy's programmes.

### Conclusions

Whilst the work at Polmadie is only partly completed it can be concluded that:

(1) The coking stoker in its present form is unsuitable for burning rdf due to the formation of massive clinker.

(2) Removal of the reciprocating bars and their substitution by a chain grate of equal length results in a hybrid stoker which gives excellent performances on rdf or coal.

(3) The hybrid stoker offers the following advantages over orthodox chain grates:
- —intense ignition without the need for an ignition arch;
- —shorter grate giving improved heat transfer in the boiler furnace;
- —the need for induced draught only, thus simplifying the system as a whole and the control gear, automatic or manual.

(4) Rdf is a viable fuel which can be burned at rates which give boiler outputs not less than those of coal.

### Acknowledgements

This work has been conducted by White Young Prentice Royle consultants of Leeds, who are contractors to ETSU acting for the Department of Energy, who are thanked for permission to publish this article.

The authors are also indebted to the Glasgow City Council who own the plant, and to their staff at Polmadie for their enthusiastic and sometimes onerous support of the work. □

# Energy Paper 58

UNDER the full title of *An Evaluation of Energy Related Greenhouse Gas Emissions and Measures to Ameliorate Them*, the latest energy paper in the Department of Energy's series is described as the UK's contribution to the Energy and Industry Subgroup of the Response Strategies Working Group of the Intergovernmental Panel on Climatic Change (IPCC). There has recently been publicity about the IPCC, which sounds like a complex organisation, and we must hope its work will prove timely and effective; just how the Institute's primary interest must be in the scientific and engineering aspects of EP 58.

It is basically in two parts: facts about energy in the UK and its emissions history, followed by assessments of the drop in $CO_2$ and methane production for the technologies that may be adopted. It is not a technical paper in the accepted sense: sources of data are rarely given, surprisingly perhaps for this controversial subject there is no reference list of authorities (all of which may be quite normal in international politics, let us not judge by wrong criteria). What is worrying about the paper is that the second, more speculative, part seems to arrive at some strange results. As the detailed reasoning is not given, the reader has to infer it, and with this in mind I chose the tidal section (pp 45-47) for a careful look.

The paper's method is to estimate for each technology its future UK usage under various price scenarios, and convert that to change in carbon released. The table, p 46, gives *different* $CO_2$ abatements ('high' and 'low' price) for the *same* levels of tidal power generation, which is not possible: the contribution from a renewable source is virtually independent of price. People forget that there are two separate decision points. Initially whether to build, governed by expected total cost suitably averaged. And secondly whether to run a station once built, when fixed charges are irrelevant. With zero fuel cost, it is always better to run and earn something towards recovery of fixed charges than to stand idle. Selling tariffs would be devised to make sure fossil-fuel was displaced whatever the time of day. So by working from averaged costs, the paper reaches the impossible result (table p 46) that tidal production and $CO_2$ abatement vary with fuel price.

It is one thing to point to an error of principle, another to account for the actual figures, which are still rather low. For want of explanations in the paper itself one may surmise that for one thing it assumed fuel displaced from a mix of coal and gas-fired stations, without allowing for sequencing in merit order. It is only once the whole inventory of coal-fired stations, starting from the least efficient, is accounted for, that gas-fired ones, more efficient and with a fuel lower in carbon, take their turn; a condition corresponding to a great deal of installed renewable power.

Such are the doubts that arise from just the tidal section; maybe similar reservations would apply to the others. The preface to EP 58 expresses the hope that it 'provides useful data to stimulate and inform the discussion'. The intention is good, and the factual historical data is helpful. Discussion however would require the assumptions and reasoning through which their figures were worked out. One cannot complain since the paper was not written for the engineering community, and at any rate it throws light on the information that is underpinning Government policy in this field. □

*Philip Warner (Hon treasurer)*

## Energy 'priced too low'

Sir,

I am responding very tardily to Len Brookes' viewpoint article "The 'fifth fuel' and the Greenhouse Effect" (*Energy World*, February 1990). While I recognise and appreciate the elegance of Dr Brookes' tight economic argument, I have an uncomfortable feeling that it is not soundly based. Indeed, I contend that it has a fundamental flaw which confines it firmly to an academic rather than a practical concept.

Dr Brookes' argument is a complex way of saying that money saved through energy conservation will be spent on goods which require energy in their manufacture, hence overall energy use will rise. Like all misleading statements this has some partial truths: energy use has inevitably increased with industrialisation and economic growth. However, technological change is now softening the link between GDP and energy use.

There is an error in broadly generalising a theory which is based solely on energy use for production, while ignoring use of energy in buildings, transportation and so on. Energy efficiency means generating the same output (or benefit) for less energy. The resulting economic advantage need not necessarily cause a demand for more energy. Money saved can be spent in the service sector (the most rapidly growing business sector) which does not necessarily generate increased energy demand.

The key issue which Dr Brookes misses is how the cost of energy relates to other costs such as labour, capital, other resources or raw materials and, of course, equipment.

Life and living require energy, and as population increases so will overall energy use. However, mankind's use of energy is abominably inefficient because energy has been priced too low.

**Julian Taylor** (*Member*)
Vancouver, Canada

## $CO_2$ emissions — a taxing problem

Sir,

Mrs Thatcher has now announced the Government's intention to seek to hold carbon dioxide emissions at the 1990 level by the year 2005. In other words the emissions will increase and then fall back to the current level. The basic approach, as I understand it, is to impose taxes on fuel in order to force investment in energy efficient equipment.

This is bad news for industry as substantial taxes on fuel will increase their costs and make them less competitive — unless their foreign competitors face similar increases in their fuel prices, which is very unlikely.

Industrialists could well find themselves bemused by recent Government actions. The privatisation of gas and electricity was principally justified by the need to introduce competition in order to reduce gas and electricity prices. Lower prices were said to be a good thing because British industry would be more competitive. Now we find that higher fuel prices are a good thing because they will encourage energy conservation.

It may be possible to solve this particular conundrum by imposing, say, a 25 per cent tax on fossil fuels and then using the revenue to subsidise the installation of energy saving equipment. A reduction in fuel consumption of 20 per cent would restore industry's costs to the present level.

In the past the installation of equipment designed to reduce consumption has only happened, in general, where industrialists could justify the expenditure of their capital in financial terms. In other words the equipment was only installed if it was profitable to do so.

If global warming is to be controlled it is necessary for energy efficiency equipment to be purchased and installed whether the accountants can justify it or not. Government subsidies are the answer. It would be small comfort when nemesis arrives to say that at least we never deviated from good accountancy practice.

Combined heat and power plants are a particularly effective way of reducing carbon dioxide emissions but, again, they are often not cost effective in normal balance sheet terms. Grants, paid for out of the fuel tax revenue, would address this difficulty. There would of course be a problem with the consequent fall in the demand for coal. There would also be a problem with gas availability if large scale plants are installed to generate electricity from gas.

Finally, but very importantly, I cannot see how we can justify massive expenditure on roads in order to provide for more and more road vehicles, particularly cars. We should be planning to control the number of cars on our roads at the present level, or even at a lower level, and ensuring that economical engines are utilised. Better public transport is also a necessity.

The situation is extremely serious and there are no painless solutions. What is needed is long term, unpopular decisions made and adhered to by the governments of the world, with no cheating.

I am pessimistic.

**J Allan** (*Fellow*)
Hartlepool, Co Durham

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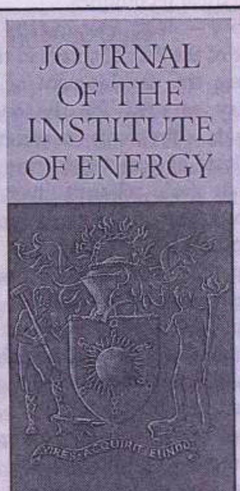
Examples of papers recently published include: *The burning velocities of methane and SNG mixtures with air* (MS Haniff, A Melvin, DB Smith and A Williams); *Optimisation of the design and operation of coal flames in cement kilns* (TM Lowes and LP Evans); and *Pulverised-coal-fired dilute-phase hybrid boilers: a new concept* (P Basu, EAM Gbordzoe and A Sett).



## For coal scientists

**'Spectroscopic Analysis of Coal Liquids'**
**Edited by J R Kershaw**
**Elsevier Science Publishers BV, 1989**
**395 pp. $152.75**

This book would be a useful addition to the library of any group engaged in the analysis of coal liquids, if only for the 'goldmine' of information available through the hundreds of references in the book. One of the book's declared aims, "To critically review the use of spectroscopic techniques for the characterisation of coal liquids", is well accomplished within its ten chapters. However, as for the other aim, "To show how the information obtained from these spectroscopic studies has been used in the development of coal liquefaction science and technology", the same cannot be said. However, it does point out in chapter ten some of the analytical techniques used to obtain certain data.

Each chapter is, in its own right, generally a very good account, but the book does not 'flow' easily from chapter to chapter. Because of the individuality of the chapters and the varying requirement of previous analytical knowledge needed to follow a chapter, any criticism of the book must be made on a chapter to chapter basis.

*Chapter 1 — Introduction*

A good little note on the origin of coal and its classification, together with the composition of the coal liquids obtained from it.

*Chapter 2 — Chromatographic Techniques*

Written by one of the foremost authorities on the chromatographic analysis of coal liquids in the UK, this chapter comprehensively examines the state of the art techniques, comparing their advantages and disadvantages in which the majority of chromatographic techniques are examined.

*Chapter 3 — Pyrolysis and Hydropyrolysis of Coal Liquids*

This chapter provides an introduction to this technology but should be placed alongside Chapter 10 rather than among the analytical techniques.

*Chapter 4 — Mass Spectrometry*

One of the best chapters in the book, it discusses the development of mass spectrometry as used for the analysis of coal liquids. Problems associated with the analysis of coal liquids are dealt with in which each relevant mass spectrometry technique is clearly explained together with its merits.

*Chapters 5 & 6 — Infra-red Spectroscopy, UV and Luminescence Spectroscopy*

Again, an excellent account of the state of the art techniques and how they are applied to coal liquid analysis. Advantages and disadvantages are discussed.

*Chapters 7 & 8 — NMR, Average Structure Determination*

The nmr section clearly explains the reasons for techniques needed to obtain $^{13}C$ spectra of coals. The use of $^{13}C$ and $^{1}H$ — nmr spectra in elucidating average structures is well laid out and clearly explained.

*Chapter 9 — Continuous Wave and Pulsed Electron Spin Resonance*

This chapter is out of place in this book. It is totally lacking in any introductory explanations to prepare the reader for what is to follow and would only be comprehensible to a handful of chemists in the UK.

*Chapter 10 — Overview of Composition of Coal Liquids*

This is a good account of some typical process options from a chemistry rather than a chemical engineering perspective, together with a description of the other general technologies available for producing liquids from coals.

Overall the majority of the book's content is excellent. It covers a broad spectrum of analytical techniques easily understandable by a graduate chemist (with the exception of Chapter 9), in which not only are the advantages discussed, but also the limitations of any technique. A worthy addition to any coal scientist's library.

*S T Walton*

## No solution yet

**'Britain's Nuclear Waste: Safety and Siting'**
**by S Openshaw, S Carver and J Fernie**
**Belhaven Press, 1989**
**207 pp. £20.00 H/B; £8.95 P/B**

A useful and readable book for those interested in the story surrounding Britain's nuclear waste problem. The problem of radioactive waste plagues the nuclear industry. Solutions appear to be as far away as ever, despite the large amounts of money spent to try to convince the general public.

This book's emphasis is not on solutions. Rather it provides some information intermingled with the authors' own views on the topic. Their writings could not be construed as any attempt to influence the reader or even be opinion forming, either pro or anti-nuclear. This is a balanced book.

It is described as a forthright book. In general, it will equip those who take the trouble to more than delve into its 200 or so pages with an understanding of both the science and engineering surrounding radioactive waste storage. Socio-political matters and economic dimensions are ably addressed and the management of such waste.

The book has eight chapters, covering a wide review of the past and present position in the UK, as well as the NIREX story and how this organisation has tackled the difficulty of finding and selecting sites. One chapter looks at Britain's present radioactive waste 'dumps'. In the penultimate chapter, the authors advance a project described as a Geographic Information System (GIS). This can be an effective tool to update the physical characteristics of many locations as a means of validation. It is certainly worthy of closer examination. A final chapter looks at Britain's needs for the future. In many ways, this part of the book portrays a pessimism on the final outcome to the problem as we approach and enter the 21st century.

The object of the book is (a) to inform (b) to provide facts (c) to offer an independent view. On the first and last of these objectives, the authors come near to attaining their goal. However, on facts, the reviewer feels they omitted useful information which should have been included. Definitions on the types of radioactive waste were in short supply. For example, one cannot find the limits of intermediate level waste. It might well have been better to have given the non-expert an early introduction into some useful definitions.

Finally, the maps produced in the book leave much to be desired. Overall, there is much to ponder, discuss and debate, in considering what, in the words of the authors, is a most difficult, unattractive yet most important of topics.

*F John L Bindon*

## A varied approach

**'Waste Heat Utilisation'**
**Edited by L R Davis, M S Sohal and S Sengupta**
**American Society of Mechanical Engineers, 1989**
**84 pp. £20.00**

These ten papers — read at the Winter Annual Meeting of the ASME in San Francisco in December 1989 — present a variety of angles on the broad theme of waste heat recovery. Two papers deal with heat pumps: one describes a combined compression/absorption cycle using a diesel/gas engine drive compressor with waste heat powering the absorption unit. A paper from EDF (French Electricity) explains the reasoning behind the 22 MWe pilot power plant near Paris in which exhaust steam evaporates ammonia in a shell and tube heat exchanger to drive a secondary turbine (the ammonia bottoming cycle).

Other papers deal with ceramic heat exchanger design for gases at 870°C/15 bar pressure; heat transfer in fluidised beds; modelling the performance of plate fin heat pipe units; computer analysis of closed loop water-cooled heat pump systems; a combined air turbine/steam turbine cycle for municipal waste power plant; and waste heat for greenhouse heating.

*Alan Field*

## Recently published

**'Fuel Science and Technology Handbook'**
**by James G Speight**
Marcel Dekker Inc, 1990, 1408 pp. $195.00 (USA and Canada); $234.00 (all other countries).

**'Directory for the Environment'**
Green Print, 1990, 264 pp. £13.99 (plus 50p p&p).

**'The Greenhouse Effect Sourcebook'**
Institution of Mechanical Engineers, 1990, 105 pp. £23.50 (plus 50p postage UK, £1.50 overseas).

## Process steam analysis & control

TELEDYNE'S Model 711 Non-Dispersive Infrared Analyser measures many different chemical components in a wide variety of process monitoring applications. Typical applications include gas phase analysis of CO, $CO_2$, $NH_3$, or $H_2O$, and gas or liquid analysis of specific saturated and unsaturated hydrocarbons.

Specifications include accuracy of + two per cent of full scale or better, reproducibility of + one per cent full scale of better, and less than one per cent noise.

For further information, contact Teledyne Analytical Instruments, The Harlequin Centre, Southall Lane, Middlesex UB2 5NH.

## CHP acquisition

Crawley based CTH Holdings Ltd recently announced their acquisition of the energy division of Watermota Ltd, of Newton Abbott, Devon.

The company, named Countryman Watermota, will continue to develop and manufacture combined heat and power units.

Countryman has 30 years experience in traditional diesel-electric power generation, whilst Watermota was the pioneering British manufacturer of gas engine driven CHP modules.

Production of existing models is being transferred to the Crawley works. The company hopes to add new models to their range.

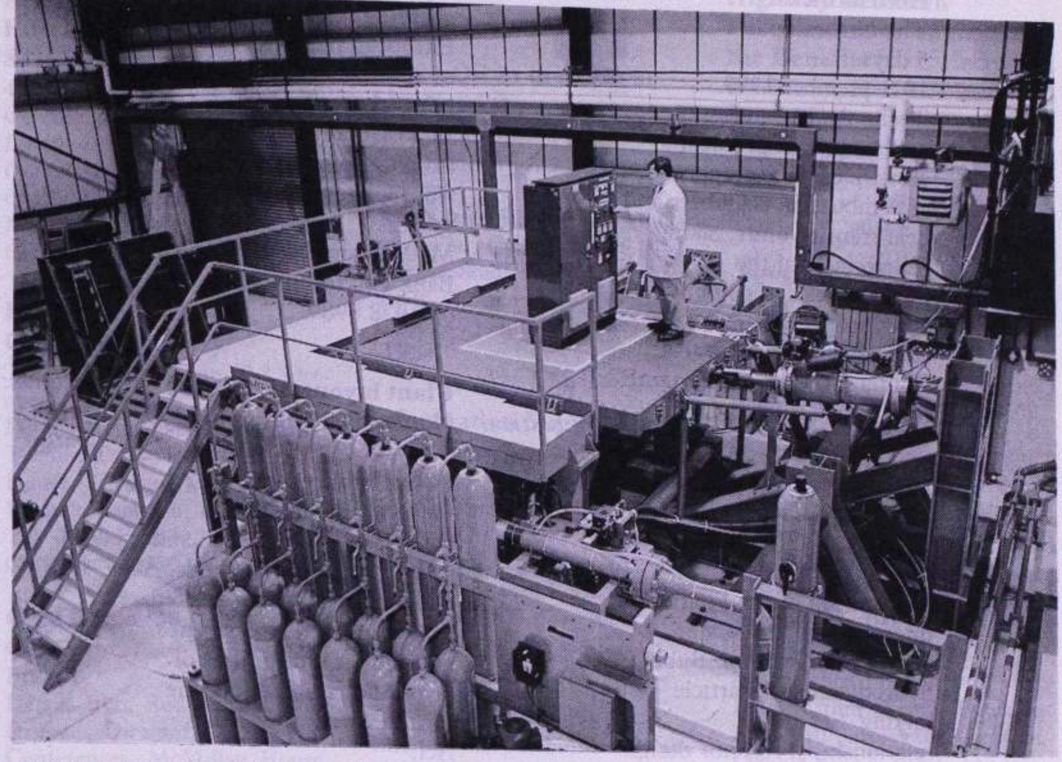
## New insulator

ONE of the world's largest capable accessory manufacturers, Raychem, has introduced a lightweight, cost-effective and reliable stand-off insulator. The Raysulate Stand-Off Insulator has an outer polymeric coating which uses non-wetting, non-tracking, high voltage insulation with 20 years' successful experience.

This new insulator, which is primarily for outdoor cable terminations at 11/22 kV, avoids using glass fibre or corrosion-prone metal. Instead, Raychem utilises a special engineering plastic, with a heat-shrink moulded part covering.

For further information contact Raychem, Faraday Road, Dorcan, Swindon, Wiltshire SN3 5HH.

## Triaxial seismic test rig facility at Whetstone



**An electrical cabinet being set up for testing on the triaxial shaker table at the Engineering Research Centre.**

AN EARTHQUAKE testing machine at the European Gas Turbine Company's Engineering Research Centre, Whetstone, UK has produced more than £230,000 of business in its first year of operation.

The triaxial shaker table, so called because it can shake in three-dimensions simultaneously, has been carrying out seismic qualification tests on equipment for the Sizewell nuclear power station and the Faslane submarine base since its opening in June 1989.

The testing has been carried out to seismic standards specified by the customer, and primarily under contract to consultants in seismic qualification.

The facility was completely designed and built by engineers at Whetstone.

The shaking table itself is a 3.3 m sq, of lattice construction, surfaced by 25 mm thick aluminium tiles to which the test object is bolted. Components can also be mounted on a steel frame to simulate wall mounting of equipment in the power station.

The motion is restricted to three orthogonal directions by a system of links and torsion tubes. Maximum movement is (+/—) 200 mm in the horizontal direction and (+/—) 125 mm in the vertical direction.

Various input signals can be applied, such as sine sweep, sine beat, random and simulated time history.

For further information contact Mr K W O Fenton, Seismic Business Controller, Cambridge Road, Whestone, Leicester LE8 3LH.

## Frequency converters — more power from the wind

THE RESTRUCTURING of the UK's electricity supply industry has brought increased interest in the development of effective wind-generated power. ABB Industry's current source inverters (CSI) are being incorporated into large 600 kW Villas Floda wind machines to better utilise the greatly varying wind speeds found in the UK.

Conventionally, the wind generator is coupled directly to the electricity grid. Although this simple form of connection benefits from low capital cost, the speed of the generator is limited by the frequency of the network, resulting in only a small part of the wind's speed range being exploited.

By using an ABB CSI frequency converter to couple the wind generator to the supply, the varying frequency of the generator, which depends upon the wind speed, is isolated from the fixed network frequency. This means output can be achieved from higher generator speeds.

Useful power outputs are achieved at wind speeds as low as 4 m/s. At this speed, 32 kW of power is available and as the wind speed increases from 12 m/s to 36 m/s, the rotor blades pitch to achieve constant rotation and maximum output is obtained.

A further advantage of ABB's current source inverter is the energy storing capability of its large choke which provides a safety mechanism. If the transmission line fails then the generated wind energy can be diverted to the choke and dissipated by triggering a thyristor circuit.

The system has been designed to operate at 660 V, which is the most common industrial distribution voltage in Europe. This is also the highest voltage for standard low voltage components and cables and standard semiconductors, all of which keep costs to a minimum.

For futher information contact Mr Geoff Brown, ABB Industry Ltd, Drives Division, Manchester International Office Centre, Styal Road, Manchester M22 5WB.

*Title:* **Fuels utilisation and environment.**
*Location:* The Netherlands.
*Duration:* 5 days.
*Starting:* 10 September 1990.
*Content:* Technological and environmental problem areas. Design and operation of combustion chambers and heat transfer units, taking full account of the fundamentals of combustion aerodynamics, flame chemistry and heat transfer.
*Contact:* Conference section, IChemE on 0788 78214.

*Title:* **Advances in fluidisation.**
*Location:* University College, London.
*Duration:* 3 days.
*Starting:* 12 September 1990.
*Content:* Mechanism of fluid-particle interaction. Particulate-aggregate transition. Bubble hydrodynamics. Particle mixing. Scaling relationships. Reactor design and scale-up. Entrainment and elutriation. Heat transfer. Operation at high temperatures and pressures. Combustion. Particle attrition. Diagnosis of plant problems. Granulation.
*Contact:* Dr J G Yates, University College on 071-387 7050×3837.

*Title:* **Training for practice in the energy related industries.**
*Location:* South Bank Polytechnic, London.
*Duration:* 1 day.
*Starting:* 13 September 1990.
*Content:* Experience in practice with marketing on-the-job training tools. Vocational studies as a means of adapting to changes in European business. Reviews of existing software packages in a training context. Reports on new teaching and training software packages from UK and continental sources.
*Contact:* Mr Newton, IoEE, South Bank Polytechnic on 071-928 8989.

*Title:* **Plant layout.**
*Location:* Nottingham University.
*Duration:* 5 days.
*Starting:* 24 September 1990.
*Content:* General layout considerations. Manual and computer layout methods. A wide range of layout-related topics. Hazard assessment and the responsibilities of layout designers under the Health & Safety at Work Act.
*Contact:* Dr J K Walters on 0602 484848×2419.

*Title:* **Incineration and energy from waste.**
*Location:* Leeds University.
*Duration:* 3 days.
*Starting:* 17 September 1990.
*Content:* Theory and practice of incineration including combustion, incinerator design, refractories and pollution. Industrial experiences of incineration of different types of waste.
*Contact:* Dr P T Williams on 0532 332504.

*Title:* **Fire and explosion.**
*Location:* Leeds University.
*Duration:* 5 days.
*Starting:* 24 September 1990.
*Content:* The major aspects of fires and explosions, including case studies. Hazard analysis techniques and specialist topics relating to explosion hazards.
*Contact:* Dr G E Andres on 0532 332493.

*Title:* **Combustion fundamentals.**
*Location:* Imperial College, London.
*Duration:* 5 days.
*Starting:* 24 September 1990.
*Content:* Fuels. The chemistry of slow combustion reactions and spontaneous ignition. Conditions for flame propagation in gas mixtures, their ignition, explosion and detonation. The thermodynamics, structure and radiation of flames. Diffusion flames, fires and the burning of droplets. Flame propagation. Flames on burners, their stability and shape. The effect of turbulence, the principles of modelling.
*Contact:* Prof F J Weinberg on 071-589 5111×4360/4498.

*Title:* **Shell boilers.**
*Location:* The Park Hotel, Cardiff.
*Duration:* 3 days.
*Starting:* 25 September 1990.
*Content:* Industrial boiler design. Combustion practice. Efficient boiler operation. Pollution aspects. Heat transfer in boilers.
*Contact:* Ms K Howells, The Technology Centre, The Polytechnic of Wales on 0443 480480×2661.

*September 1990*

**Weldex 91**
International exhibition, 2-6 September, Birmingham.
To exhibit contact Janet Garner, tel: 021-705 6707, fax: 021-705 4380, tlx: 337073.

**Computer integrated manufacture in the process industries**
Conference, 5-6 September, London.
Details from Liz Hide, tel: 071-236 4080, fax: 071-489 0849, tlx: 888870.

**15th Annual Symposium of the Uranium Institute**
5-7 September, London.
Details from Uranium Institute Symposium, c/o Conference Associates and Services Ltd, 55 New Cavendish Street, London W1M 7RE. Tel: 071-486 0531, fax: 071-935 7559, tlx: 934346 CONFAS G.

**Automotive power systems — environment and conservation**
International conference, 10-12 September, Chester, England.
Details from Alison Elgar, tel: 071-222 7899, fax: 071-222 4557, tlx: 917944 IMELDN.

**EC Wind Energy Conference**
10-14 September, Madrid, Spain.
Details from H S Stephens & Associates, Agriculture House, 55 Goldington Road, Bedford MK40 3LS.

**INPOWER '90**
Conference and exhibition, 25-26 September, London.
Details from FMJ International Publications Ltd, Queensway House, 2 Queensway, Redhill, Surrey RH1 1QS. Tel: 0737 768611, fax: 0737 761685, tlx: 948669 TPPJNL G.

**World Renewable Energy Congress**
Conference, 23-28 September, Reading, England.
Details from Prof A A M Sayigh, Department of Engineering, University of Reading, Whiteknights, PO Box 225, Reading RG6 2AY. Tel: 0734 875123, ext 7575, fax: 0734 313835, tlx: 847813 RULIB G.

*October 1990*

**Applications and Efficiency of Heat Pump Systems**
4th international conference, 1-3 October, Munich.
Details from The Conference Organiser, Heat Pumps, BHR Group Ltd, Cranfield, Bedford MK43 0AJ. Tel: 0234 750422, fax: 0234 750074, tlx: 825059.

**Risk Analysis in the Offshore Industry**
Three day workshop, 2-4 October, Aberdeen.
Details from Natalie Cox, IBC Technical Services Ltd, Bath House (3rd Floor), 56 Holborn Viaduct, London EC1A 2EX. Tel: 071-236 4080, fax: 071-489 0849, tlx: 888870.

**CoalTrans '90**
Conference, 2-4 October, Brussels.
Details from Rod Cargill, Conference Director, CoalTrans Conferences, McMillan House, 54 Cheam Common Road, Worcester Park, Surrey KT4 8RJ. Tel: 081-330 3911, fax: 081-330 5112, tlx: 8953141 Carsys G.

**6th Battery Conference and Exhibition**
4 October, London.
Details from Miss Linda Jelly, Conference Organiser, ERA Technology Ltd, Cleeve Road, Leatherhead, Surrey KT22 7SA.

**Oil & Gas Project Finance**
Conference, 5 October, London.
Details from Cindy Elliot-West, IBC Financial Focus Ltd, 57-61 Mortimer Street, London W1N 7TD. Tel: 071-637 4383, fax: 071-323 4298.

**World Oil in the 1990's: The Need for Cooperation**
Conference, 8-9 October, London.
Details from Karen-Anne Holliday, The Centre for Global Energy Studies, 17 Knightsbridge, London SW1X 7LY. Tel: 071-235 4334, fax: 071-235 4338.

**Information Support for the Energy Industries**
Conference, 9 October, London.
Details from Miss Caroline Little, Conference Officer, The Institute of Petroleum, 61 New Cavendish Street, London W1M 8AR. Tel: 071-636 1004, fax: 071-255 1472, tlx: 264380.

**Hydrocarbons '90**
International exhibition and conference, 9-11 October, London.
Conference details from Themedia Ltd, tel: 060884 700; exhibition details from Westrade Fairs Ltd, tel: 0923 778311.

**NSCA Annual Conference**
15-18 October, Brighton, England.
Details from NSCA, 136 North Street, Brighton BN1 1RG, tel: 0273 26313, fax: 0273 735802.

**The US Strategic Highway Research Programme — Sharing the Benefits**
Conference, 29-31 October, London.
Details from The Conference Office, Institution of Civil Engineers, 1 Great George Street, London SW1P 3AA.

*November 1990*

**European Oil & Gas Export Technology Forum**
International forum, 5-6 November, Edinburgh.
Details from Nadia Ellis, IBC Technical Services Ltd, 56 Holborn Viaduct, London EC1A 2EX. Tel: 071-236 4080, fax: 071-489 0849, tlx: 888870.

**World Quality Symposium**
8 November, London.
Details from Tracy Hawkins, BQA, 10 Grosvenor Gardens, London SW1W 0DQ. Tel: 071-730 7154, fax: 071-824 8030.

**The Automotive Industry and the Environment**
International conference, 13-14 November, Geneva.
Details from Helen Conry, Environmental Matters, 43 Manchester Street, London W1M 5PE. Tel: 071-224 1876, fax: 071-224 4961.

# INSTITUTE OF ENERGY CONFERENCES

The following programme is currently being organised by The Institute of Energy.

**For further details please contact Judith Higgins on 071-580 0008.**

**In 1990**

19 September — **The Costs of Flue Gas Desulphurisation**
**Venue:** Scientific Societies Lecture Theatre, London W1
**Chairman:** Dr A Sanyal (Babcock Energy)

31 October — **Electricity from Gas**
**Venue:** The Royal Garden Hotel, London W8
**Chairman:** Mr J Masters (British Gas)

**In 1991**

30 April-1 May — **Fire & Explosion Hazards: Energy Utilization**
**Venue:** Fire Service College, Gloucestershire
**Chairman:** Mr P G Redpath (British Steel)

**Conferences co-sponsored by The Institute of Energy**

**In 1990**

25-28 September — **World Renewable Energy Congress**
**Contact:** Professor A A M Sayigh, Reading University on (0734) 318 588

17-18 July — **3rd International Conference on Small Engines and their Fuels for use in Rural Areas**
**Contact:** Mrs P Harris, Reading University on (0734) 875 123

26-27 September — **Piper Alpha - Lessons for Life-Cycle Safety Management**
**Contact:** Conference Office, Institution of Chemical Engineers on 0788-78214

15-18 October — **3rd International Conference on Circulating Fluidised Beds**
**Contact:** Professor Hira Ahuja on (902) 439-8300 ext 2014 (Canada)

4-5 December — **NEMEX '90 — National Energy Management Exhibition and Conference**
**Contact:** Energy Systems Trade Association on 0453 873568

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