ENERGY WORLD

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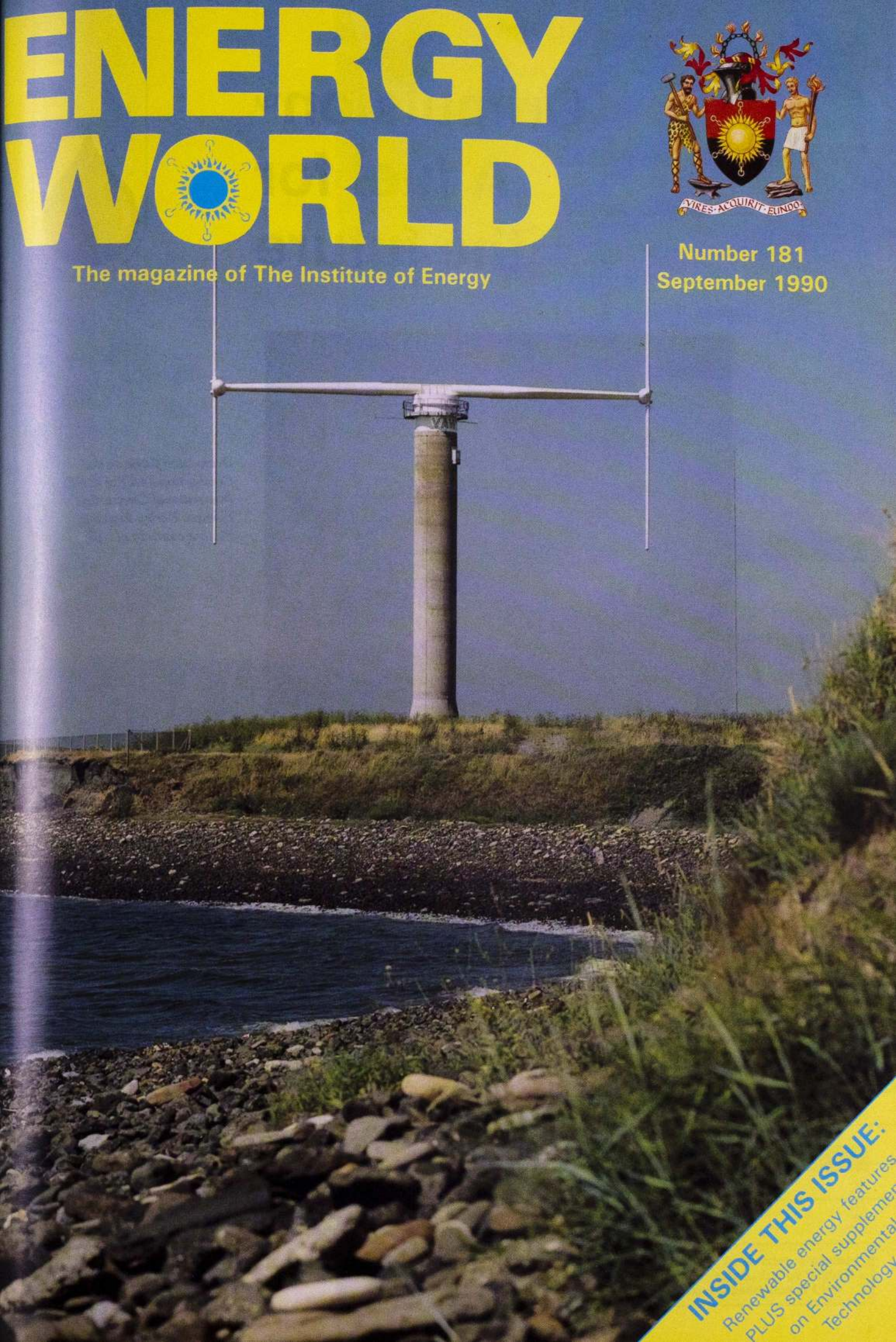

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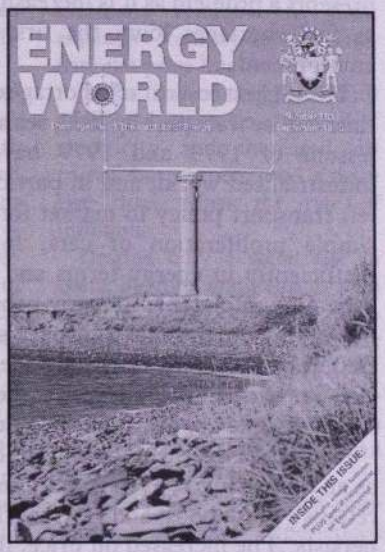
COVER STORY



This month's cover photograph shows the new vertical-axis wind turbine, the VAWT 850, viewed from the shoreline of Carmarthen Bay near Burry Port, South Wales. The new machine was formally 'switched on' by Colin Moynihan MP, the new Energy Minister in the UK Government, on 23 August.

The new machine, with its H-configured blades rotating about a vertical, as opposed to a horizontal axis, is capable of producing up to 500 kWe and is the largest wind turbine of its type in Europe. Some of the more conventionally-configured horizontal-axis machines at present have greater electrical power ratings of up to 3MW.

It is envisaged that the VAWT 850, which is a demonstration machine, will be scaled up in size for offshore siting. Although the optimum size has not yet been defined, it is expected that the full-scale version will be rated up to at least 2MW.

The VAWT has been designed and project-managed by the company of the same name, which is a subsidiary of Sir Robert McAlpine & Sons Ltd. The contractors assisting the project have included Slingsby Aviation Ltd (aeronautical and blade design and manufacture), Markham & Co (mechanical engineering), NEI Peebles Ltd (electrical engineering), SEMA (control and monitoring systems), and Sir Robert McAlpine & Sons Ltd (civil engineering).

For an in-depth appraisal of the future prospects for wind powered electricity generation, turn to our feature article beginning on page 9.

*Cover photograph by courtesy of National Power plc.

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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.**

Gulf crisis: impact on energy

IN THE autumn of 1973 the OPEC oil producers quadrupled the cost of oil and cut back exports by around five per cent in a last desperate attempt to get the West and particularly America to use its influence to halt the Israelis who were all too successfully engaged in the Yom Kippur war with the Arabs. To the surprise and relief of the Arab Oil Producers the 'oil weapon' worked. The US, at that time, imported 20 per cent of its oil from the Middle East and the prospect, and later reality, of shortages created hysteria in motorists amongst others. By Christmas 1973 the oil price had risen to $12 a barrel. Energy analysts predicted disintegration of the whole economic fabric of the world but the economy proved more robust than that. Despite contracting enormous debts oil-less economies around the Pacific Rim continued to grow and even survived the second more serious oil price hike of 1979, which led to oil at $35 a barrel in late 1980 (in 1990 money that is equivalent to $75 per barrel!!!)

During the decade following 1973 the developed, industrialised countries embarked upon a strategy of steadily reducing their dependence upon oil; it was called CoCoNuke, coal, conservation and nuclear power.

Despite the steady growth in oil demand post-1983 as the OPEC cartel cracked and the price of oil dropped sharply to below $10 per barrel for a time, oil demand now is only the same as it was in 1979. This is in part due to the CoCoNuke strategy and in part to the spectacular increase in the availability and use of natural gas which now accounts for 22 per cent of all fossil fuel use, although oil still dominates at 43 per cent with coal at 26 per cent.

Gas usage is growing at almost five per cent per annum whereas oil is increasing at 1.8 per cent and coal at about the same rate. Overall energy demand is rising at around two per cent; the fastest growing energy source through the 1980s was nuclear power which averaged 11 per cent per year, all part of the CoCoNuke strategy.

As for energy efficiency and conservation, there has been a steady decline in energy intensities in the developed countries; that is, in the ratio of primary energy demand to Gross Domestic Product. This has unfortunately, but not unexpectedly, been mirrored by an increase in non-OECD countries over the same period. This reflects the problems of industrialisation with a surging demand for energy to fuel the process which is not matched by an increase in trained man power to ensure efficient energy use.

It is this growth in energy demand by the developing world, as it industrialises and as populations soar, that will come to dominate the world energy scene over the coming decades. The current crisis in the Gulf and the threat of a reduction in world oil supply of some seven per cent, the combined production of Iraq and Kuwait, for however short a time, together with the associated rise in oil price to $26 a barrel and probably more, must strike chill in the hearts of those running developing countries' economies and also the emerging Eastern block countries currently trying to repair economies damaged by decades of communism. They need oil at a reasonable uninflated price.

There is no world shortage of oil at the moment; supply is constrained by war, politics, financial greed and mismanagement. At current rates of demand there are reserves which will last for 40 years.

Saudi Arabia, which sits on one quarter of the world's oil reserves could increase production to replace the oil from Iraq and Kuwait, for a time at least, although it will be under pressure not to do so by its OPEC confréres who would prefer to see the price rise.

The non-OPEC producers, Mexico, Norway, ourselves in the UK and others will increase supply, although the biggest producer, Russia, which supplies 20 per cent of world demand, will find it difficult to do so.

Natural gas will take over from oil in areas like electricity generation where a switch is fairly easily arranged. Coal presents a problem as it is increasingly seen as a 'dirty' fuel but as fuel shortages loom the first casualty may well be the environment.

The biggest loser if oil shortages do persist for any length of time will be transport by land, sea and air, and it is here that the lessons of 1973 and 1979 have not been learned. The industrialised world, and in particular the USA and UK, has left transport policy to market forces which has resulted in a simple proliferation of cars, lorries and roads operating inefficiently in energy terms and escalating pollution levels, becoming intolerable in many urban areas.

A switch to public transport systems and carrying more freight by rail, with electricity the preferred energy form, is a way out of this dilemma, and if the present crisis leads to such a policy some good will have come out of the affair.

As for the UK, the impact of the crisis will be felt less because as an oil producer, even if a declining one, the pound sterling retains a petro boost and is strengthening all the time the crisis persists. The increased oil price, if it is maintained, makes the development of a number of small North Sea fields economic.

In addition, the UK is extraordinarily well blessed with coal, natural gas, nuclear power and considerable renewables potential if it is developed, all available to offset any oil shortages that may arise. There is also the prospect of importing 'Orimulsion', the product of a joint venture between British Petroleum and Venezuela, to burn in power stations.

This embarrassment of fuel riches has unfortunately led in the past to an indulgent view of energy planning in the UK. However the debate on the pros and cons of nuclear power goes, the lights still stay on and even the tortuous writhings of the soon-to-be-privatised electricity supply industry do not yet strike fear of impending electricity shortages in the nervous. Of course our transport policy has the worst attributes of unfocussed laissez faire and could prove to be our Achilles heel, but in general the UK is well cushioned against oil blows providing events in the Gulf do not worsen. However this third major crisis in the Gulf in less than two decades should be a real, possibly final, global warning to wean the world economy off cheap oil and on to a balanced fuel diet.

Prof Ian Fells *(Fellow)*
Past President
and Professor of Energy Conversion
University of Newcastle upon Tyne

Joint project for low-grade coal conversion

THE US DEPARTMENT of Energy will join ENCOAL Corp, Houston, Texas, in a $72.6 million effort to demonstrate a process that converts low grade coals that are abundant in the western United States to two new, clean-burning, high value fuels. The demonstration plant will be built at Triton Coal Company's Buckskin Mine, outside of Gillette, Wyoming.

The ENCOAL project is the first of 13 clean coal technology projects selected last December to finish negotiations with the Energy Department. The five months of negotiations mark the fastest the Federal Government has been able to complete an agreement on a clean coal technology project.

The $5 billion Clean Coal Technology Programme is a joint government/industry effort to demonstrate a series of advanced technologies that use abundant US coal resources while protecting the environment. Following three nationwide rounds of competition, 38 projects in 19 states have been selected to receive government assistance.

When complete, the plant will process 1,000 tons per day of subbituminous coal from the Powder River Basin of northern Wyoming to form two clean-burning products: a low sulphur oil, similar in quality to Number 6 fuel oil, that can be used to displace imported oil in industrial and utility boilers; and a solid fuel, similar in quality to bituminous coals but without the sulphur pollutants typical of these coals. Each of the two new fuels will be capable of meeting or exceeding the nation's strictest environmental requirements.

International electricity survey — UK prices remain high

THE UK experienced price increases and maintained relatively high electricity costs in spite of claims that the move towards privatisation would benefit consumers. This is the major finding of the National Utility Services (NUS) 1990 International Electricity Price Survey.

In the lead up to privatisation, the electricity supply industry has been faced with a series of problems which have marred the restructuring of this industry as it moves from public to private ownership.

A summary of the survey's findings reveals that:

In spite of falling prices, Germany remains the most expensive country in the international price league.

Italian consumers, faced with additional taxes on the sale of electricity and increased oil prices, have experienced a price rise three times the rate of inflation.

Despite only a small rise in costs, Belgium maintains its high rank in the price league table. Prices are expected to fluctuate and be unpredictable.

The Irish Government continues to ensure that costs remain in line with the European average.

Most of the 24 utility companies surveyed experienced modest increases attributable to fuel price adjustments. Nuclear safety issues and the advent of self-generation will most likely have an impact on future prices.

In order to control inflation, the French Government continues its policy of depressing electricity prices in spite of 3.5 billion franc loss for the industry.

Once again the Dutch experienced the only electricity price reduction.

An increased nuclear power facility is expected to reduce Finnish reliance on electricity imports.

Norwegian prices parallel inflation, with stable prices forecasted for the next 12 months.

Prices in line with inflation in Sweden are expected as politicians make an about-turn on nuclear power.

The possible interconnection of electricity grids between Australian states could affect prices, which have remained relatively low.

Canadian prices remain the lowest of the 13 countries surveyed, but a possible new tax may push up prices next year.

ABB embarks on joint ventures in Poland

IT WAS announced in Warsaw on 11 July that a basic agreement has been reached on the proposed joint venture between ABB Asea Brown Boveri Ltd, Zürich, and Dolmel, involving some 3,300 employees.

Dolmel will be organised in two new companies, ABB Dolmel and Dolmel Drives, which are expected to commence operations in September 1990. ABB Dolmel will manufacture turbo-generators, hydro-electric generators and low-speed diesel generators, and will provide related services. Dolmel Drives will be responsible for drives, traction motors and other products and services.

New shareholder takes stake in Thames Power

CANADIAN Utilities Limited of Canada, through its CU Power division, has formally agreed to take a 45 per cent shareholding in Thames Power Limited, significantly strengthening the position of the London-based independent power generator. This follows a preliminary understanding reached between the parties in March.

The other shareholdings in Thames Power are held by international cables to construction group BICC (45 per cent), and London merchant bank J Henry Schroder Wagg (10 per cent).

Discussions taking place in parallel with Scottish Hydro-Electric plc with a view to them also becoming shareholders have been called off as it has not proved possible to agree mutually acceptable terms.

Thames Power's first power station project, a 1000MW gas turbine combined cycle plant at Barking in east London, is currently going through the planning process. The company is actively evaluating other potential projects consistent with its objective of becoming a major force in the power generation market in the UK.

Joint venture for Ballymoney power station

ABB Energy Ventures and Ballymoney Power Company Ltd have announced the signing of a joint venture agreement to develop a new base load lignite fired power station to be located in Northern Ireland adjacent to the low sulphur content Ballymoney lignite deposit proven by Meekatharra Minerals Limited.

The power station project would be owned equally by the two companies. ABB will provide power station engineering and construction and arrange finance. Meekatharra will own and develop the mine to supply fuel to the proposed power station.

ABB Energy Ventures is a wholly owned subsidiary of Asea Brown Boveri, the Swiss-Swedish electro-technical engineering group. Ballymoney Power Company Ltd is a wholly owned subsidiary of Australia's Meekatharra Minerals Limited.

Czech public opinion favours nuclear power

A PUBLIC opinion poll conducted by the Czechoslovak Public Opinion Institute shows that 46 per cent of the Czechoslovak population are in favour of continuing operation of nuclear power plants, with 41 per cent opposed.

The strongest opposition to nuclear power plants was in the East and Central Slovak regions, the weakest in North Bohemia, North Moravia, and partial in West Bohemia and in Prague.

Opinions at places where these plants are already operating, are being built or their construction is being prepared did not differ much from those in other parts of the country.

Czechosolvakia now generates energy from two nuclear power plants: Jaslovske Bohunice, West Slovakia, which has four 440 MW units, and Dukovany, South Moravia, also with four 440 MW units.

Another plant with four 440 MW units is being built at Mochovce in West Slovakia. Construction of two units of a plant continues also at Temelin, South Bohemia, where four 1,000 MW units were originally planned. The construction of the two others has thus far been suspended and a decision is to be taken on it.

Boost to measured lignite reserves at Ballymoney

CURRENT drilling in the north east extension of Meekatharra Minerals' vast lignite deposits in Northern Ireland has boosted measured reserves and outlined shallower and thicker seams, so saving infrastructure and development costs, the company says in its end-June quarterly.

As a result, 120m tonnes of previously delineated indicated reserves have been upgraded to the measured status and 30m tonnes of new measured reserves have been added in the new area. The new seams will allow a better waste stripping ration than in the 1987 mine plan area, the company adds.

Since the end of the quarter, Meekatharra signed a joint venture agreement with ASEA Brown Boveri to develop a new, jointly-owned, base load lignite-fired power station adjacent to the Ballymoney deposits. The agreement successfully concluded negotiations conducted with ABB and other major international power industry groups over a period of more than six months.

Meekatharra also says it has commissioned a further report on electricity generating planning in Northern Ireland from US experts Putnam Hayes and Bartlett. This will assess a number of changes that have occurred since the first PHB report was submitted to the UK Government last November.

Texaco to join in Soviet hydrocarbon development

TEXACO INC announced on 14 August that its subsidiary, Texaco Petroleum Development Company, has signed an agreement on Principles of Co-operation with the Ministry of Geology of the Soviet Union for proposed joint participation in the exploration, development and production of hydrocarbons — including development of areas of identified and established oil reserves — in onshore Soviet Union.

Texaco anticipates beginning a feasibility study this summer, focused on some areas of the Timan-Pechora region. This region is located in the Northern European part of the Soviet Union. These areas have high prospects for exploration, and the development of oil and gas fields with reserves estimated to be well in excess of five billion barrels of oil. Texaco is studying information provided by the Ministry relating to the oil and gas resources of these areas and their infrastructure.

Ruston gas turbines for Canada

RUSTON Gas Turbines Inc, the Houston-based subsidiary of GEC ALSTHOM's European Gas Turbine Company (EGT), is supplying aeroderivative gas turbine equipment to Trans-Canada Pipelines for gas compression and combined cycle applications.

Ruston is to supply two 18750HP RLM1600 compressor sets incorporating the high efficiency power turbine manufactured at EGT's plant in Lincoln, UK, and the advanced LM1600 gas generator manufactured by GE in America. The units will be located at the Pembroke and Stittsville stations in eastern Ontario. Both units have now been delivered to Houston from Lincoln for packaging and testing.

Under a separate contract Ruston Gas Turbines Inc is also supplying a 21 MW rated RLM2500 gas turbine generating set for a new combined cycle power plant located at Trans-Canada's existing Nipigon compressor station in north western Ontario. Electricity generated by the plant will be sold to the local power utility.

The RLM2500 coupled to a GEC ALSTHOM generator and heat recovery steam generator (HRSG) will operate alongside an existing gas turbine compressor set which will be retrofitted with an HRSG. Both units will be fired on natural gas. Steam from both HRSGs will power a 14MW steam turbine generator set which will be provided by GEC ALSTHOM from their Rugby factory.

Delivery is scheduled for July next year.

Recycling aircraft engines for industrial power plants

AS A RESULT of stricter noise control regulations, many aircraft engines currently in use will have to be scrapped because they do not meet proposed guidelines. To find a use for these engines, European researchers have recently investigated recycling aero gas turbines for industrial power plants.

In examining the conversion of aero engines, Jose M Morquillas, of the Universidad del Pai Vasco, Bilbao, Spain, and Pericles Pilidis, Cranfield Institute of Technology, UK, said that such a conversion "can yield good levels of output and efficiency, while also reducing lead time for procurement."

The researchers presented their findings in their paper, " 'Recycling' of Gas Turbines from Obsolete Aircraft," at the 1990 ASME Turbo Expo, in Brussels, Belgium, on 11 June. The conference is sponsored by The Institute of Energy's associated body, the American Society of Mechanical Engineers' (ASME) International Gas Turbine Institute.

Morquillas and Pilidis studied the conversion of a conventionally designed two-spool bypass engine, which has been in service since the 1960s in a variety of applications. As there are a large number of aircraft fitted with this engine, there is a large supply of second-hand gas turbines available.

For its industrial application, they proposed combining two aero engines to produce a single unit. In this configuration, a complete turbofan is coupled to a second one, the latter having the fan removed. Since the airflow into the high pressure compressor is roughly equal to the flow through the bypass duct, the bypass flow of the first engine, the master engine, can be utilised by the core of the second engine, the slave engine.

The authors observed that the conversion of aero engines could be particularly advantageous to developing countries with an unfavourable debt situation. Many aircraft earmarked for decommissioning are already in these countries, which have a more pressing need to replace inefficient power equipment with less expensive new equipment.

A converted aero engine will be slightly less efficient than a similar purpose built aero-derived gas turbine. However, Morquillas and Pilidis noted that "its efficiency compares very well with other gas turbines and other thermal plants currently in service."

Copies of this paper may be obtained from the ASME Customer Service Department, 22 Law Drive, Box 2300, Fairfield, NJ 07007-2300, USA.

Togo strengthens power system

TOGO will use a credit of SDR 11.4 million ($15 million) from the International Development Association (IDA) to strengthen its electric-power utility and expand people's access to electricity.

The project will strengthen the operations of Compagnie Energie Electrique du Togo (CEET), rehabilitate and expand CEET's plant, particularly the distribution system in Lome, reduce power losses, and generate additional sales.

Pakistan expands natural-gas distribution system

PAKISTAN will reduce oil imports through a project designed to expand the distribution of natural gas. The World Bank is supporting the project with a $130 million loan.

Pakistan has extensive natural-gas reserves, but inadequate transmission and distribution facilities have led to shortages of the fuel and increased use of other, more costly forms of energy.

The project includes the construction of a gas-purification plant at Sui, in the south western part of the country. The capacity of the country's natural-gas distribution network will be expanded by about 300 million cubic feet a day to serve an increasing number of residential and commercial consumers in the northern and central parts of the country.

Support for wind energy projects to be increased

THE BRITISH Government plans to give more help next year to wind power operators who are attempting to develop new projects. This announcement was made by Colin Moynihan MP, the recently-appointed Energy Minister, when he inaugurated a new vertical axis wind turbine (VAWT) at National Power's Wind Demonstration Centre at Carmarthen Bay, South Wales, on 23 August.

Mr Moynihan went on to say that the Government's research and development expenditure on wind power already exceeds £35 million to date, and annual expenditure continues to mount steadily. This year it is expected to exceed £6 million; an increase of around a fifth on the previous year.

"At the same time, the provisions of the Non Fossil Fuel Obligation (NFFO) should also help to encourage more wind operators to enter the market," said Mr Moynihan.

"It is the Government's expectation that the first NFFO order for renewables, which is expected fairly shortly, will result in a significant amount of new renewable capacity being contracted.

"It is estimated that if the present development programmes are successful, and significant improvements in economic costs can be achieved, it is feasible that onshore wind energy in the UK could generate up to 30 Terawatt hours of electricity a year by 2025 — equivalent to some 10 per cent of current consumption. And there is the prospect of a good deal more from offshore in the longer-term, though probably at a higher cost.

Responding to this spirit of optimism, Dr Peter Chester, National Power plc's executive director for technology and environment, announced at the same event that National Power are planning to install a major wind generator farm in Cornwall. A planning application to install the wind farm, with 23 wind turbines each about 30 metres high, was to be made to North Cornwall District Council a week after the inauguration of the latest VAWT at Carmarthen Bay.

Dr Chester said that the Cornish wind farm is planned for a site of approximately 675 acres at Cold Northcott near Launceston. It will have a total electrical output of about 7 MW.

The capital cost of the wind farm is estimated at around £10 million. It is expected to be operational by 1992 provided planning permission is received by the end of this year.

This development reinforces the fact that the joint wind power programme, funded by National Power, PowerGen, and the Department of Energy, would now concentrate on two sites — the Carmarthen Bay site and the one at Cold Northcott. Dr Chester confirmed that a third wind farm originally envisaged for the northern Pennines would not be included because of engineering and environmental complications at the two sites investigated.

Progress of the VAWT

THE COMMISSIONING and official 'switch on' of the new VAWT 850 marks the introduction of Europe's largest vertical axis wind turbine, with an output capacity of 500kW.

This latest machine follows the successful construction and operation of both the 17m and 25m turbines and incorporates the results of detailed testing on these earlier machines. Although the rotor diameter of the new machine is only 10m longer, at 35m, than its predecessor VAWT 450, its power rating is very much greater — 500kW as compared with 130kW.

However, the latest VAWT is only half the size of what is expected to become a multi-megawatt wind turbine designed for offshore installation.

The VAWT 850 (the 850 relates to the area swept by the two-bladed machine in m^2) brings to four the number of wind turbines that are currently operational at the Carmarthen Bay site. The oldest operational machine on site is the VAWT 450, which was inaugurated in 1986. The other two are the three-bladed, horizontal axis Howden Wind Turbine, rated at 300kW, and a two-bladed, horizontal axis machine designed by Wind Energy Group Ltd, that is also rated at 300kW. Both of these machines were inaugurated in 1988.

New Chairman of National Power

JOHN WAKEHAM, Energy Secretary, has announced the appointment of Sir Trevor Holdsworth as Chairman of National Power.

Sir Trevor retired as Chairman of GKN plc in 1988 and was President of the CBI from 1988 to 1990. He is Chairman of British Satellite Broadcasting, Allied Colloids Group plc and Deputy Chairman of Prudential Assurance plc.

Encouraging potential for CHP

JOHN WAKEHAM, UK Energy Secretary, said on 11 July that the time and climate was now right for combined heat and power to play an important part in electric generation. Speaking in London at the last in a series of road shows, held over the previous six weeks, to promote the commercial case for CHP around the country, Mr Wakeham said that three factors in particular had combined to create promising opportunities for combined heat and power.

"First, electricity privatisation has had the effect of substantially increasing the competitive pressures to make the most efficient possible use of energy. Second, growing concerns about global warming have helped to highlight the potential advantages of CHP in curbing greenhouse gas emissions. And third, the new Electricity Act contains a number of special provisions to encourage CHP.

"For the first time legislation actually gives CHP operators the right to break streets to install heat mains. It will also allow those operators using renewable energy resources to contract under the Non Fossil Fuel Obligation provisions.

"In addition, it exempts the majority of operators with on-site own generation from having to hold a licence.

"All this has combined to give CHP probably the biggest boost it has yet had in this country. A recent report by my Department suggests that around 2000MW of new CHP capacity could be commissioned over the next decade, which would double existing CHP capacity.

"There are currently something over 400 different CHP schemes operating in Britain which provide some three per cent of our total electricity demand. So we still have some way to go before we start to match some of our European partners in this area."

Speaking at the launch of Power Plus 90, a campaign led by the Combined Heat and Power Association (CHPA) and backed by National Power plc, PowerGen plc, British Gas and British Coal, together with other leading members of the industry, the former Minister said: "According to our calculations and estimates, more widespread use of CHP in the UK could reduce CO_2 emissions by up to 10 per cent by the early years of the next century."

Productivity record

BRITISH COAL achieved its best ever productivity results for the week ending 14 July when deep mined output per manshift rose to 4.81 tonnes. The previous best was 4.77.

It was the third time this year that productivity had reached a new peak. The high output figure was mainly due to an exceptionally good performance from the £1.3 billion Selby coalfield, where miners reached 9.03 tonnes per manshift.

Extra funding for 'clean coal' research

A £2.5 million research package for the development of 'clean coal' technologies was announced on 16 July by Tony Baldry, junior Energy Minister.

The package will cover three projects — the design and performance of high temperature, high pressure, filters; research into reducing nitrogen oxide emissions; and modifying combustion processes to reduce harmful emissions contributing to acid rain.

The Department of Energy's contribution towards these research projects is £1.2 million. British Coal, British Gas, PowerGen, Babcock Energy and NEI-ICL will contribute a total of £1.33 million.

Proposal for wind farm in Bronte country

The Yorkshire Windpower team, pictured at the recent press conference to announce the Ovenden Moor proposal. From left to right: Stewart Reid, project manager; Gill Stead, communications manager; and Keith Pitcher, planning and technical manager.

A PLAN to build a wind farm on Ovenden Moor, in the Pennines, was announced on 23 August by a new company formed by Yorkshire Water and Yorkshire Electricity.

Yorkshire Windpower Limited is a joint venture company formed to develop this project.

The proposed wind farm will be made up of 25-35 wind turbines on Yorkshire Water land between Thornton Moor Reservoir and Warley Moor Reservoir west of Bradford. The turbines, sited in this general area, will be 25-30 metres high with up to three blades.

The electricity generated will be connected into the distribution network already operated by Yorkshire Electricity, and will provide the equivalent amount of electricity that would be used in 4,500 homes.

A special study will be carried out by a landscape expert to advise the company on the best possible siting which will have the least intrusion on the landscape, but still enable best use to be made of the wind resources.

NEI-ABB win contract for Killingholme

NATIONAL POWER plc announced in July that the contract to build its first combined cycle gas turbine (CCGT) power station has been awarded to NEI-ABB Gas Turbines Ltd (NEI-ABB).

Under the terms of the contract, NEI-ABB will be responsible for the design, construction and commissioning of the 650 MW plant at Killingholme on South Humberside. About half the value of this substantial contract is expected to be spent in the UK.

The station — to be known as Killingholme A — will have three gas turbines and a steam turbine of proven design. With a thermal efficiency level of more than 50 per cent, it will burn less fuel to produce the same amount of electricity as an equivalent coal or oil-fired station.

The plant is expected to bring environmental benefits. It will emit no significant amounts of sulphur dioxide, a gas associated with acid rain, and produce only about half the amount of carbon dioxide of a similar sized coal station.

Construction of the power station will start around the end of this year. It is due to be completed in the autumn of 1993, and will produce electricity equivalent to the needs of nearly three quarters of a million people.

National Power, the UK's largest generating company, has already received investment approval and planning consent from the Secretary of State for Energy to build the station, as reported in the May edition of *Energy World*.

The power plant will be supplied with gas from the Caister field in the southern North Sea operated by Total Oil Marine.

John Baker, National Power's Chief Executive, said: "I believe we have reached a good agreement with NEI-ABB. The contract, together with our gas supply deal, makes up an attractive package for the construction and operation of Killingholme A. The station will be a very energy efficient plant, produce low cost electricity and bring environmental benefits."

Sale of PowerGen reverts to flotation

A FURTHER turn in the saga of electricity privatisation took place on 23 August, when Energy Secretary, John Wakeham, announced a reversion to public flotation, ruling out the possibility of a private sale of PowerGen to Hanson Trust.

The indecision over how PowerGen is to be privatised is the second major upheaval in the process of the sell-off of the electricity companies National Power and PowerGen. The decision to remove the nuclear element, in the form of the hived-off Nuclear Electric, from the sale caused the first upset.

The latest announcement was welcomed by both management and unions in the electricity supply industry.

Wind turbine research

THE National Engineering Laboratory (NEL) has been awarded a £1.3 million contract by the DTI, in support of research to produce draft European standards for wind turbines.

The research will be carried out by NEL's National Wind Turbine Centre over the next four years and will cover safety, structural integrity, performance and electromagnetic compatibility for both wind turbines and hybrid systems. The search is part of the UK's technical contribution to a European activity to establish harmonised international standards.

CHP scheme in the balance

LEICESTER could cut carbon dioxide emissions by up to 2 million tonnes a year if the city's combined heat and power scheme goes ahead.

The multi-million pound scheme, backed by the City Council and a number of other major private companies, had to be shelved 18 months ago following Government plans to privatise the electricity supply industry.

It meant that an agreement to sell the electricity generated from the CHP plant had to be renegotiated but, so far, it has not been possible to reach a conclusion.

New members

Fellow

Noel David Deam, Walsall Metropolitan Borough Council (*transfer*)
Joseph Kay, ICI Engineering, Northwich (*transfer*)
Youself Salameh Najjar, King Abdulaziz Univ Saudi Arabia (*transfer*)
Ronald Edward Williams

Members

Stephen Burnley, Thomson Laboratories, Milton Keynes
Joseph Cachia, Roger De Giorgro & Partner, Malta
James Carew, EOLAS, Glasnevin, Dublin (*transfer*)
Tuan Chiong Chew, National University of Singapore
Andrew Collins, South Manchester Health Authority
Colin Michael Fitzgerald, BP International, London
Robert Geoffrey Fenton, Hyde, Ove Arup & Partners, London
Ron James Moore, G K Salter & Associates, Swanley, Kent
Stephen Graham Mitchell, Dairy Crest Foods, Wrexham, Clwyd
David Arthur Spalding, Trans-Natal Coal Corp, S Africa

Associate Member

Michael Joseph Clifford, British Gas North Thames, London
Jeffrey Robert Puddy, Royal Mail, Croydon
David James Reid, Rendel Hancox Consulting Engineers, Dundee
Keith Williams, Nat Vulcan Engineering Insurance Group, Manchester
Edward James Wrigley, North West Water, Salford

Associate

Ian Peter McKay, Leicester City Council, Leics

Graduate

James Robert Patterson, NIFES Consulting Group, Herts (*transfer*)
James Anthony Goth, NIFES Consulting Group, Herts
Tom Metcalf, SEEBOARD plc, Maidstone, Kent
Michael John Brendan Walker, Nuclear Electric, Manchester

Student

Sukunan Devadasan, Babcock Construction, Kent
Hesham S A Kameshki, Leeds University
Emma Jean Wright, Leeds University

Group Affiliate

Airoil-Flaregas Ltd, West Drayton, Middlesex
Babcock Energy Ltd, Renfrew, Scotland
Calor Gas Northern Ireland Ltd, Belfast
James Proctor Ltd, Burnley, Lancs
Scottish Power Plc, Glasgow
Silverlight (UK) Ltd, Tonbridge, Kent

Changes to the Institute's membership procedure

THE CHANGE to The Institute of Energy's membership procedure is both important and far reaching. It relates to section 5.7 of The Engineering Council's Policy Statement on Standards and Routes to Registration (SARTOR). Section 5 deals with registration at Stage 3 of the Register and 5.7 with the Professional Review for Chartered and Incorporated Engineers.

Section 5.7 of SARTOR states that 'each candidate for admission to Stage 3 of the CEng or IEng sections of the Register must satisfy the requirements of a professional review which normally includes a written report and an interview'. We have, for the last two years, incorporated a 2000 word written report with our application form for corporate or IEng membership and have conducted selected interviews in London and the Branches.

However, the interview part of the professional review has become a clear requirement for Institute membership and Engineering Council registration. Consequently it has been decided that in future all applicants for admission to Chartered Engineer or Incorporated Engineer status, and all applicants for Corporate Membership without CEng registration, will be required to attend an interview, conducted as part of the Professional Review.

It is hoped that interviews will be held in ten main centres: London, Belfast, Birmingham, Cardiff/Bristol, Glasgow/Edinburgh, Leeds, Liverpool, Newcastle-upon-Tyne, Nottingham and Portsmouth. The interviewers will normally be Chartered Engineers, but where an applicant is seeking IEng registration it is hoped that a registered Incorporated Engineer will be a member of the interviewing panel.

Whilst it is our clear intention to put this change into effect immediately, it cannot be accomplished without having the interviewers necessary to carry it forward. May I therefore ask all Corporate Members and Incorporated Engineers to volunteer your services to the Institute, as part of the larger interview panel in your branch area, from which two or three could be selected to conduct interviews as and when necessary. The frequency will depend, of course on demand, and all volunteers will be given practical guidance on the conduct of interviews, which normally take one to one and half hours each.

If you have any queries on the subject please do not hesitate to contact Colin Rigg (Secretary), Jim Leach (Deputy Secretary) or Pauline Powell-Fuller (Membership Secretary) who will be only too pleased to help.

D M Willis (President)

New engineering organisation a possibility

THE CREATION of a new organisation for professional engineers is the possible outcome of discussions underway between the Institution of Electrical Engineers (IEE) and the Institution of Mechanical Engineers (IMechE).

The Councils of IEE and IMechE welcome the opportunity for two leading engineering Institutions to explore the possibility of a new organisation which will be better equipped to serve the needs of the modern engineer.

The two Institutions have defined the many advantages that would result from a merger. Points for discussion will include:

- the aims, objectives and name of the new organisation;
- the proposed time scale for the merger;
- the Royal Charter, by-laws and council structure;
- the structure of its organisation, international operations and membership;
- the scope of its learned society, publishing and business activities.

The possible amalgamation is independent of the previously announced merger discussions between IEE and the Institution of Production Engineers, the outcome of which would not affect an IEE/IMech merger.

Any final decision on whether to seek approval for a merger from membership will be taken by the councils of the two Institutions.

'Fascinating Science' campaign

THE INSTITUTION of Engineers launched its 'Fascinating Science Campaign' in North London in July. The campaign aims to provide a 'science box' for each of the 20,000 primary schools in the country by encouraging science based companies, large and small, to 'sponsor a box' for a local primary school in their area.

Two North London companies are the first in the UK to join the campaign — Johnson Matthey plc, the precious metal refiners, and Merck Sharpe & Dohme, the health care and pharmaceutical manufacturers are each to provide 10 science boxes for 20 primary schools in their area.

The science box, which was developed by Northamptonshire County Council's Science Advisers, costs £125 each and contains 50 wallets of simple investigations for children to carry out.

MBE for member

WILLIAM MARTIN (*Member*) has received an MBE in the recent Honours List.

Mr Martin, who joined the Institute in 1968, is Senior Health Physicist at the Ministry of Defence.

IEE tells Patten 'UK should take world lead'

THE Institution of Electrical Engineers (IEE) has urged the Government to take a lead on the issues of pollution and global warming. The call was made in an IEE submission to the Secretary of State for the Environment, the Rt Hon Christopher Patten MP in July.

The IEE submission focused on the environmental aspects of electricity generation and use and on the strategic and technical issues involved.

It's principal recommendations were:

- The stabilisation of carbon dioxide emissions at the present level by the year 2005, as now proposed by the Government, is inadequate and a stricter target should be set.
- Legislation will be required to meet the stricter target by conservation measures, as efficiency measures alone will not be sufficient.
- Nuclear power should be re-assessed before 1994 because of its role in reducing the overall level of greenhouse gas emissions from the power generation.
- More encouragement should be given to the exploitation of renewable energy sources.
- There should be an active policy to promote electric transport particularly in urban areas, and all rail commuter lines should be electrified.

The submission concluded by stressing the need for adequate resources to be made available for the development of energy-efficient products and processes, by both Government and the private sector.

RSC research

THE Royal Society of Chemistry (RSC) research fund exists to assist members in their research by the provision of grants of up to about £350, for the purchase of chemicals, equipment or for running expenses of chemical research.

A limited number of grants will be awarded for 1991. Applications from members of the Royal Society of Chemistry will be considered on merit, but account will be taken of any other source of financial aid available to applicants.

Application forms may be obtained from Mr S S Langer, The Royal Society of Chemistry, Burlington House, London W1V 0BN. The closing date for application is 1 November 1990.

Post-graduate awards

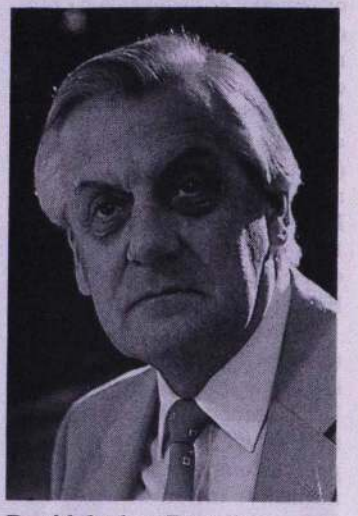
BRITISH GAS is looking for 12 ambitious graduates to take up three-year PhD Research Scholarships on science and engineering projects awarded to universities and polytechnics around the country.

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.

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

Obituary

D A Bramley



David Arthur Bramley.

DAVID ARTHUR BRAMLEY (Associate) died on 30 June 1990. He joined The Institute of Energy in 1983.

Mr Bramley was the director general of the British Combustion Equipment Manufacturers Association (BCEMA), where he celebrated 25 years of service at their annual luncheon earlier this year. He was also a Companion of the Chartered Institution of Building Service Engineers (CIBSE).

Mr Bramley's early career began as a toothpaste salesman. He went on to work for Camron Engineering and OBC. In 1965 he began his association with BCEMA, when he became director and editor of the publication *Oil Firing*.

A great believer in the European ideal, Mr Bramley made a major contribution to preparing BCEMA's membership for the single European market in 1992.

He leaves a wife, Janette, herself the Secretary of the BCEMA, and their two daughters Andrea and Michele.

Appointments

AUGUST saw the promotion of Chris Marchant (*Member*) and Robert Brown (*Fellow*) within British Gas plc.

Mr Marchant has been appointed Director of Construction at British Gas headquaters in London. Mr Brown becomes the Head of Power Generation — a new post — also at the London HQ.

In addition to being a member of The Institute of Energy since 1966, Mr Marchant is Vice-President of the Institution of Gas Engineers, also representing them on The Engineering Council's executive committee, and on the International Gas Union committee on distribution of gases.

Mr Brown joined The Institute of Energy in 1964. He is also a European Engineer, a Fellow of the Institution of Gas Engineers, a past Chairman of both the Wales region of the Confederation for the Registration of Gas Installers, and of the Wales District Section of the Institution of Gas Engineers, with whom he has also served as a council member.

Agreement of co-operation

AN AGREEMENT of co-operation was signed in Paris in June between the Institution of Mechanical Engineers (IMechE) and la Société des Ingenieurs et Scientifiques de France (SISF).

IMechE and SISF have increased their links to enable their members to benefit from the activities of both organisations.

Both are involved in the development and transfer of engineering technology. IMechE has 78,000 members, and SISF has 60,000.

Prospects for wind power

by Prof D T Swift-H

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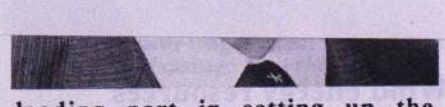
A Visiting Professor at Kings College, London, he lectures widely, and is also currently Chairman of Swift-Hook Associates, a consultancy specialising in alternative energy.



factors for wind power plant on good sites are around 30 per cent but that is determined by wind availability rather than by the power

**Visiting Professor, King's College, London & Chairman, Swift-Hook Associates*

Prospects for wind power

*by Prof D T Swift-Hook MA, MSc, PhD, CEng, FInstE, FIEE, CPhys, FInstP, FIMA**

The inauguration of England's largest wind turbine at Richborough, Kent, in July heralds a new era for wind power in the UK. Despite this particular renewable energy source's obvious advantage over nuclear, coal and even gas power generation, it has been criticised in the past for being prohibitively expensive, and for creating potential eyesores on the landscape. In this article, Prof Swift-Hook argues the case in favour of wind energy.

NUCLEAR power produces radioactivity, although it is true that the quantities are not normally excessive. Arguments over precisely how much radioactivity is acceptable and how much will be produced will no doubt continue to keep nuclear specialists in employment for many years to come, but occasional abnormal events such as Windscale and Chernobyl are quite sufficient to cause deep public concern in every country. In some countries, this concern is forcibly expressed by the formal declaration of a nuclear mortorium, while in others it is the commercial costs of safety measures and insurance that call a halt.

Coal produces sulphur dioxide, as well as dust and smoke. These pollutants can be removed at a cost, although the cost tends to be very high. Oil, too, produces sulphur dioxide as well as nasty acid smuts at times. Great care, and some cost, is needed to avoid serious problems, but even with massive clean-up equipment for de-sulphurisation and dust removal, combustion releases into the atmosphere huge quantities of carbon dioxide, which is a greenhouse gas. There is no practical way to avoid that.

In Britain, it only seems to have been recognised fairly recently that gas turbines can run on gas to provide cheap, large scale power generation. It is claimed that gas is beautifully clean and, compared with coal, it certainly is, but it still produces carbon dioxide.

One cheap method of generation that does not produce any of these sorts of pollution is wind energy. It produces no radioactivity, no acid rain and no greenhouse gases of any sort. It is also reasonably cheap — the most authoritative estimates are that an installed capital cost of around £600/kW can be achieved when wind turbine generators are in series production. [1,2]. Wind energy costs less than coal or oil or nuclear energy.

Development of wind technology

The reason that wind energy is so cheap is that it has been widely and actively developed in recent years. In America, Denmark and several other countries around the world, Government support has encouraged private investment in wind power and more than 16,000 wind turbines of various sizes have been built for power generation. Many of these are in California where more than 1 GW of generating capacity was installed during a three-year period in the 1980s when the tax credits were at their height.

Under the stimulus of these subsidies, engineering techniques and standards developed rapidly and costs fell so that wind energy is now attractive economically. Some of the most successful installations have been British, for example British Aerospace and Taylor Woodrow, a leading civil engineering company, formed a joint venture under the name of the Wind Energy Group and they have many successful machines and wind farms operating around the world (eg 3).

Reliable wind power plant

Plant availabilities can be very high for wind turbines compared with most other power plant because of their relatively small unit sizes. A modern multi-megawatt wind farm usually consists of a number of medium sized wind turbines, each individually rated at around a quarter or one third of a megawatt. Erection of an individual machine is typically completed in a couple of days on site, and any major repairs, such as a blade or gear-box replacement, can normally be carried out on a similar time scale.

Plant availabilities in excess of 95 per cent are the norm for successful wind farms [3] and this is in sharp contrast with other types of power plant. The best modern combustion plant finds it difficult to average 92 per cent. The maintenance schedules required for nuclear plant make it difficult to achieve better than 80 per cent and most nuclear stations fall well below that level; 50 per cent or less is all too common.

The load factor of most combustion plant is determined by its place in a merit table and the way in which power system requirements vary. Most fossil fuelled plant spends most of its life two-shifting or on single shifts at best. A lifetime load factor of 30 per cent is quite normal, particularly now that plant lifetimes are being extended to 40 years or more. Load factors for wind power plant on good sites are around 30 per cent but that is determined by wind availability rather than by the power

**Visiting Professor, King's College, London & Chairman, Swift-Hook Associates*

The author

Following National Service in 1950-51, Donald Swift-Hook took up an open award at Trinity College, Cambridge, to read Mathematics and Engineering (Electronics), before joining GEC at Wembley.

In 1959 he transferred to the CEGB, to work on novel methods of power generation, moving to CERL in 1962.

From 1964 Prof Swift-Hook worked at the CEGB's Marchwood Engineering Laboratories, where he was involved in the development of many applications of plasmas.

In 1974 he initiated CEGB activities in wave power, and also took over chemical engineering and combustion activities, before moving to CERL in 1976 to take charge of the Applied Physics Branch.

Prof Swift-Hook was elected Chairman of the British Wind Energy Association in 1982, and played a leading part in setting up the European Wind Energy Association.

A Visiting Professor at Kings College, London, he lectures widely, and is also currently Chairman of Swift-Hook Associates, a consultancy specialising in alternative energy.

Clusters of the James Howden-built 330kW wind turbine generators, part of a 25MW wind farm in California's Altamont Pass. This development is just part of a huge wind park in the area which now comprises some 4,000 machines installed by a number of companies.

system demand curve.

Wind turbines will tend to sit at or near the top of any merit table because they have such low generation costs. The wind blows free and the operating costs of a wind turbine with automatic start-up and cut-out can be very low indeed. Less than 0.3 p/kWh is reported on the best Californian wind farms[3] and this figure includes both planned and unplanned maintenance. Wind power will therefore be used whenever it is available, and that is likely to be around 30 per cent of the time throughout the whole life of wind power plant.

Firm power from the wind

Most power systems around the world accept that the majority of their load is uncontrollable and statistically fluctuating, predictable only within limits. This description fits wind power quite well and most power system operators would be very happy if a significant proportion of their individual load connections had 30 per cent capacity factors, as wind plant has. Indeed, wind power plant can be incorporated directly into any power system model by treating it as negative load.

One criticism directed at wind power is that it is not dispatchable because the wind does not necessarily blow when it is wanted. This point is usually made by Americans [4]. It might be more readily understood if it came from the Germans who are quite wide-spread in their use of disconnectable-load tariffs.

Power that is dispatchable is convenient for a power system operator, just as dispatchable or disconnectable loads are, but it is by no means necessary. Firm power generating capacity does not have to be predictable, any more than the load it is meeting. It is quite sufficient for it to be available statistically to meet periods of maximum demand. To first order, any type of power plant provides firm capacity equal to its average [5] and wind power benefits because the average power available is higher during the winter[6].

Obviously this first order argument cannot be taken too far. If all of the plant on a power system were wind-dependent, the power system could only have the same availability as the wind. In fact it turns out that second order effects are not important until as much as 30 per cent of the installed capacity is wind power plant.[7] Such a capacity of more than 10 GW of wind power is evidently a long way off in the United Kingdom — but it is not beyond the bounds of possibility. Resources of that order are available on land[8,9] and substantially more off-shore at a rather higher price.[10,11]

Wind energy resources

The total wind resource in the whole country is very large. Each square kilometre could accommodate some 4 MW of wind turbines, for example if sixteen 250 kW machines, each 25 m diameter were spaced 10 diameters apart. On that basis, if the entire country, which is some 250,000 square kilometres, was covered with wind farms, it would add around 1,000 GW[9] and that would be about be about twenty times the installed capacity of our present power system!

Winds as strong as those on the successful Californian wind farms are available in the UK over substantial areas of countryside, perhaps 1,000 square kilometres [9], 0.4 per cent or so of the total land area. That would be sufficient to generate as much as 4 GW of wind power if the whole area could be used for wind farms.

Only 1 per cent of the land over which a wind farm extends is actually occupied by wind turbines or their connecting access roads and the rest of the land can continue to be used for crops, grazing or other activities. Nevertheless, even such limited coverage would obviously be wholly unacceptable over large parts of the country. Urban areas must obviously be rejected and environmental and other constraints will limit the rural areas that can actually be used. National Parks, areas of great natural beauty, sites of special scientific interest and many others should obviously be avoided as far as possible but most of the countryside is given over to ordinary farmland and there is plenty of that.

It is usually envisaged that only a small fraction of the total amount of farm land around the countryside would be wind farmed in this way, perhaps a few per cent of the total area. This would still be sufficient for, say 20 GW of wind power plant. So, a fair amount of wind power is available from the windiest sites

and a good deal more altogether.

European technocrats envisage that in twenty years time 5 per cent of all electricity in the European Community will be generated as wind power and the CEC have major research, development and demonstration programmes to support that aim.[12]

The first wind farms should be on the windiest sites. Less windy sites produce less electricity for a given installation and so their generation costs tend to be higher but these later installations will benefit from savings of scale in production. A common rule-of-thumb used by production engineers is that doubling output capacity reduces costs by 10 per cent. Halving the cost typically requires a one-hundred-fold increase in volume of output. Such increases in capacity and such savings in cost are obviously possible, given the small scale of existing installations and the large resource available. Then all of the wind resources in the UK will become economic [9] and not just the windiest sites.

Wind farms planned for Britain

The first major wind farm in Britain is likely to be at Capel Cynon in West Wales, 24 km from Cardigan along the A486 to Aberystwyth. It will be operated by PowerGen. The site covers some 750 acres and the space needed for the permanent installation, including wind turbines, a substation, a control centre and access roads, will be less than 1 per cent of the land area. The rest of the site will be able to be farmed normally. It is planned to build 25 wind turbines, on cylindrical towers 25 to 30 m high with 33 m diameter rotors, two- or three-bladed, each generating around one third of a megawatt of electrical power to be fed into the local network.

The recently-inaugurated Howden 1MW wind turbine generator at Richborough in Kent.

Planning permission has already been given for the first privately-owned wind farm at a site in North Cornwall (*Energy World* No. 179, p 5). National Power recently announced that they hope to operate a second wind farm in Cornwall. They have applied to North Cornwall District Council for permission to build 23 wind turbines on a 675 acre site at Cold Northcott on the edge of Bodmin Moor near Launceston, to generate about 7 MW of power from the wind, to be fed into the local electrical network.

National Power announced that they have abandoned their plans for a third wind farm in the North of England. They had investigated sites at Langdon Common near Middleton in Teesdale and at Redburn Common near Rookhope in County Durham because of engineering and environmental complications. Both sites were in areas of outstanding natural beauty and there had been considerable local opposition to their choice.

At the same time, Yorkshire Electricity and Yorkshire Water hope to get consent for an 80 acre wind farm at Ovenden Moor by the end of 1990. Other developers are also in the field.

Construction

As soon as a wind farm receives planning approval, it should take no longer than a year for it to be operational. Six months was the typical time from ordering to commissioning a wind farm during the recent Californian wind rush, when tax deadlines had to be met [3] but a more careful approach will be adopted in Britain.

During the construction of a typical wind farm costing up to £10 million, there will be up to 50 workers on the site for a two or three month period. 5,000 sq m of land would be used for site offices, workshops and storage but this land would be temporarily leased and returned to the owner for normal use after reinstatement at the end of the construction period.

Equipment and materials will be delivered by road, with permanent and temporary access tracks across the site being laid as close to hedges as possible to keep disruption of the land and its uses to a minimum. A mobile crane will be used to lift heavy components into place once the foundations have been laid. The aim at each site will be to minimise disruption to farming and other local interests and to avoid any long term damage to the land.

Other UK developments

The planned wind farms will all use medium sized wind turbines on tubular steel towers with two or three bladed rotors about 30 m in diameter. Such designs, generating 0.3 MW or 0.4 MW seem to be the most economical ones at this stage. James Howden of Glasgow have

The two-bladed, 300kW demonstration wind turbine generator designed by Wind Energy Group Ltd and located at Carmarthen Bay, S. Wales.

manufactured more than 100 of their HWP300/28 series. WEG, the joint venture between Taylor Woodrow and British Aerospace, have already built more than 20 of their three-bladed MS2 machines [3] and they have eight of their two-bladed MS3s operated or being manufactured. The MS3 is the most advanced proven British design available [13]; it has a teetered hub, and it will be a strong contender for the various wind farm contracts. Nevertheless, Danish, Dutch and Belgian manufacturers will no doubt be reminding the privatised power companies of their European obligations and pressing for serious consideration of their tenders.

Multi-megawatt developments, such as the 3 MW British LS1 built by WEG for the North of Scotland Hydro Electricity Board on Orkney [14] and equivalent American, Swedish and German designs, have proved less immediately successful than the more recently developed medium-sized machines. But the tendency now is to move back towards higher ratings. A 500 kW version of WEG's two-bladed MS3 is planned while other manufacturers have recently built larger developments of their earlier machines.

James Howden of Glasgow recently constructed a 1 MW wind turbine [15] for PowerGen behind Richborough Power Station in Kent, which started operating at the end of 1989. The three-bladed rotor is 45 m in diameter and has variable-pitch tips for aerodynamic control.

Sir Robert MacAlpine recently installed their VAWT 850, a 500 kW version of their straight-bladed vertical axis design at Carmarthen Bay where National Power, PowerGen and the Department of Energy have a joint Wind Energy Demonstration Centre. Colin Moynihan, the Minister for Energy, started up this machine in August 1990.

To back up all these developments, there is a substantial national programme of research and development [16] which is managed for the Department of Energy by the Energy Technology Support Unit at Harwell Laboratories.

Obtaining planning consents

Little effort has so far gone into obtaining planning consents for wind farms, compared with that put into consents for nuclear and other power plant in the gigawatt range. The planning problems for large numbers of wind turbines will be akin to obtaining consents for transmission towers, which are quite comparable as far as the size and number of units required are concerned. Such problems are far less contentious than those of nuclear reactors or coal-fired stations.

With a transmission line, the difficulty is not to find acceptable sites for the majority of towers but to find a continuous line for all of them between two fixed points. There is no such problem for wind turbines. If some of the potential sites prove unacceptable, they can be omitted without destroying plans for the whole project, which is always the most serious difficulty with a transmission line.

Wind turbines are widely regarded as more visually appealing than lattice transmission towers or pylons. Indeed, James Howden of Glasgow built more than 100 replicas of their elegant three-bladed design which won a Scottish design award. Environmental and planning objections to wind parks seem certain to be considerably less than those to other sorts of power station or to transmission lines.

Unfortunately, it is not clear that present efforts to obtain consents for a few hundredths of a gigawatt of wind power plant are at all relevant to the serious problem of consents on the gigawatt scale. An analogy would be using a public enquiry for a footpath behind the local church as a guide to obtaining consent for a six-lane motorway. The people involved, the scale of the activity, the questions to be addressed, will all be very different. Success or failure in obtaining consents for such small projects will give little guidance one way or the other for the large projects that must be envisaged if a wind energy programme is to be worth pursuing at all. What is worse, the time spent may simply delay addressing the real problems on the gigawatt scale.

There is a similar problem as far as demonstrating economic and reliable operation is concerned. Single demonstration units, sold on a one-off basis and maintained by factory-based teams, can give little indication of the realistic costs of quantity production or operation, nor of the reliability that can be expected using specialist maintenance teams permanently working on site, handling large numbers of wind turbines. Only significant numbers of complete wind farms can provide the sort of demonstation that is required.

The new VAWT 850 (output rating 500kW), inaugurated last month at National Power's Wind Energy Demonstration Centre, Carmarthen Bay.

Environmental constraints

The environmental effects of wind turbines over large areas of private farmland will be localised to the farms themselves, and will therefore concern local farmers and land-owners much more than members of the general public. Private land-owners are likely to welcome the construction of wind parks on their land since there will be substantial increases in land values and revenues.

The density of wind turbines on a farm will be around 4 MW per square kilometre. This represents an investment of up to £15,000 per acre, which is probably more than ten times the entire value of the farmland which is usually worth less than £1,000 per acre in remote, windy areas. A land-owner would only need to lease 1 per cent of the land area for building wind turbines and access paths, but otherwise most farming uses would be largely unaffected. The situation would be similar to that for transmission towers, many thousands of which are spread across farmlands and other countryside areas with little or no effect upon the farming that is carried on around them.

What proportion of the £15,000 investment per acre to be put into wind power plant should or could be paid to lease a small part of the land for construction would be a matter for individual negotiation. Wayleaves for transmission towers cost very little but only a few per cent on the generation cost of wind power would suffice to purchase the entire land area outright, not just to lease the small fraction of it actually required to erect the wind turbines. Evidently agricultural farmers could find it very lucrative to become wind-farmers.

The environmental effects of wind turbines are very localised compared with almost any other type of power plant. Radioactivity, acid rain, carbon dioxide and greenhouse gases associated with other methods of generation have polluting effects that spread worldwide.

The environmental problems that do exist with wind power,[17] such as visual amenity, noise or TV interference, have far less serious consequences. The general public will not be greatly affected but to the extent that they are, their objections are not likely to be very strong because the wind power plant is inherently non-polluting and not particularly offensive. Those most directly affected, the local farmers and private land owners, will be amply recompensated in cash for any inconvenience which they may be caused. They can be expected to encourage wind power developments on their own private farmland.

Future obligations

When it became clear that nuclear energy was longer competitive with fossil fuels, the Government decided that it must be protected and supported by means of an NFFO — a Non Fossil Fuel Obligation. Renewable energies were able to take advantage of this scheme and the first NFFO order is expected fairly shortly. This will result in a significant amount of new renewable capacity being contracted for on favourable terms but there will not be many wind power projects under this first order.

It is a disappointment that only a handful of wind proposals will be able to sign contracts. One reason is the anti-protectionist legislation emanating from the Commission of the European Communities in Brussels which only allows the government to provide support for a period of eight years, far less than the useful life of the plant. In view of the difficulties, the Government is now planning to set a new tranche of NFFO next year, specifically reserved for wind energy.

This promise of support should help operators who are trying to put together new wind energy projects. We can look forward to some interesting prospects for wind power over the next few years.

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Solar photovoltaic energy for the 1990s

*by Mark Hammonds**

Global warming, depletion of the ozone layer and now the crisis in the Gulf all highlight the urgent need to develop alternative forms of energy, which are renewable, clean and reliable. Mark Hammonds of BP Solar Systems Ltd examines the available solar photovoltaic technology, with reference to a specific project for the Sierra Leone National Telecommunications Company.

EVERY year articles appear announcing the breakthrough of solar power as a 'new' power supply alternative. What many readers will already appreciate is that far from being 'new' this is now an established choice of technology to solve particular energy problems. The reality is the only 'new' aspects of this type of power are the higher efficiency figures and lower costs that are reported. The current situation in the Gulf, with its consequent effect on oil prices only serves to highlight the benefits of solar power. What follows for those not so familiar is a brief resume of the technology culminating in a description of a typical project.

The sun is responsible for most of the earth's energy in one way or another. Plant photosynthesis provided the basis of our fossil fuels such as coal and oil. Heat from the sun and specifically its effect on weather patterns, is indirectly responsible for that other form of renewable energy, wind power.

Solar power, in its accepted working definition, is the supply of energy directly from the sun. It is essentially made up of two very distinct technologies, solar thermal and solar photovoltaics. The first technology is based on the principle of using the sun's direct heat energy and is most commonly used for supplying hot water for houses and swimming pools. Regular visitors to Mediterranean countries will have noticed this type of application in abundance, with panels often mounted on roofs to provide domestic hot water. However, it is photovoltaics which is of interest here. This is a technology where the light is the visible spectrum, from the sun is converted directly into DC electricity.

Despite its rise to prominence in the last two decades, the photovoltaics industry can trace its origins back 150 years. The photovoltaic effect — the conversion of light into electricity — was first noticed over 150 years ago by the French scientist Becquerel. He observed a light dependent voltage between two electrodes immersed in an electrolyte.

Satellites

Further practical application of this work had to wait until the acceleration of the space programme during the late 1950s. Solar electric power became the only viable source for orbiting satellites, despite its initial high costs, for what is the remotest of locations. Any fuel carried would have only a limited life, and the more fuel carried the larger the initial weight, in turn requiring more fuel to send the device into space. The satellite programme therefore provided the initial impetus in the use of solar electric power supplies and formed the basis of the technology used in today's terrestrial applications.

During the mid to late seventies, major improvements in silicon processing techniques resulted in cheaper, more efficient solar cells. This coupled with other industry wide developments, eg reductions in power consumption of many devices provided the necessary spur for the adoption of solar as a viable energy source for such applications. This also being the time of dramatic rises in conventional fossil fuel prices together with men's realisation that such reserves would eventually run out, renewable energy sources attained a level of prominence which resulted in extensive investment being made in research and development.

Technological advancement, notably in solar cell processing techniques, continued apace throughout the late 1970s and early 1980s. Improvements in conversion efficiencies coupled with material cost reductions made photovoltaics an economic proposition for both higher power loads and an increasing range of applications.

So what constitutes a solar power system?

The basic component of any solar electric system is the solar cell, which, using a simple analogy, operates in a manner similar to a diode. Silicon is intensely refined to remove all the unwanted impurities. Half is then doped with boron which has excess positive electrons and half with phosphorous which has excess negative electrons. When light energy (photons) falls on the front surface of the cell, an excess of energy results in the movement of electrons between these devices exactly as a P-N junction diode. This is then collected, by a metal backplate and grid on the cell, as electricity.

The early work by Becquerel used selinium, and it wasn't until 1954 that the present dominance of silicon as the major raw material for solar systems began. Silicon (in its many forms) is one of the most abundant elements on earth, it's most well known manifestation being sand. Therefore, it's plentiful availability combined with high light-to-electricity energy conversion rates made it the predominant raw material within the photovoltaic's industry.

Future development work on improving the performance of solar energy systems, both in terms of cost reduction and higher power output, is heavily concentrated in this area. The solar cells constitute a significant cost element in any solar electric power system and hold the secret of increased energy conversion. Current research encompasses other semiconductor materials as well as improvements in the existing silicon based technology.

Cells are made as thin as practicable for cost reasons. As a result of this, one avenue of investigation is in the cutting of wafers to minimise material wastage. The thinner the wafer, the less the material wasted and therefore the cheaper the cell.

To withstand the harsh environmental conditions in which they operate, cells are laminated in a manner similar to that of a car windscreen, between a layer of special high

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**Marketing Executive*
BP Solar Systems Ltd

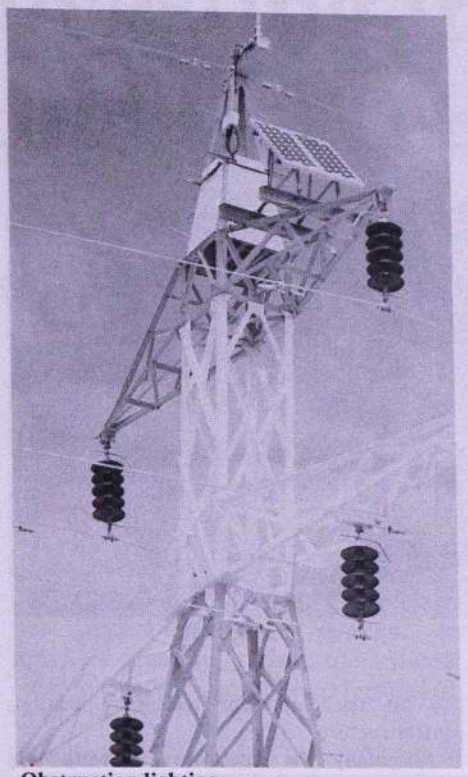
transmission glass and weatherproof plastic. To provide a unit of optimum power configuration, as dictated by the electrical characteristics of the solar cells, usually 36 silicon cells are linked or 'tabbed' together to give a module typically 1m × 0.5m. Such a unit, typically, has an output of 50 watts at 12 VDC under industry standard test conditions.

Solar batteries

The remaining elements of a complete solar electric power system are specifically designed batteries, to store energy and thus ensure continuity of power supply and a charge control unit to create an effective and efficient battery charging regime.

To maximise output, the solar modules have to be so sited that they get the most light. This light comes from three sources: direct light from the sun, diffuse light reflected from the atmosphere and reflected light from the earth's surface. In most instances it is direct sunlight which provides the most important element. As a generalisation, modules must be so sited that they face the equator and are tilted at an angle of tilt approximate to that of the angle of latitude. Whilst conceptually systems which track the sun have the most appeal, the mechanisms required to achieve this tend both to consume too much power, and the moving parts involved reduce reliability and increase maintenance requirements, so negating the key benefits of solar. Therefore, with reliability in mind most solar module support structures are designed to be of both fixed tilt and orientation with the possible small loss in module output power countered by the advantages of increased reliability.

As already mentioned, to provide power during the times when the sunlight is insufficient either during the night or periods of poor weather, eg heavy cloudcover, a method of energy storage is required. The most efficient medium for this is the battery. Whilst it is true almost any type of battery can be used, providing the electrical parameters are suitable, solar systems have some particular design requirements. These are effectively low maintenance (ie infrequent battery top-up) and long life (ie able to withstand the heavy daily battery cycling required under these conditions). To meet such rigorous service demands, battery cells have been specially developed, an example being the P series developed by BP.



Obstruction lighting.

Variable output

The output from the solar modules will vary considerably with the prevailing sunlight and temperature conditions. Whilst it is possible to connect directly to the batteries, in unattended situations this may result in considerable water loss from the batteries, due to uncontrolled cycling, thereby considerably reducing overall system life. To counteract this, electronic control units form an important part of the overall system design, creating a charging mechanism which reflects the characteristics of the battery itself. This will effect efficient energy transfer coupled with the minimal battery water loss. In BP Solar Systems' case this is done by a dual voltage principal. Charging the batteries at a high 'boost' voltage, early in the day, to transfer the maximum energy into the batteries, then switching back to a lower 'float' voltage to minimise water loss (and therefore preserving, the long maintenance top up interval).

Having briefly explained the major system components, a high emphasis is needed on designing the optimum configuration, in terms of numbers of modules and an associated battery capacity, for any particular application. Regardless of individual component quality, system reliability and longevity depend ultimately on the overall system design.

System design techniques have consequently been the focus of considerable development activity themselves. From hand calculated methods on a single sheet of paper the methodology has evolved to sophisticated computer programs involving weather pattern probability analysis. Only accurate sizings of the system will result in the benefits of solar being obtained by users. Demonstration systems such as the 30kW solar plant (jointly funded by BP, the DTI and EEC) which was sited at Marchwood power station near Southampton have provided comprehensive data on system performance. Data such as this, again coupled with wider monitored experience and intensive research allows system modelling and design to be computed for all corners of the earth with confidence.

Benefits of solar

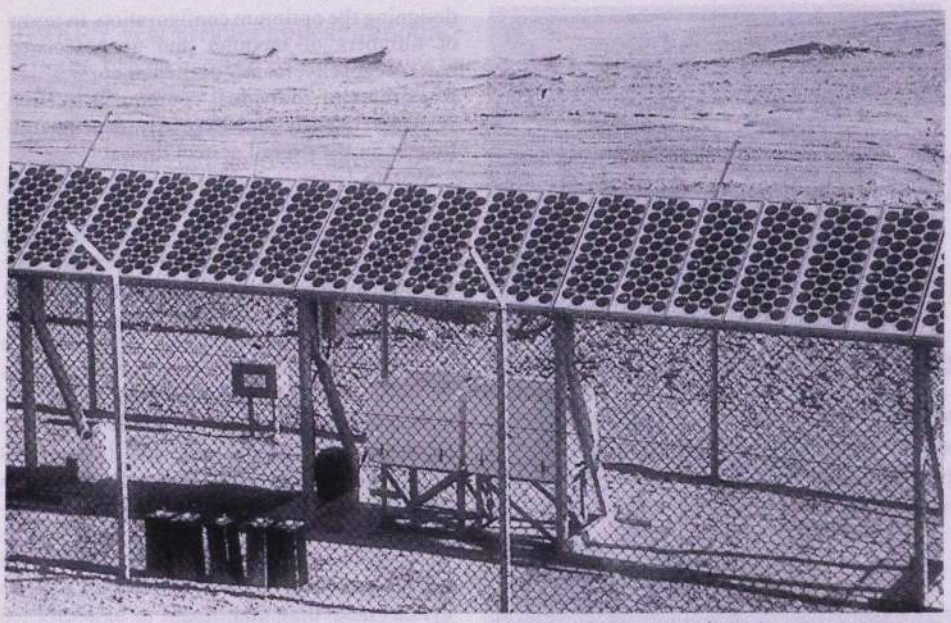
Having described the systems, why is it people should choose to adopt solar in preference to other power supplies?

The main benefit of solar power systems is their use of 'free' fuel from the sun, resulting in only minimal running costs (just distilled water for topping up batteries). Equally important for users is the minimal maintenance requirement, with the critical element, the solar modules, having no moving parts. Indeed examples of life cycling costing show a strong advantage when compared to diesel generators, or even in some cases, the electricity grid system when maintenance costs are taken into consideration.

So where is photovoltaic technology currently in use?

In effect its uses are limited only by the imagination. At present however economic reality currently dictates that they predominantly exist to power telecommunications, manpack radios, provide impressed current corrosion protection, telemetry, navigational aids, water pumping and lighting. These are typified by their need for a reliable, remote power source requiring minimal maintenance. Even the UK, until recently not famous for its sunshine has found economic

Different applications of photovoltaics: at a ski resort (left), and for a solar powered pumping system (right).



Photovoltaic system in the desert.

applications. The TV transmitting station of the BBC at Dychliemore in Scotland used a solar/wind generator hybrid system for its power supply. Many small telemetry stations for water authorities throughout the UK are now solar powered.

One such project illustrating the state of the art solar power contract has been systems for the Sierra Leone National Telecommunications Company (SLNTC).

Sierra Leone like many African countries was hit badly by the volatile fluctuations in world oil markets. One of the effects of this was to hit the important telecommunications infrastructure.

Originally the microwave network was powered by fuel inefficient closed circuit vapour turbine (CCVT) generators. However, CCVT and diesel generators need a reliable and regular source fuel supply. Shortage of this fuel due to high prices coupled with the inability to obtain spare parts meant at times there were breakdowns in the network.

With the aid of an EEC funded contract, British Teleconsult were appointed as consultant to recommend improvement to the network. Solar power was chosen as a solution to this problem. Using the abundant 'free' sunshine coupled with the use of more efficient radio equipment meant solar was the obvious solution.

Solar systems are reliable, and easy to install. Maintenance requirements are minimal, typically just panel cleaning and an annual electrolyte top up of the batteries.

Following provision of further EEC funding, the project was awarded to BP Solar Systems Ltd. The project involves supply of 11 systems on a full turnkey basis for SLNTC, encompassing supply of equipment, civil works and site preparation, installation and commissioning and provision of training.

If further evidence was ever needed, it is projects such as this which confirm that solar power is not seen as the 'new' source of power. It is now an established alternative: which given its unique advantages continues to gain even wider usage.

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SUPPLEMENT

Investing in Environmental Technology

by Bryan Townsend, Chairman and Chief Executive, Midlands Electricity plc

Based on the 1990 Institute of Energy Jim Ellis Memorial Lecture

POLLUTION control, environmental management and efficient use of all resources are now perceived by every thinking person as essential to the survival of the human race.

These issues are important ones. They represent a challenge to the ingenuity of our engineers, an opportunity for our businesses and a responsibility that none of us can avoid.

Rapidly Changing Attitude

A start has been made. The last two decades have seen a recognition of all the steps that have to be taken, a realisation that heavy industrial pollution must be avoided and a rapidly changing attitude to the standards legally required in all types of manufacturing industry. This has already resulted in a pollution control industry with an estimated turnover of £4,000 million in the UK alone. The cost is spread over four key media – air, water, waste and noise. Industry expenditure, when compared with total expenditure, is higher than average for air and water, and significantly less for waste and noise.

Environmental technology thus represents a major business area – one that is rapidly developing as the world's inhabitants come to expect clean and comfortable surroundings at home, at the workplace and in leisure or social centres. A myriad of electrical techniques have been developed to match all the requirements for personal environmental control.

Despite an ever increasing sophistication in plant and controls of the personal environment, the major opportunities cover a much wider area of application.

This was recognised by the Department of the Environment when the Environmental Protection Technology Scheme was introduced within a European framework. This scheme was designed to promote the benefits that can accrue to businesses, employees and shareholders if the right new technologies are applied. It provides grant aid, helps to evaluate clean processes and offers information to industry.

We have already reached the stage where all responsible industrialists are examining their activities to identify potential sources of pollution, to evaluate the benefits from improved standards and to see whether they can profit from the new technologies. Most important of all, there are many examples of new investment projects designed to decrease pollution levels,

Metal melting equipment at Midlands Electricity's Power Technology Centre at Halesowen. Electric melting plays a key role in reducing foundry emissions.

to reduce energy and raw materials content, to make processes more efficient and benefit the workforce by improving the working environment.

This represents a massive opportunity for the electrical plant and supply industries – and, indeed, for all the fuel interests. This opportunity is available in six principal areas:

1. **New process designs**
2. **Recycling waste materials**
3. **Recovery of surplus raw material (especially the heavy metals)**
4. **Conversion of waste into 'clean' effluent**
5. **Production of a clean working environment**
6. **Elimination of health and safety risks**

By the nature of industrial endeavour, this cannot be an exhaustive list. New processes can use cheaper or smaller volumes of raw materials, production scrap can be minimised and new, 'clean', so called 'green' products can be made with greater customer appeal.

Substitution

But where do the opportunities lie? Manufacturing processes and their by-products range from being intrinsically clean to positively hazardous. Substitution of offending plant and/or chemicals by non-polluting alternatives represents one opportunity.

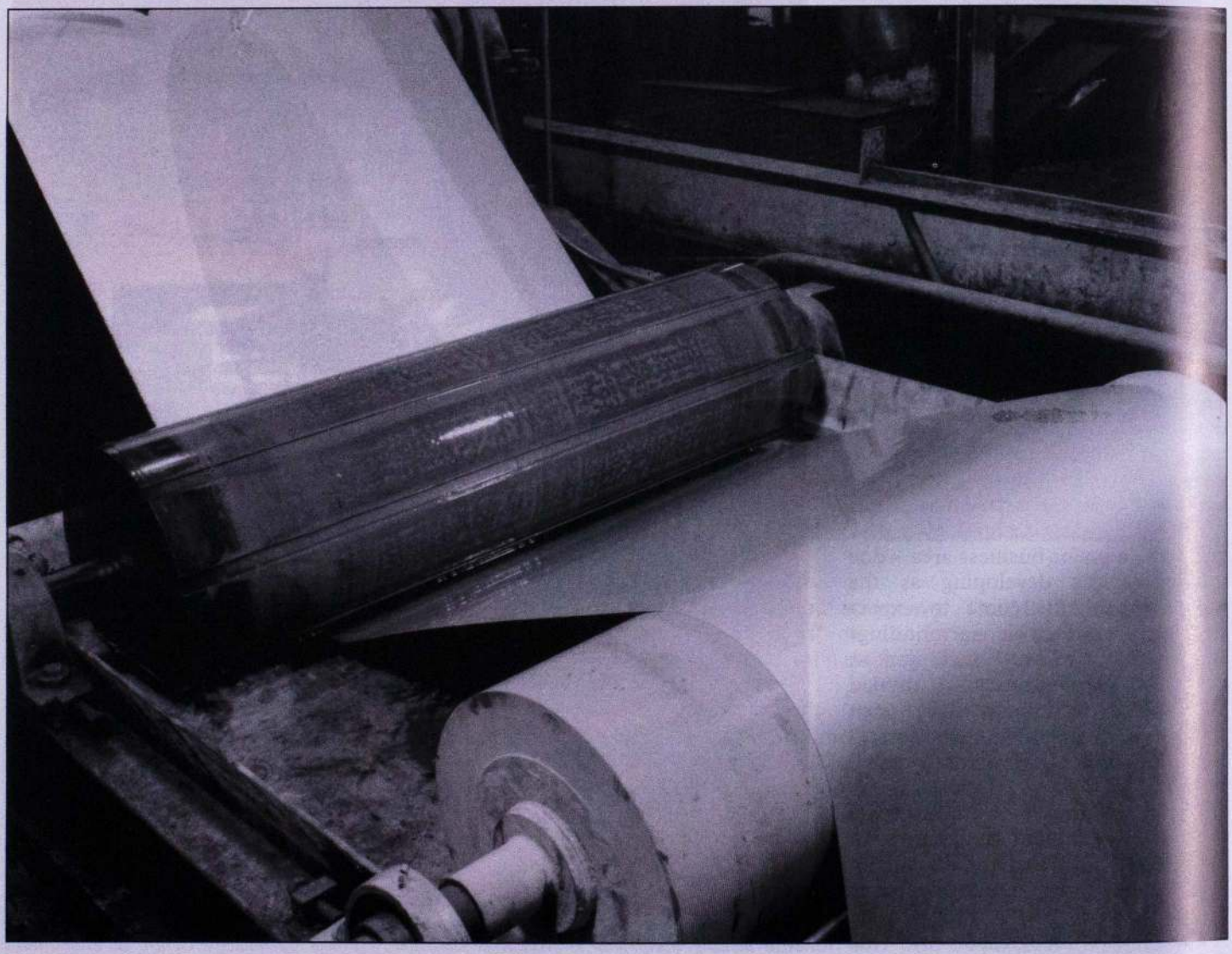
A second, equally vital, way is to introduce secondary plant which tackles pollution at or near the source.

Both these approaches can be applied throughout industry, but I would argue that the metals and chemicals industries represent a major challenge. Of course, resources need to be channelled to implement change and, in the current climate of high interest rates, this is no easy solution. However, in many situations the capital and energy costs are more than offset by production benefits. In most cases there is, at least, a partial offset.

Other areas also present major opportunities, especially paint, print and associated processing. In particular, dangerous evaporative solvents represent a difficult and sometimes intractable problem. The food and agriculture sector also depends on high volumes of process water which, after use, generates pollution because of the high biological content of the waste liquids.

Let us start with one area of vital interest for the Midlands – the automotive industry. Here, the problems of metal processing, the use of hydrocarbons, and energy conservation, are all interlinked. One of the major trends has been the substitution of metal components by plastic ones. Comparisons can be drawn between the various manufacturing processes required to produce chromium plated steel, for example, and its plastic counterpart.

But, even certain plastic substitutes, with all their additional advantages for weight saving and reduced fuel consumption, still have to be coated. The coating process – involving wet paint application, can be streamlined using new painting and curing techniques to reduce paint usage, reduce or eliminate solvents, and thus radically reduce the costs of expensive raw materials, at the same time as reducing labour costs and improving



Electrolytic methods help maintain acid strength to conserve expensive raw materials.

operator safety levels and preventing noxious emissions.

While plastics and new curing processes illustrate the benefits of material and plant substitution in automotive component production, there are a number of sectors, where far more radical redesign of the production process is needed if pollution problems are to be substantially reduced.

This re-design is especially important to the metal and chemical industries. The various types of electric metal melting furnaces have now become a popular option. This dramatically illustrates the link between economic and environmental advantages to be gained by plant substitution. Whether the new electric furnaces are of the coreless or channel induction type, or perhaps one of the various types of resistance crucible furnaces, their introduction into existing foundries has transformed conditions, both within the melting shop and in the surrounding locality.

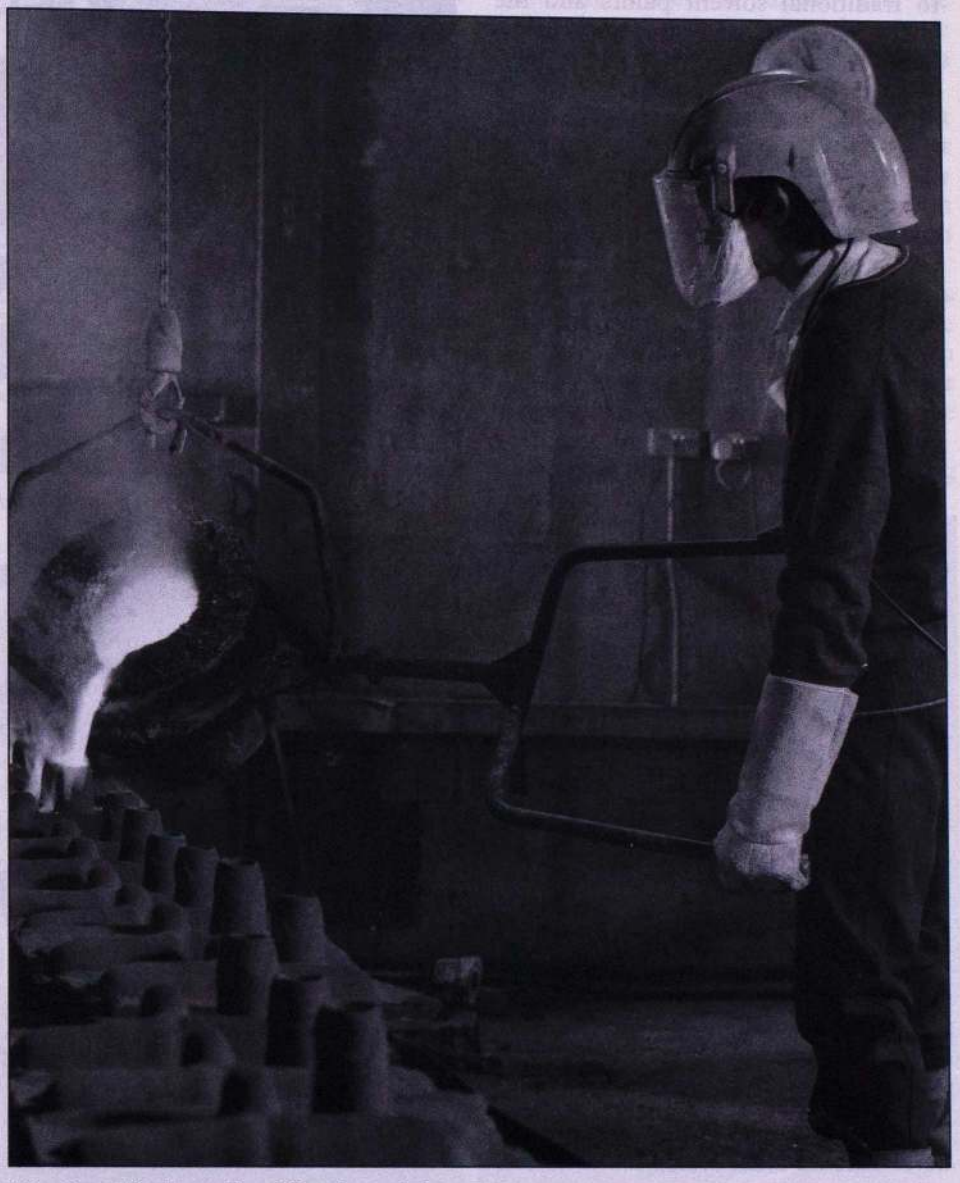
The virtual elimination of fume and waste gases not only creates better environmental conditions, but is accompanied by large reductions in slag and dross levels. To the operator the large reduction in radiated heat and noise levels is a very welcome bonus. The additional economic benefits include improvement in metal yield, metal quality and alloy flexibility. It would be difficult to quantify all the anti-pollution benefits involved, but recorded improvements in metal yield alone helps explain their growing popularity

While these benefits are self-evident, the increased flexibility and control over the melting process given by electrical techniques also has other advantages. The introduction of the Wilman process, developed by the Electricity Research and Development Centre at Capenhurst, enables production steel scrap to be utilised for SG iron castings, thus reducing total energy costs and eliminating a potential waste product at the same time. Cannop Foundry, in the Forest of Dean, used this new process to cut costs, improve operator working conditions and carve out new markets for its skills.

Efficient Recycling

The metal industry (and the electronics industry) have presented excellent examples of electrolytic techniques. These reduce the discharge of hazardous materials and can enable expensive metals to be efficiently recycled.

Water effluent containing dissolved metals from industrial processes such as electroplating, ranges from mildly polluting to highly toxic, especially with such elements as cadmium. Needless to say, water authorities have extremely low consent limits to the discharge of certain substances so that the surface water quality standards, now becoming mandatory, can be met.



Electric melting has reduced foundry emissions.

Metals can, of course, be recovered from solutions by chemical or physical precipitation methods; both expensive processes with possible toxic residues.

A far cheaper alternative is to electro-chemically deposit the metal. However, the concentration of metal in drag-out rinse waters, although often high by effluent discharge standards, is extremely small by plating standards. This is particularly so in the depleted boundary layer zone surrounding the cathode – the deposition site.

The Chemelec cell removes this 'barrier' by a variant of the fluidised bed technique. Circulation of the fluid agitates and suspends glass beads. This ensures that the deposition rate is fast enough to make the system feasible. In the case of certain metals, including gold, silver, nickel and copper, the recovered metal can be re-introduced into the manufacturing process. This often achieves payback in just a few weeks or months.

Thus the Chemelec cell not only reduces pollution, reduces water costs and saves global resources, but gives economic returns to its investors, while enabling them to comply with local discharge regulations.

A variant of the CEER process is used in the steel industry to maintain the strength of the ferric chloride etching solution, vital for the following nickel plating process. This new technique reduced the required quantities of hydrogen peroxide and hydrochloric acid and, in turn, lowered process costs and minimised risks to workers and the environment.

Heavy metals are by no means the

only valuable raw material which businesses are anxious to conserve, both for their intrinsic value as well as avoiding the possibility of waste and potentially hazardous emissions. Painting and printing operations and, indeed, all processes which use expensive hydrocarbon solvents, have major environmental problems.

High solids and water-based paints are now emerging as serious rivals to traditional solvent paints and the potentially hazardous two-pack formulations. Electricity, by providing very compact drying systems, such as infra-red, enables paint and solvent users to substitute water in place of the hydrocarbon solvent.

A similar substitution has taken place in many cleaning processes where ultrasonic water-based cleaning systems have replaced the familiar 'trike' bath.

The electric infra-red oven has undoubtedly been a major factor in the rapid growth of powder coat finishing. However, major advances can be made by combining the benefits of a number of electrical techniques.

One company invested in a unique production line which converts sheet steel to fully finished painted components in a continuous flow process.

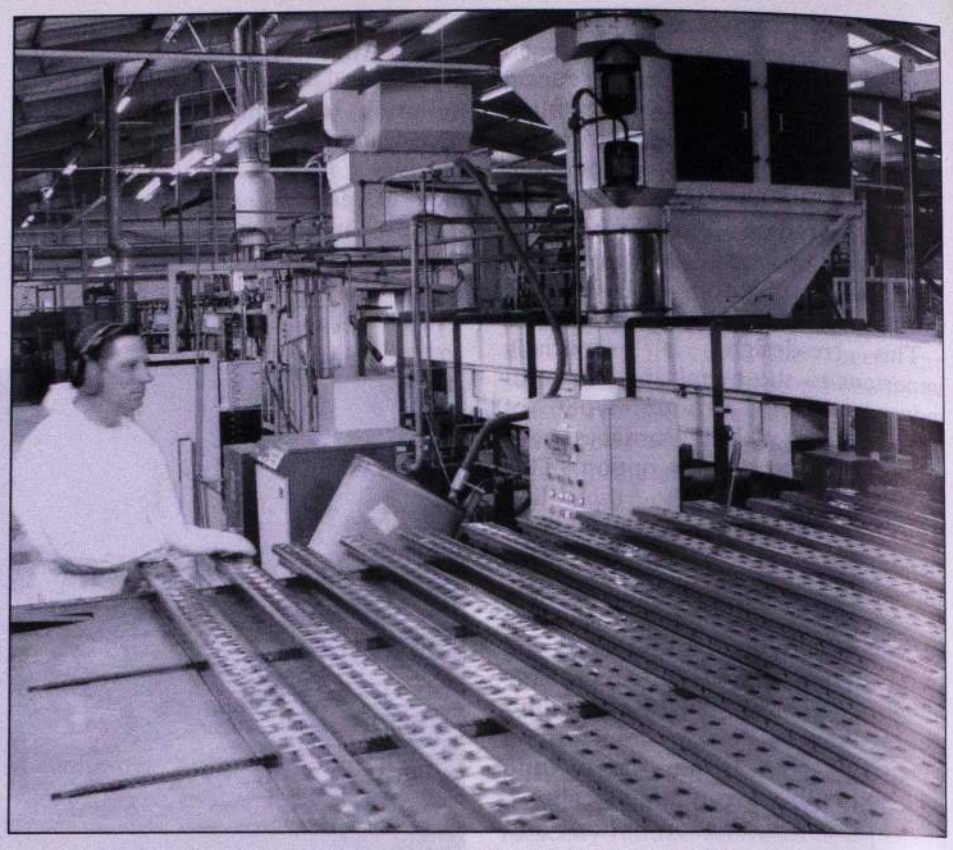
Although annual electricity charges increased by £22,000, the efficiency of the new system, using electrical induction, generated annual savings valued at £140,000.

After manufacturing, sheet steel components an an automated line, they pass under an air knife using technology originally developed by Midlands Electricity's Power Technology Centre at Halesowen. This safely removes surplus solution. After this the components pass to an automatic multiple rinsing process and are dried using a second automatic air knife system.

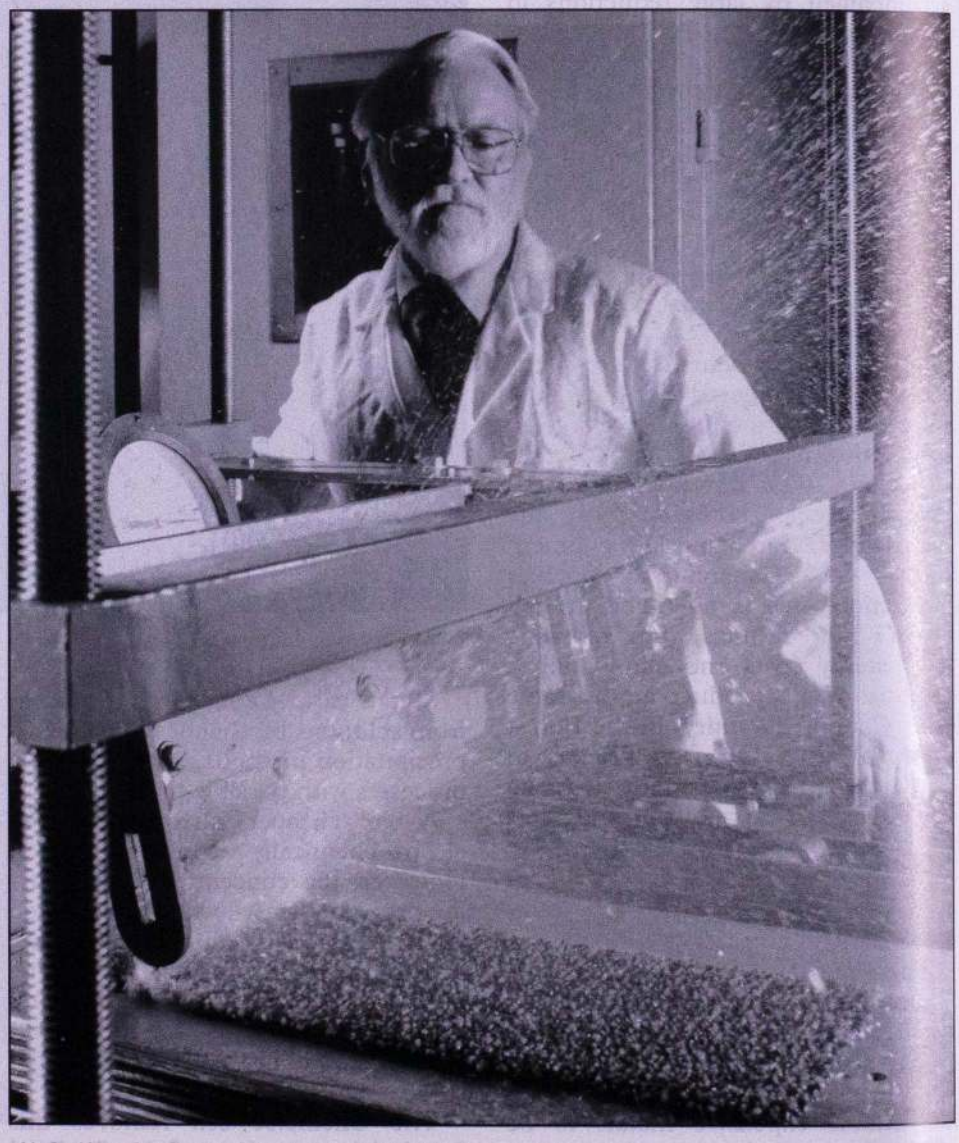
An automatic powder coating unit then applies powder paint electrostatically to both surfaces of the component.

Electrical induction heating then heats the sections to the correct stoving and curing temperature of 220°C. After curing the sections pass down a cooling conveyor to be packed and stored.

This new process cut the number of production stages from nineteen to seven, achieved improvements in quality and productivity during a period when production increased by 25 per cent and eliminated the relatively unpleasant manual spray painting. This improved the working



The introduction of powder coating has reduced hydrocarbon solvent emissions.



Air knife technology achieves a radical reduction in drying costs.

conditions and, most important of all, eliminated the hydrocarbon solvents from the production process.

For final metal finishing processes, the use of solvent-free epoxy and polyester resin powder coatings has grown in recent years. Compact methods also exist of heating hot melt adhesives or curing thermo-setting adhesives or fillers, with minimum or zero use of toxic solvents.

Waste Processing

Despite the re-appraisal of plant and processes in this environmentally conscious world, there will continue to be unacceptable by-products of agriculture and the allied processing industries.

A vast range of organic substances still need to be rendered harmless before they can be safely discharged into the atmosphere, water courses or land fill sites. To help meet this challenge, new techniques have been developed to supplement traditional waste processing methods which prove inadequate when judged against current standards for environmental protection.

Four relatively new techniques serve to illustrate progress in this area:

V02 aeration
UV/ozone
plasma arc
and a variant of the traditional arc furnace

Liquid effluents arise from modern agriculture, especially pig farming, as municipal sewage, and also from manufacturing processes such as brewing and food processing. These processes can produce such large volumes that eventual discharge, by landspreading and direct, into rivers and seas can present substantial environmental hazards even with high levels of dilution.

Without treatment, the biological and chemical oxygen demands of these liquors are a substantial source of water pollution, not to mention smells. This, of course, has a 'knock-on' effect, involving both plant and animal life. The still considerable accidental discharge of such untreated slurries provides many examples of their devastating effects, particularly on fish populations.

The safe disposal of these liquors is only possible providing that a very large reduction in the oxygen demand of the waste products has been achieved. By promoting the action of aerobic micro organisms, aeration reduces the level of suspended solids and deals with the oxygen demand.

The V02 venturi aerator provides the necessary oxygen in the form of injected air and quietly stirs the liquor by cheap, reliable equipment based on electrically-powered pumps and motors.

At Cadbury's plant in Marlbrook, Herefordshire, a process of evaporating milk and mixing it with sugar and cocoa forms chocolate crumb. Daily cleaning of the road tankers which deliver the milk from local farms, together with cleaning water from the plant, swells the effluent to approximately 800,000 gallons per week.

By introducing a V02 aerating tank, the previously overloaded sludge treatment plant now fully meets the requirements of the local river authority.

In addition there are other valuable benefits. The inevitable odours arising from the treatment of milk effluent have been considerably reduced. The quantity of sludge for off-site disposal has fallen by over sixty per cent.

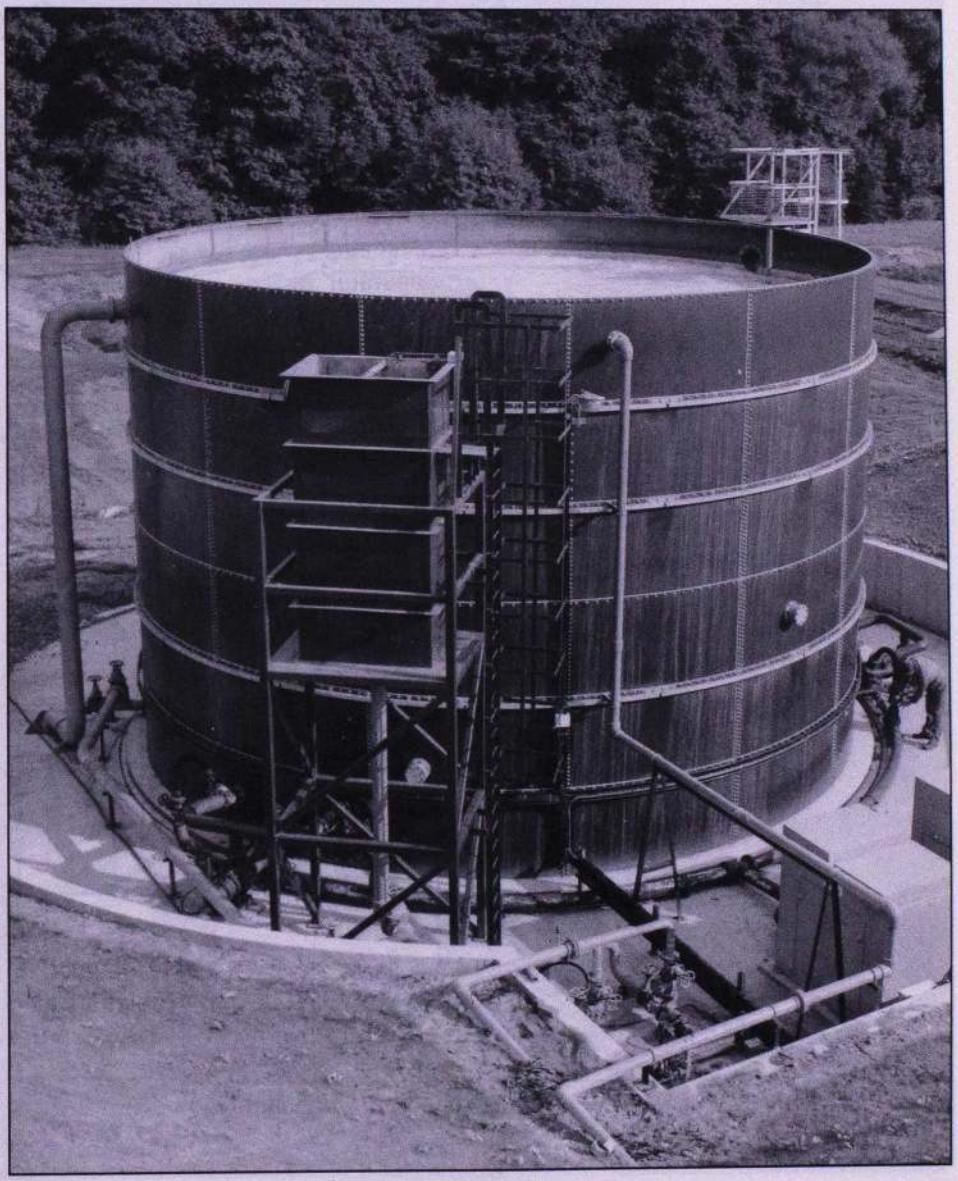
Aeration is far from being a technique used solely for effluent processing. V02 aerators have been used in industry in a corrosion resistant plastic form to increase the rate at which scrap copper is recovered in a sulphuric acid bath.

Unwanted odours are perhaps the most obvious evidence of pollution to the average man or woman. Here, too, new electrical methods have come to the rescue. The powerful oxidising effect of ozone can be utilised to break down and remove trace organic contamination from water and air.

In this process intense ultraviolet energy beamed on the polluted water injected with ozone converts the hydrocarbons to water and carbon dioxide at temperatures close to room temperature.

As well as removing odours, this process can radically reduce the energy required to produce high purity pyrogen-free water for hospitals, laboratory use and the medical supply industry.

In a recent variant for the cleansing



Venturi aeration systems reduce biological oxygen demand.

of air, the polluting organic compounds are first removed in a water scrubber, the air then passing through a mist eliminator and carbon filter to remove airborne droplets and particles.

The UV/ozone system acts on the water collecting in the sump of the scrubber to convert the organic impurities to water and carbon dioxide. No chemical reagents are required and the contaminated liquid waste associated with traditional scrubbing systems is eliminated.

Enhanced photo-oxidation is still a somewhat specialised technique, but aeration is now frequently part of the sewage and sludge treatment process. Unfortunately we are now reaching the stage where the complexity of sewage and allied wastes is creating serious processing difficulties.

This is especially true where complex organic chemicals are becoming a hazardous constituent of both industrial and household waste.

Rather more powerful techniques are being employed to tackle this problem. Research teams in Europe and the United States have been developing the plasma arc as a means of producing the high temperatures required for the destruction of dioxins and other complex hydrocarbons, celluloses and allied toxic substances.

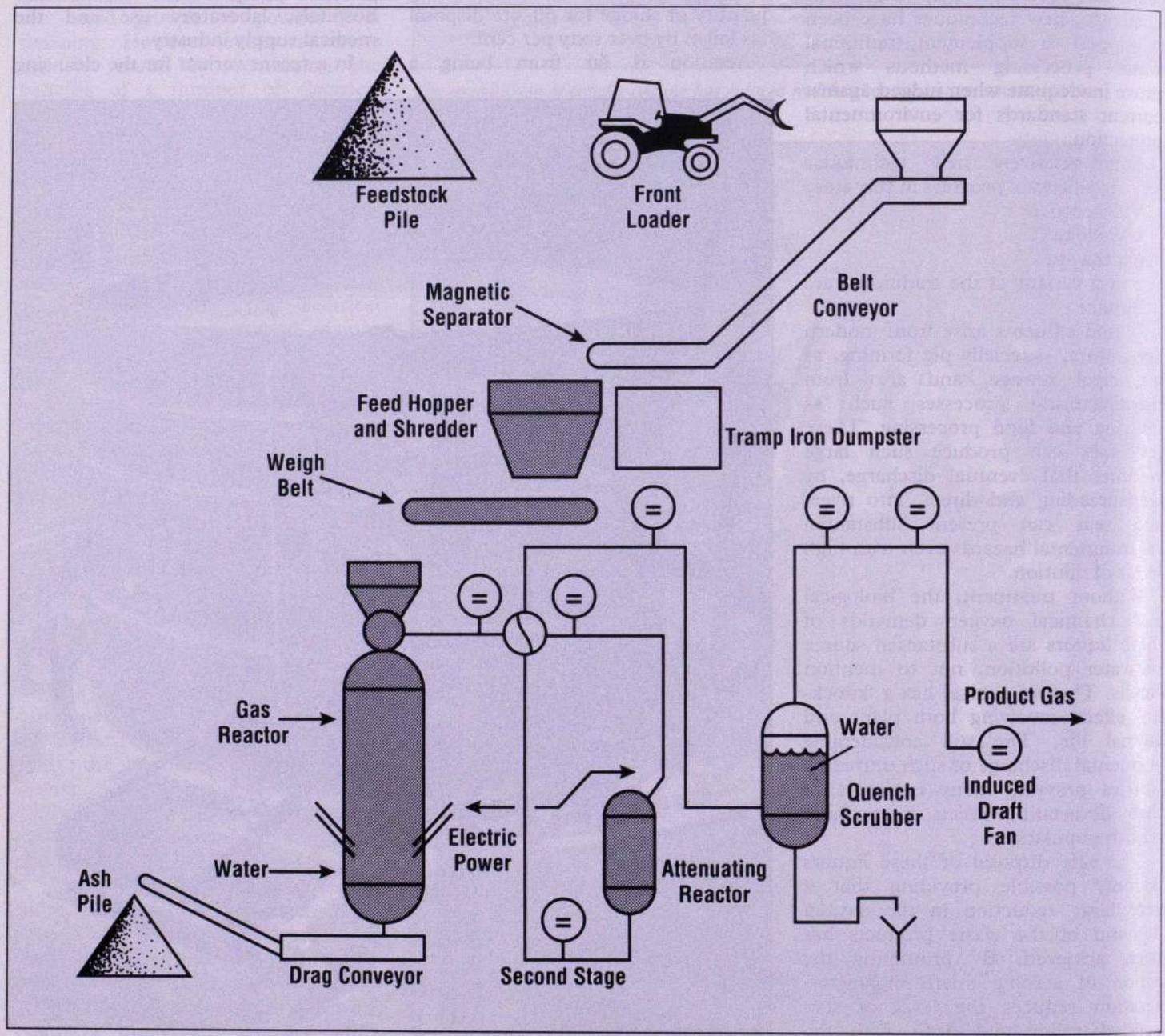
Plasma Research

The American Skygas process delivers finely divided waste into a liquid reactor. The liquid is vaporised by the plasma arc and raised to a temperature high enough to produce a process gas, principally hydrogen, carbon monoxide, carbon dioxide and methane. The process gas then passes through a coke bed, eventually producing a mixture which is mostly hydrogen and carbon monoxide. This could, of course, be used for steam production, electricity generation or as chemical feed stock. It will be interesting to see the results of the pilot plant operation. The early results indicate that even dioxins are broken down successfully.

Skygas requires large and expensive plant, however a research team from Strathclyde University has developed a small scale device with a 20 kW plasma gun working at temperatures up to 6000°C.

Research teams in Japan do not believe a plasma arc is needed for this, and one group has succeeded in processing waste using conventional electric arc technology.

These ideas may well make a substantial contribution to pollution control in the next decade, but as



Skygas process converts carbonaceous feeds into medium BTU gas.

suppliers of energy it is essential to consider how this energy can be used to best effect. It is one profitable way for all industries to reduce direct and indirect pollution.

Perhaps the most obvious area of development in total efficiency and conservation is heat pump technology and the allied skills of refrigeration and cold storage.

Modern heat pumps can economically channel energy to satisfy many of today's special needs. Examples abound in the leisure and recreation industry – swimming pools, ice rinks and beer cellars for example. Large plant meets the need for air conditioning in hotels, while relatively small units can control humidity in the local squash club if required.

Refrigeration

Cold storage of fresh fruit and vegetables for extended periods under strictly controlled conditions avoids contamination resulting from unsaleable produce due to damage caused by fluctuations in the weather or when supply temporarily exceeds demand. Heat pump technology is increasingly used in this area to provide the appropriate temperature, humidity and velocity levels in the storage atmosphere.

For potatoes and certain other root vegetables, storage life can now extend from the end of one growing season to the start of early harvesting in the next. A high humidity of 90 to 95 per cent and temperatures close to 0°C, depending upon the crop, must be maintained within the cold store.

Refrigeration of part-processed food represents a similar route for extended storage. Provided that hygiene standards are met, frozen storage can smooth out variations in the annual harvest, avoid waste and maximise the food supply.

The provision of a clean and safe working environment is beneficial to a company's product, its workforce and, last but not least, its image. Air filtration and heat recovery can make real improvements to the working environment.

One ceramic ware manufacturer uses a heat recovery system to extract heat from the pottery kilns. This energy is then used to heat incoming fresh air and recirculated air cleaned by high grade filters, before it is distributed around the building. There is sufficient heat recovered to meet the factory's hot water needs. The new system, governed at each stage by computer, maximises fuel economy.

Furthermore, tableware emerging from the kilns is now at a lower, 'handleable' temperature and the previously intolerably hot working conditions in that area of the factory have been transformed to achieve a

Wastage of fresh foods is reduced by refrigeration.

comfortable working environment and additional floor space.

Alternative Energy Sources

These examples represent a fraction of the technology now available to control pollution. This technology enables manufacturers to make maximum use of scarce and expensive raw materials and helps to provide the clean and attractive conditions that everyone would like at home and in the workplace.

As one of the new breed of energy utilities, Midlands Electricity are making every effort to develop techniques to meet the requirements of pollution control in the internal and external environment.

Perhaps the most interesting development will be that of alternative sources of energy, something in which Midlands Electricity are taking a very active interest. One example which fits today is the use of methane, produced by waste disposal sites, for electricity generation.

The landfilling of domestic refuse accounts for the disposal of an estimated 90 per cent of Britain's household waste. Landfill is the cheapest disposal option – sometimes as low as a few pounds per tonne for household waste, but this disposal method also has a potential bonus. Biochemical reactions within organic waste produce vent gases rich in methane and carbon dioxide.

On some sites the uncontrolled build-up of gases creates a safety risk to neighbouring buildings. However, on one of the largest sites in the UK, at Packington in the West Midlands, careful management techniques are used; the waste is capped with a layer of clay and the gas collected. A gas turbine generates over 3MW of electricity from this non-traditional fuel. Elsewhere, other opportunities have been and are being taken for some refuse and waste products to be used directly for generation by incineration. Privatisation of the electricity supply industry can only spur such moves.

Thus, the correct approach to pollution control and environmental management can generate profit and create opportunities for everyone connected with energy supply and utilisation.

This is not to say that we should be profiting from the world's misfortunes of pollution. It is probably fairer to say that the development of environmental technologies can make a real contribution to improving the human condition.

Clean technology must be a good investment for every industry, and investment in environmental control can provide a good financial return and help to make life more pleasant and comfortable for all mankind.

Heat pump technology conserves energy by transferring heat from production areas to offices.

30 MW solar thermal power station — an investigation

*by Hans W Fricker**

Solar thermal power stations of the tower type have been shown by the European Phoebus consortium to be capable of economic and commercial viability, provided the system's suitability and location are taken into full account. In the following investigation Hans Fricker examines the possibility of constructing a demonstration plant, concluding that such a venture would be justified.

SOLAR thermal tower power stations with a central receiver, so called CRS (Central Receiver Systems) plants, have been tested on an experimental scale, for example Solar One (USA), SSPS and Cesa 1 (Spain), Themis (France)[1].

In CRS-plants, a number of movable mirror units (heliostats) reflect the sun's rays onto a central unit, the receiver. This means that the radiation from the sun (maximum about 1kW/m^2) is highly concentrated, so that the receiver can be constructed to be relatively small and to lose very little of the energy incident upon it. In the receiver, the concentrated solar radiation is converted into heat on dark surfaces. This thermal energy is transferred by a suitable heat transfer medium. The heat transfer medium is for example, subsequently used to heat a steam generator or a thermal storage unit. Mechanical or electrical energy is then generated in a conventional steam circuit (Fig 2).

The GAST[2] Federal German Technology Programme, the Swiss Metaroz investigation[3] and an American study[4] have been concerned with further development towards larger units. In the Phoebus investigation, carried out by German, Spanish, Swedish and Swiss firms and organisations, the experience of all concerned was utilised in the layout design, construction and commissioning of CRS systems to produce the optimum version of a 30 MWe plant. These activities are in parallel with the Eureka project supported by Switzerland.

The firms working on the Phoebus project have formed a consortium. The objective of this consortium is to undertake all measures required for the design, construction and commissioning of a 30 MWe electric power station and thus to demonstrate that solar power plants can:

- produce electricity when needed and have high operating reliability,
- be built in commercially acceptable sizes,
- function so as to produce electricity at an acceptable competitive cost by further optimisation and development activities.

The activities required were divided into four phases:

phase 1: feasibility study
phase 2: detail design
phase 3: construction
phase 4: commissioning

No plant site was available at the beginning of phase 1 in spring 1986. Hence a phase 1A was first defined in which four different systems, differing from each other as regards to the coolant used, were compared. These results are presented in this paper.

Phase 1B follows in which a project concerning a defined site including financing possibilities is being worked out.

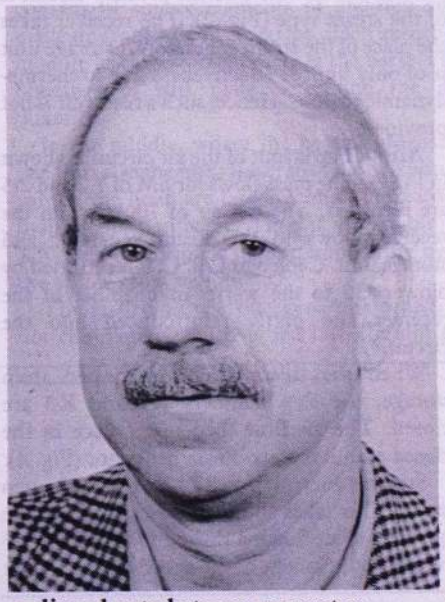
Boundary conditions

Size of installation — This was chosen as 30 MWe firstly so as to be a sufficient size to demonstrate an industrial installation and secondly so that it is within the financing limits applicable.

Two solar multiples (SM) were investigated, namely 1.2 and 2.5. The solar multiple is the ratio of the output of the receiver to the input of the turbine. The higher SM is, the greater the availability and the thermal storage capacity.

*Independent Engineering Consultant

The author



After serving a shop-floor apprenticeship from 1948 to 1952, Hans W. Fricker obtained a degree in mechanical engineering from the Burgdorf technical college in Switzerland in 1956.

Three years of research and development work on gas turbines at Escher Wyss in Zurich were followed by a five year secondment to the OECD High Temperature Reactor Project Dragon in Winfrith, England, working on the development of machine elements with special consideration of tribological problems.

From 1965 to 1989 Herr Fricker worked at Sulzer company in Winterthur, Switzerland, doing design and development work on heat exchangers for nuclear applications. One of his more important assignments was the design and project management of the steam generators for the German 300 MWe high temperature reactor THTR.

In 1977 he became involved with the experimental solar 500 kWe plant in Almeria, Spain, designing and supplying the sodium cooled receiver and the sodium heated steam generator.

Attempting to simplify the thermal circuit Herr Fricker invented the air cooled volumetric wire receiver. Subsequent receiver developments and plant studies (Metaroz, Phoebus) confirmed his belief in a successful application of this simple technology.

He is presently acting as a private engineering consultant.

The consortium partners represent experience of several systems and coolants. In order to produce a common basis, six systems were first evaluated on the basis of a questionnaire (Table 1).

The first four systems were chosen for detailed analyses in phase 1A, the last two rejected.

Site location — The location has an important influece on the design and operation of the plant. Since no site was available, a fictitious one was used for this purpose:

Geographical location:
*Barstow, California (35° North)
Meteorology:
*Barstow, California (35° North)
Infrastructure:
*Almeria, Spain

It is assumed that these conditions concerning locations can be achieved or more than achieved in almost all continents, with the exception of Europe.

In parallel with this, a working committee was assigned to carry out a systematic evaluation of sites in 58 countries.[5]

Secondary circuit

All variants use a conventional steam circuit without intermediate reheater (Fig. 2, Table 2).

This layout is basically a simple steam circuit with dry cooling at a hot location. Improvements in efficiency are possible, including lowering of the condensate temperature, intermediate reheating or increased feedwater preheating in the air circuit.

Primary circuit

Steam — In this case the primary circuit is of the steam type (Fig. 2). The receiver takes the place of the steam generator. A storage unit is of only limited effectiveness due to thermodynamic reasons. Hence, such a reservoir is not provided.

Air — The layout of the air circuit is shown in Fig. 3. The mass flows for SM of 1.2 and 2.5 are recorded. The hot air of 700°C from the receiver flows to the steam generator and storage unit. Cooled to 170°C, it is returned by blower G2 to the warm air chamber of the receiver and partly reintroduced into the circuit.

When the steam circuit is heated from storage, the flap dampers K1 and K3 are closed. The air flow then takes place in the closed circuit storage-steam generator (Fig. 4).

Stepless control is possible between the two cases. This takes the form of controlling the quantity of air flowing through the receiver by suitable adjustment of the speed of the blower G2. Suitable matching of the receiver ouput is thus obtained.

The blower G1 delivers the air through the steam generator and is likewise equipped with speed control. This means that the steam generator can be operated independently of the receiver as long as the storage can provide heat, a state of affairs which is very advantageous for the operation of the installation.

The storage is built up from suitable steel elements. Alternatively, it can be made from ceramic or stone. For SM = 1.2, full load from the storage is available for half an hour. For SM = 2.5 for seven hours.

Sodium and salt — The principle is that sodium is pumped from a cold storage tank to the receiver and fed into the hot storage tank. From there, a second pump transfers it to the steam generator and thence back to the cold reservoir. Furthermore, for filling and emptying tanks and expansion vessels, a number of connecting lines and the associated values are required.

The circuit medium itself serves as the storage medium. This is an advantage of these coolants. As for air, the reservoir is designed to provide full load for half an hour or for seven hours respectively.

Layout — The optimisation calculations, carried out with a specially developed program

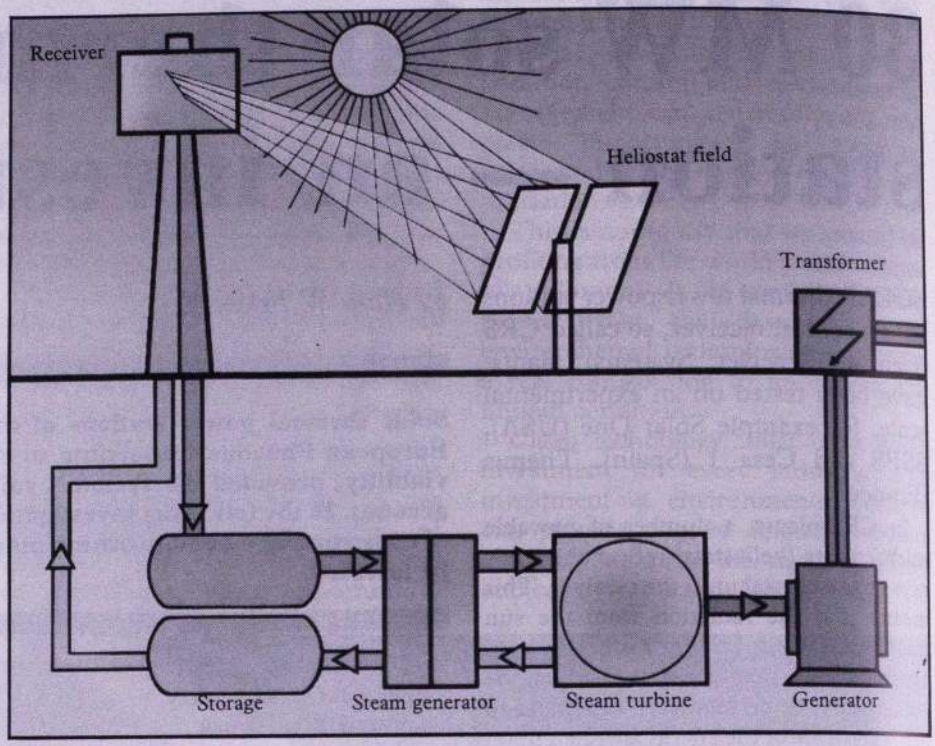


Fig 1: Schematic diagram of a central receiver system.

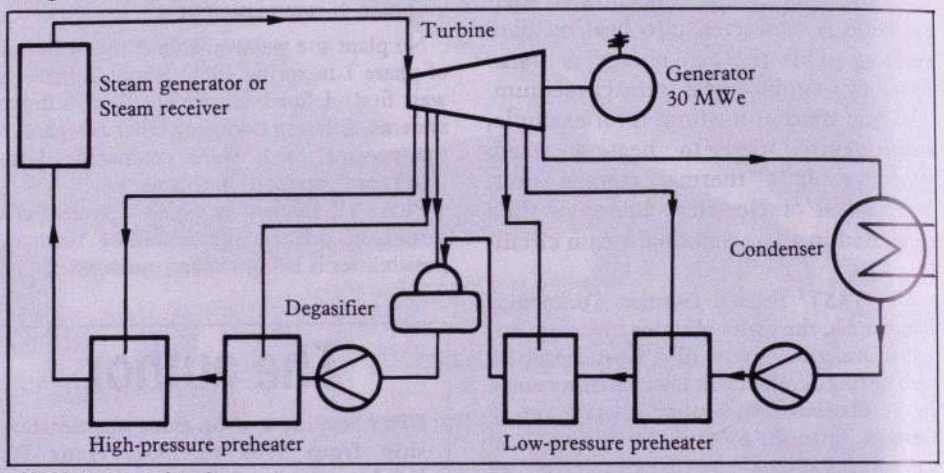


Fig 2: Steam circuit.

Table 1: Evaluation of various plant systems

Coolant	Power converter	Points	Ranking
Salt	Steam turbine	5	1
Water/steam	Steam turbine	9	2
Atmos. air	Steam turbine	10	3
Sodium	Steam turbine	16	4
Com. air	Gas turbine	21	5
Sodium/salt	Steam turbine	23	6

Table 2: Circuit data

Primary circuit		Air	Sodium/salt	Steam
Generator output	(MWe)		30.1	
Steam pressure	(bar)		100	
Steam temperature	(°C)		482	
Steam consumption	(kg/s)	33.0	36.0	38.5
No. of preheaters	(—)	1	5	5
Feedwater temperature	(°C)	105	202	260
Condensate temperature	(°C)		55	

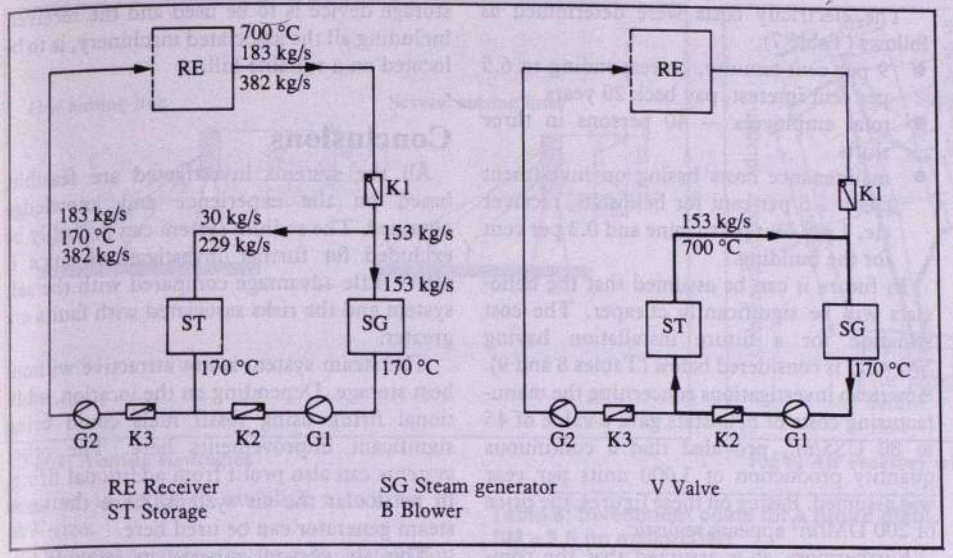


Fig 3: Air circuit, full load operation.

Fig 4: Air circuit, operation from heat storage.

Table 3: Data for heliostat fields

	Air		Sodium		Salt		Steam
Solar multiple (SM)	1.2	2.5	1.2	2.5	1.2	2.5	1.2
No. of heliostats	3435	7072	2861	6153	2758	5912	2841
Land area km²	1.40	2.29	0.75	1.87	0.71	1.74	0.74

Table 4: Receiver data

Coolant		Air		Sodium		Salt		Steam
Solar multiple (SM)		1.2	2.5	1.2	2.5	1.2	2.5	1.2
Output	(MW)	125	260	107	223	102	213	106
Outlet temperature	(°C)	700	700	540	540	540	540	490
Outlet pressure	(bar)	1	1	6	7	5	7	110
Inlet temperature	(°C)	110	110	280	280	310	310	202
Mass flow	(kg/s)	183	382	322	671	281	585	45.0
Diameter/active width	(m)	18.3	2×18.3	8.4	12.6	9.7	13.4	9.1
Active height	(m)	—	—	9.0	12.6	9.0	12.5	11.7
Absorber surface	(m²)	264	2×264	238	496	273	526	331
Maximum heat flux	(kW/m²)	800	840	1500	1500	800	800	690
Mean heat flux	(kW/m²)	480	500	500	500	430	460	320
No. of panels	(—)	—	—	12	20	12	18	28
Number of tubes	(—)	—	—	1392	2080	2892	3366	1400
Tube diameter x x wall	(mm)	—	—	18×1.5	18×1.5	10×1.5	12×2.0	20×2.2

showed, that a circular arrangement of the heliostats is to be preferred. Fig. 5 shows such an arrangement with the receiver in the south of the field (north field). This applies for the air circuit having SM = 1.2 — northern hemisphere.

When the receiver is placed within the field, the number of heliostats can be reduced and consequently the area of land required (Fig. 6). In the case of the circumferential field, the receiver has also to absorb solar radiation circumferentially.

These field layouts are based on a Spanish heliostat of 65m² surface area and 3.9 mrad accuracy.

A tower height of 150 m was assumed for the installations having SM = 1.2 and a height of 200 m for those with SM = 2.5. These are, however, not optimised values.

The different receivers allow thermal loadings of different values. In the case of air, salt and water, it is therefore necessary to choose several aiming points for the heliostats in order to maintain the radiation loading suitably low. In the case of sodium this is not necessary (Fig. 7). The data for the heliostat fields and the receivers are given in Tables 3 and 4.

It is to be noted that cylindrical receivers with circumferential fields were postulated for sodium, salt and steam. In contrast the air receivers, depending on the rating, have one or two cavities oriented essentially to the north.

Air receiver

The air receiver having SM = 1.2 is a cavity receiver oriented to the north (Fig 8). It consists essentially of the flat absorber of 18.35 m diameter with supporting structure and the hot air chamber with housing. The absorber plane is inclined by 15° to the front. The absorber consists of square elements of 250 mm size made up from wire mesh strips. Each absorber module has a perforated plate at the back. The openings of this plate determine the air quantity.

In the middle, where the heating intensity and thus also the mass flow rate have maximum values, the holes are larger or more numerous than at the perimeter. Thus it is possible to achieve a uniform air outlet temperature over the whole cross section.

The air from the steam generator which is not completely cooled is fed into the hot air

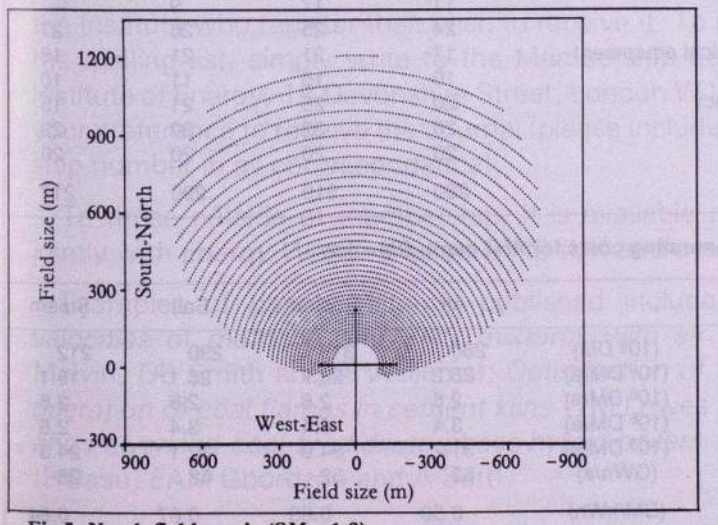


Fig 5: North field — air (SM = 1.2).

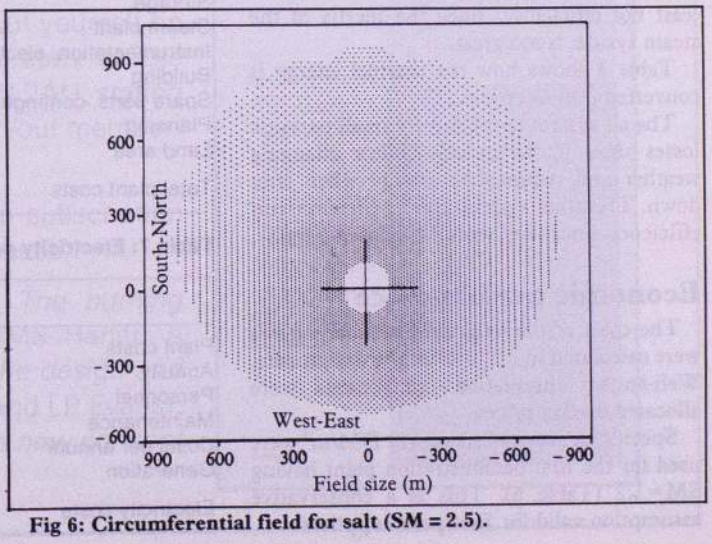


Fig 6: Circumferential field for salt (SM = 2.5).

chamber upstream of the absorber. From here it flows through suitable jets in the direction of the absorber. By this means 60 per cent of the warm air can be returned to the circuit.

Sodium and salt type receivers

Cylindrical receivers have been chosen for operation with sodium and salt.

The absorber consists essentially of parallel perpendicular tubes arranged in groups. Coolant flows from the cold collector below through the tubes upwards to the hot collector. The mass flow rate through each of the parallel connected tube groups is matched to the incident radiation via a control valve. The collectors are suspended in such a way that the tubes can expand freely at high temperature.

Steam type receiver

The steam type receiver is likewise cylindrical and consists of perpendicular tubes similar to the salt type receiver. The circuit of the individual tube groups is chosen so that a stable flow is obtained even at non-uniform heat incidence. This is attained principally through the use of two auxiliary evaporators which permit overfeed of the main evaporators.

Operating characteristics

A calculation of the thermal energy gained by the plant over a year was carried out using the HFCAL computer program. This processes measured meteorological data and takes into account both optical losses and the load dependent efficiencies of the receiver.

During the conversion of the thermal energy, parasitic losses occur in addition to those brought about by thermodynamic effects. These parasitic losses occur, for example, at start up or shut down, for the circulation of the circuit media, by thermal conduction or to keep the sodium or salt circuit warm.

A detailed analysis shows that these losses depend relatively markedly on the system chosen. To keep the sodium and salt systems hot requires relatively high energies. In the case of the steam system, the frequent start up and shut down cycles cause high losses because of the missing reservoir. In addition, short periods of sunshine cannot be utilised or at least not efficiently, since the inertia of the steam system is too great.

Table 5 shows how the thermal energy is converted into electricity.

The air system has relatively small parasitic losses since it can quickly follow changing weather and requires no energy when shut down. The other systems have a better circuit efficiency since they work as a closed circuit.

Economic performance

The costs of the solar specific components were calculated in detail from the design data. Well-known installation components were allocated market prices.

Specific heliostat costs of 510 DM/m^2 were used for the first demonstration plant having SM = 1.2 (Table 6). This is a conservative assumption valid for European suppliers.

The electricity costs were determined as follows (Table 7):

- 9 per cent annuity, corresponding to 6.5 per cent interest, pay back 20 years
- total employees — 40 persons in three shifts
- maintenance costs basing on investment costs: 1.5 per cent for heliostats, receiver etc, 1 per cent for turbine and 0.3 per cent for the building.

In future it can be assumed that the heliostats will be significantly cheaper. The cost situation for a future installation having SM = 2.5 is considered below (Tables 8 and 9). American investigations concerning the manufacturing costs of heliostats gave a value of 45 to 80 US$/m^2, provided that a continuous quantity production of 3,000 units per year was assumed. Basing on these figures, the price of 200 DM/m^2 appears realistic.

Furthermore, it is assumed that the components can be bought in at a better quality to price relation based on experience and the activity of competitors. In addition, a ceramic storage device is to be used and the receiver, including all the associated machinery, is to be located on a suitable hill.

Conclusions

All the systems investigated are feasible, based on the experience and knowledge obtained. The sodium system can probably be excluded for further investigations since it offers little advantage compared with the salt system and the risks associated with faults are greater.

The steam system is not attractive without heat storage. Depending on the location, additional firing using fossil fuels could bring significant improvements here. The other systems can also profit from additional firing, in particular the air system, since the same steam generator can be used here.

The air system appears to provide the simplest, lowest risk operation. It has also by far the smallest electricity generation costs. On the other hand, further investigations are

Table 5: Energy data per year (GWh/year)

Coolant	Air	Sodium	Salt	Steam
SM = 1.2				
Thermal, gross	292	218	206	168
Circuit, efficiency	0.911	1.0	1.0	1.0
Thermal, parasitic	19	31	31	26
Thermal, nett	228	187	175	142
Electrical, gross	68	61	59	44
Electrical, parasitic	6	9	11	6
Electrical, nett	62	52	48	38
SM = 2.5				
Thermal, gross	533	437	413	—
Circuit, efficiency	0.911	1.0	1.0	—
Thermal, parasitic	33	51	47	—
Thermal, nett	450	386	366	—
Electrical, gross	141	131	129	—
Electrical, parasitic	11	17	20	—
Electrical, nett	130	114	109	—

Table 6: Investment costs for first plant, SM = 1.2 (in million DM; 1987)

	Air	Sodium	Salt	Steam
Heliostat field	114	95	92	90
Receiver	13	14	16	5
Tower	7	3	3	3
Heat transfer system	5	43	27	4
Steam generator	14	9	14	—
Storage	11	17	9	—
Steam plant	24	25	26	27
Instrumentation, electrical equipment	17	21	21	16
Building	10	15	11	10
Spare parts, contingency	20	25	21	15
Planning	25	32	30	22
Land area	20	20	20	20
Total plant costs	280	319	290	212

Table 7: Electricity generating costs for first plant, SM = 1.2

		Air	Sodium	Salt	Steam
Plant costs	(10^6 DM)	280	319	290	212
Annuity	(10^6 DM/a)	25.2	28.7	26.1	19.1
Personnel	(10^6 DM/a)	2.6	2.6	2.6	2.6
Maintenance	(10^6 DM/a)	3.4	3.4	3.4	2.6
Costs per annum	(10^6 DM/a)	31.2	34.9	32.1	24.3
Generation	(GWh/a)	62	52	48	38
Electricity costs	(DM/kWh)	0.50	0.68	0.67	0.64

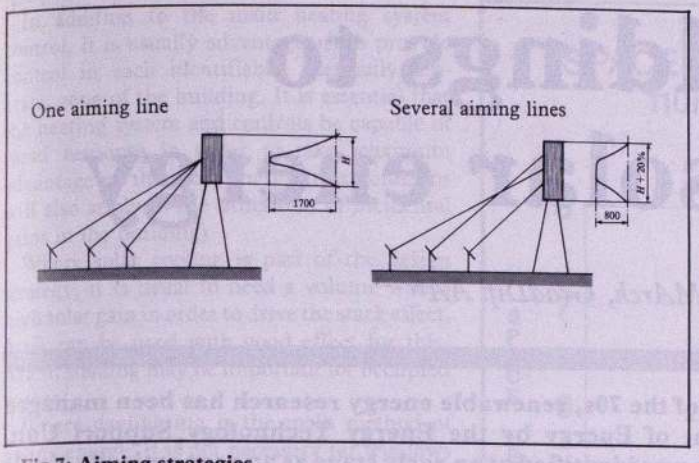


Fig 7: **Aiming strategies.**

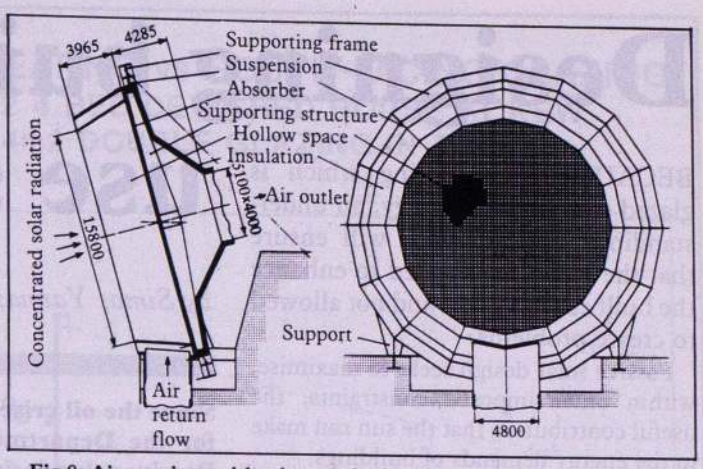


Fig 8: **Air receiver with wire mesh absorber (Sulzer).**

required in order to establish a receiver of MW-size.

The extrapolation to the n-th installation indicates electricity generation costs of scarcely more than 0.2 DM/kWh. Still lower values can be attained by increasing the size of the plant into the 100 MW range.

This very promising survey has certainly to be consolidated with further studies and appropriate technological developments. The most essential condition for reaching these values is the construction of a demonstration plant which would encourage industry to make the necessary investments.

In order to reach this objective, it is necessary to:

- choose a suitable location,
- define the most suitable system for it, and
- establish the financing of such an installation.

Table 8: Investment costs for a future plant, SM = 2.5 (in million DM)

	Air
Heliostat field	91
Receiver	16
Heat transfer system	10
Steam generator	12
Storage	45
Steam plant	20
Instrumentation, electrical equipment	13
Building	10
Spare parts, contingency	20
Planning	21
Land area	12
Total plant costs	270

Table 9: Electricity generation costs for a future plant, SM = 2.5

Total plant costs	(10^6 DM)	270
Annuity 9%	(10^6 DM/a)	24.3
Personnel	(10^6 DM/a)	2.8
Maintenance	(10^6 DM/a)	3.2
Costs per annum	(10^6 DM/a)	30.3
Net production	(GWh/a)	138
Generation costs	(DM/kWh)	0.22

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Designing buildings to use solar energy

*by Simos Yannas MArch, GradDip AA**

Since the oil crises of the 70s, renewable energy research has been managed for the Department of Energy by the Energy Technology Support Unit. Passive solar design was identified at an early stage as an economically viable technology. Efforts since then have been aimed at quantifying the benefits and formulating robust advice for the marketplace. Dr Yannas presents his view of the current understanding of this important topic, and encourages designers to think about sunshine at the beginning of each new project. The advice and suggestions in this article apply only to the British Isles.

BECAUSE any building which is glazed admits solar energy, an understanding of this subject will ensure that the solar gain is used to enhance the built environment and not allowed to create problems.

Passive solar design seeks to maximise, within other imposed constraints, the useful contribution that the sun can make to the energy demands of buildings.

It does this by manipulating architectural elements to provide the best environmental comfort and energy economy. It is not a technology; the ancient Greeks were aware of the benefits and many architects have espoused its use. In the 1930s, the RIBA offered the following:

Until the habit of thinking in terms of sunshine has been acquired, buildings will continue to deprive their occupants of values which might have been enjoyed without cost over the whole life of the building.

As this advice implies, there is evidence that the ambience of a good passive solar design is much preferred both at work and at home.

In spite of this, less attention has been paid to the value of solar design in recent years than previously. While commercial pressures are doubtless responsible, it is possible to accommodate solar design in many cases in an economically viable way.

Although there are examples of extreme solar designs to be seen around the country, there is no evidence that they work substantially better than more modest efforts that are more acceptable to building occupants and developers. The Department of Energy's programme is looking at ideas which have a large potential for replication, so that the effect on the nation's energy consumption would be significant.

It is not possible to isolate one aspect of energy in buildings from all the others; the various methods of saving energy should not compete with one another; the aim is to achieve integrated designs to give buildings with the minimum use of delivered energy. Energy conservation is as important as the use of 'free' energy. It is true that there will often be more than one alternative, but it is common for other criteria (eg cost, planning constraints) to be the determining factors in the choice.

In a glazed building the incoming short wave solar radiation is absorbed by solid surfaces; very little of it heats the air directly. These surfaces emit long wave radiation which is trapped by the glass. This is beneficial in winter, but in summer there may be a need to prevent it from entering the building. Fortunately this is possible with suitable shading.

**Director, Energy and Environment Studies Programme, Architectural Association Graduate School, London*

The benefits

As well as giving the benefit of a more pleasant ambience, solar energy may be used directly in buildings for heating, cooling or lighting. Which is most important will depend on the particular circumstance, though it is possible to envisage a building in which all three are successfully combined.

In housing, heating is always the dominant issue, whereas in non-domestic buildings, lighting and cooling are likely to be more important (though not exclusively so). In both sectors, where highly glazed structures are used for reasons other than energy conservation, it is possible to generate cooling air flows by the strategic placings of passive ventilators (preferably thermostatically operated) and use of the stack effect.

Siting

Passive solar design is concerned with the internal arrangement of rooms and areas within a building, and the layout of the site. These are decisions that are made at a very early stage. Constructive use of passive solar energy involves design, whereas energy efficiency measures are mainly about specification. It is much easier to make use of solar energy if the building has been correctly oriented and the site laid out effectively at the start. To illustrate this, thermal simulations conducted in the Department of Energy programme have suggested that, in a conventional house of about 110m^2 with 24m^2 of glazing distributed evenly between two opposite sides, the benefit from a north-south orientation compared with east-west is of the order of 500 kWh per annum. Further benefits are obtained from redistribution of glazing and paying attention to the details of the window design.

Climate, geography, location

All parts of the British Isles can benefit from passive solar design; indeed the present evidence is that northern sites can obtain more useful gain than other areas provided that overshadowing does not become a problem. This happens because temperatures are lower and the heating season is longer and extends into the period of longer daylight and sunshine.

However, although there are no geographical limitations, the local topography and environment may limit the available solar energy, and, in some cases, make it impossible to achieve any great benefit. For this reason, inner city sites, north-facing slopes, and other sites that are heavily overshadowed may have very limited potential. Even here, though, ingenious solutions involving roof glazing can still save energy and are often cost-effective.

Forms of passive solar design

The particular way in which solar energy is admitted to the building will depend on whether the most important benefits are to come from heating, cooling or daylighting. In the area of heating it is usual to divide the field into direct gain, indirect gain and isolated gain.

In the first of these, the intercepted energy is used in the space where it is received.

Indirect gain includes devices in which heated air is moved by convection to other parts of the building; these are usually called thermosiphons. Trombe walls contain, in addition, some mass for energy storage. In general, it is believed that these are not cost effective, and it is usually difficult to incorporate them into the building in a manner that is architecturally satisfactory.

Isolated gain includes conservatories, atria and roof collectors. Whereas the latter must be made to save energy (and probably cost-effectively), since they have no other function, the first two have amenity value and are not solely to save energy; however, in these two cases there is the potential for misuse which will invoke an energy penalty.

In addition to the main heating system control, it is usually advantageous to provide control in each identifiable, thermally separate, zone of the building. It is essential that the heating system and controls be capable of rapid response in order to take maximum advantage of the solar energy (this comment will also apply to the utilisation of incidental gains in the building).

Where solar cooling is part of the design strategy, it is usual to need a volume with a high solar gain in order to drive the stack effect. Atria can be used with good effect for this. Again, shading may be important for occupied spaces.

Where daylighting is the main method of saving energy, it is not necessary for windows to face south unless the solar gain is also useful. Frequently, rooflights will be used in order to get access to deep plan areas. It may be necessary to provide a mechanism to exclude direct sunlight. It is essential to have a lightning control strategy to minimise the use of electric lights.

Guidelines — housing

Direct gain works best — (1) Orient the dwelling so that the main living rooms and bedrooms point roughly south; the term 'south' here denotes an orientation between south-east and south-west. The penalty for varying from due south but keeping within this range is generally not very large.

(2) Plan the site so as to minimise overshadowing. Studies by NBA Tectonics[1] suggest that 85 per cent of the benefit of a green field site can be realised on most estates outside of the inner city.

(3) Built form — a compact built form will reduce energy losses, but must allow an effective internal layout.

The total amount of glazing in a typical dwelling is most often an architectural decision. Place as much of this on 'south' facing surfaces as possible. Fig 1 shows how the energy consumption of a four bedroom detached house varies with the fraction of glass on the south face. Note that the benefit from a full solar design is comparable with that to be obtained from increasing the insulation from the current building regulations to superinsulated standards.

Rooms with high incidental gains (kitchens and bathrooms) are best placed away from the south side of the house in order to avoid also receiving high solar gains with a consequent risk of overheating.

Thermal weight above that provided by conventional construction, is not useful for storing solar gains as the time constants are generally too short; it also imposes an energy penalty since, in winter it must be warmed by the heating system. Overheating is best combatted by the provision of shading and adequate ventilation.

Windows should be double glazed for energy conservation. In addition the inner pane of double glazing will always be much warmer than any single glazing; because the human body is more sensitive to the temperatures of the surrounding surfaces than to air temperature, this gives a greater sense of comfort.

Wide frames and glazing bars neither keep in heat not admit solar energy and are to be avoided. If deep frames are being used, then the glazing should be at the outside edge. Frames made of conducting materials should incorporate an adequate thermal break. The useful energy balance of glazing depends on context, but is generally:

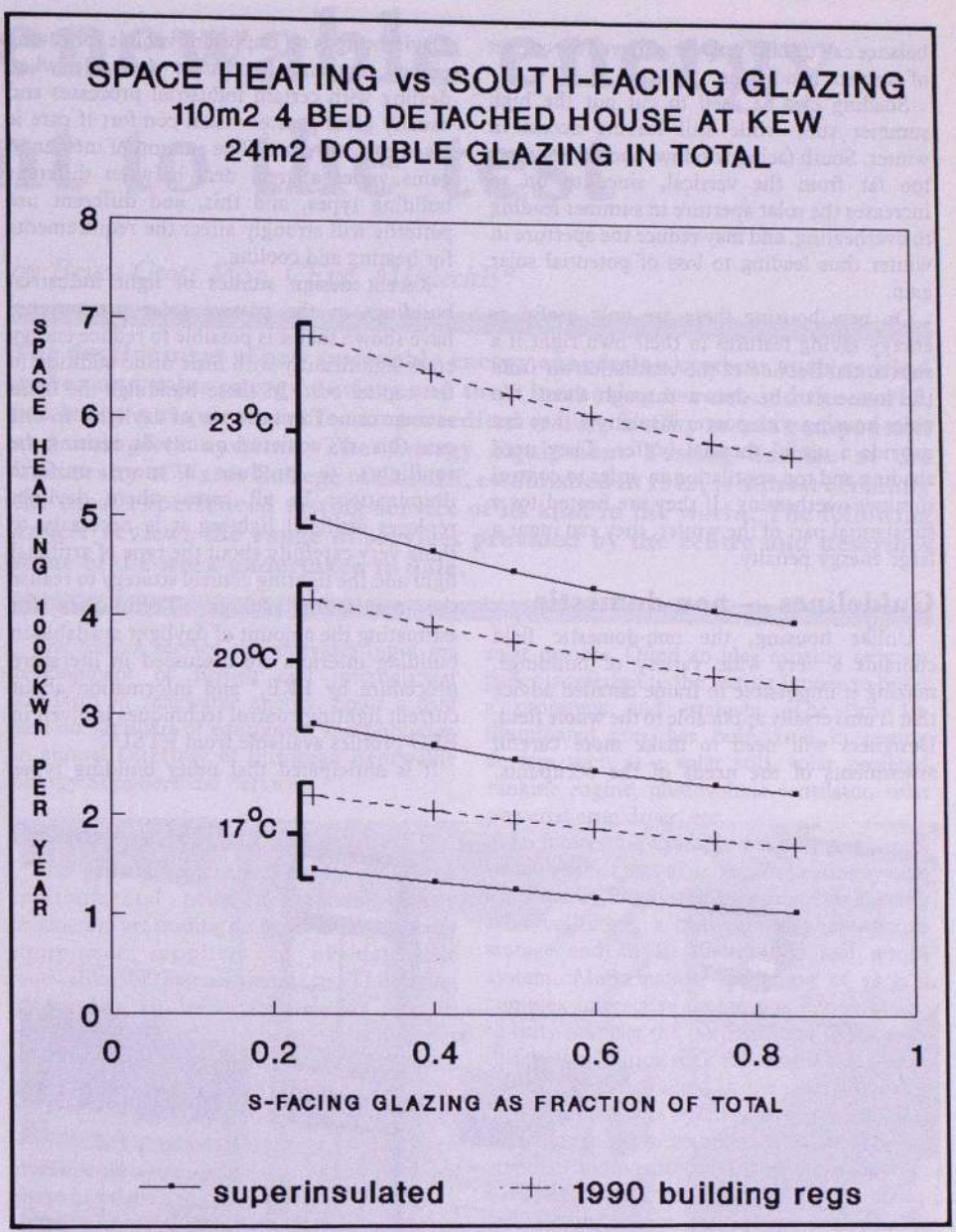

Fig 1: Typical variation of space heating with south-facing glazing in housing.

for south facing glazing

single	definitely negative
double	slightly positive to slightly negative
coated double or triple	significantly positive

for other orientations the balance for single and double glazing is always negative with north facing worst; higher standards of glazing may be neutral or better.

The energy balance of a well-insulated wall is slightly negative.

If there is an option to vary the amount of south facing glazing (keeping everything else constant), then the energy consumption of the building is reduced by using the minimum if single glazing is employed (which is not generally recommended), and the maximum if coated double or triple glazing is used. For double glazing, the energy consumption is relatively insensitive to the area of south facing glazing, and the decision if often made on architectural merit. Generally, the higher the standard of insulation in the house, the more likely is the energy balance of the windows to be slightly negative.

Night insulation over windows always saves energy if handled correctly by the occupants.

It is important to specify the heating system. The size should be the same as that for any house of the same insulation standard, but the control system should be capable of responding to the available solar and incidental gains. Independent control for each room of the house (eg by thermostatic radiator valves in a conventional system) will usually prove cost effective. Evidence from measurements in the houses at Great Linford in Milton Keynes suggests that only 11 per cent of the space heating energy was delivered upstairs, yet comfortable conditions were maintained at all times.[2] Balancing a heating system will not achieve the same effect, since the correct

balance can usually only be achieved for one set of ambient conditions.

Shading can be used to cut out the high summer sun, while still leaving access in winter. South facing windows should not stray too far from the vertical, since to do so increases the solar aperture in summer leading to overheating, and may reduce the aperture in winter thus leading to loss of potential solar gain.

On new housing these are only useful as energy saving features in their own right if a substantial fraction of the ventilation air from the house can be drawn through them. On older housing with poorer insulation, they can provide a useful thermal buffer. They need shading and top ventilation in order to control summer overheating. If they are heated for a substantial part of the winter, they can incur a large energy penalty.

Guidelines — non-domestic

Unlike housing, the non-domestic field contains a very wide variety of buildings, making it impossible to frame detailed advice that is universally applicable to the whole field. Designers will need to make more careful assessments of the needs of the occupants.

Daylighting is an important vehicle for saving energy, and is often more desirable when dealing with certain industrial processes and usually gives greater visual comfort if care is taken to avoid glare. The amount of incidental gains varies a great deal between different building types, and this, and different use patterns will strongly affect the requirements for heating and cooling.

Recent design studies of light industrial buildings in the passive solar programme[3] have shown that it is possible to reduce energy costs significantly with little or no addition to the capital cost. In these buildings the main savings came from the use of daylight. In one case this was achieved mainly by resiting the rooflights to produce a more uniform illumination. In all cases where daylight replaces artificial lighting it is necessary to think very carefully about the type of artificial light and the lighting control strategy to realise the maximum savings. Techniques for estimating the amount of daylight available in building interiors are discussed in literature procedure by BRE,[4] and information about current lighting control techniques is given in EEO profiles available from ETSU.[5]

It is anticipated that other building types that are primarily occupied during daytime (offices, schools etc) will also show a large saving from the use of daylight to replace artificial light. In some cases this may result in an increased heating bill since the incidental gains from the light fittings also heat the building. But, since lighting is usually provided by peak rate electricity, this will result in both a reduced cost for the consumer and reduced impact on the greenhouse effect. In some buildings, the incidental gains from artificial lighting contribute to overheating in summer and hence a further benefit from using daylight is that of reducing the cooling load. Since cooling energy is usually also peak rate electricity, this is an additional cost benefit and further reduces impact on the greenhouse effect.

Whether a non-domestic building can benefit from passive solar heating will need to be determined from an estimate of the incidental gains. In some buildings with high occupancy densities and much heat-producing equipment these can already satisfy a large fraction of the heating needs. Isolated gain techniques may be appropriate. However it is important to ensure that these will not increase the risk of overheating in summer; if this cannot be counteracted by shading and ventilation then it will usually be better to forego some of the solar gain.

An example of a building which successfully combines all three benefits is Gateway 2 — designed by Arup Associates for Wiggins Teape. The central atrium (Fig 2) allows daylight to penetrate the core of the building and in winter provides a buffer space which reduces the heat loss from the building. In summer the ventilators at the top of the atrium can be opened and cooling air can be drawn through the building.

There are many opportunities for modest passive solar design in today's buildings. In general simple assessments allow an estimate of the benefits and simple procedures work well. The Department of Energy's research programme at ETSU is continuing and should result in design advice and design aids being produced. These will include the design guide for housing being written at the Architectural Association which will be published in the near future.

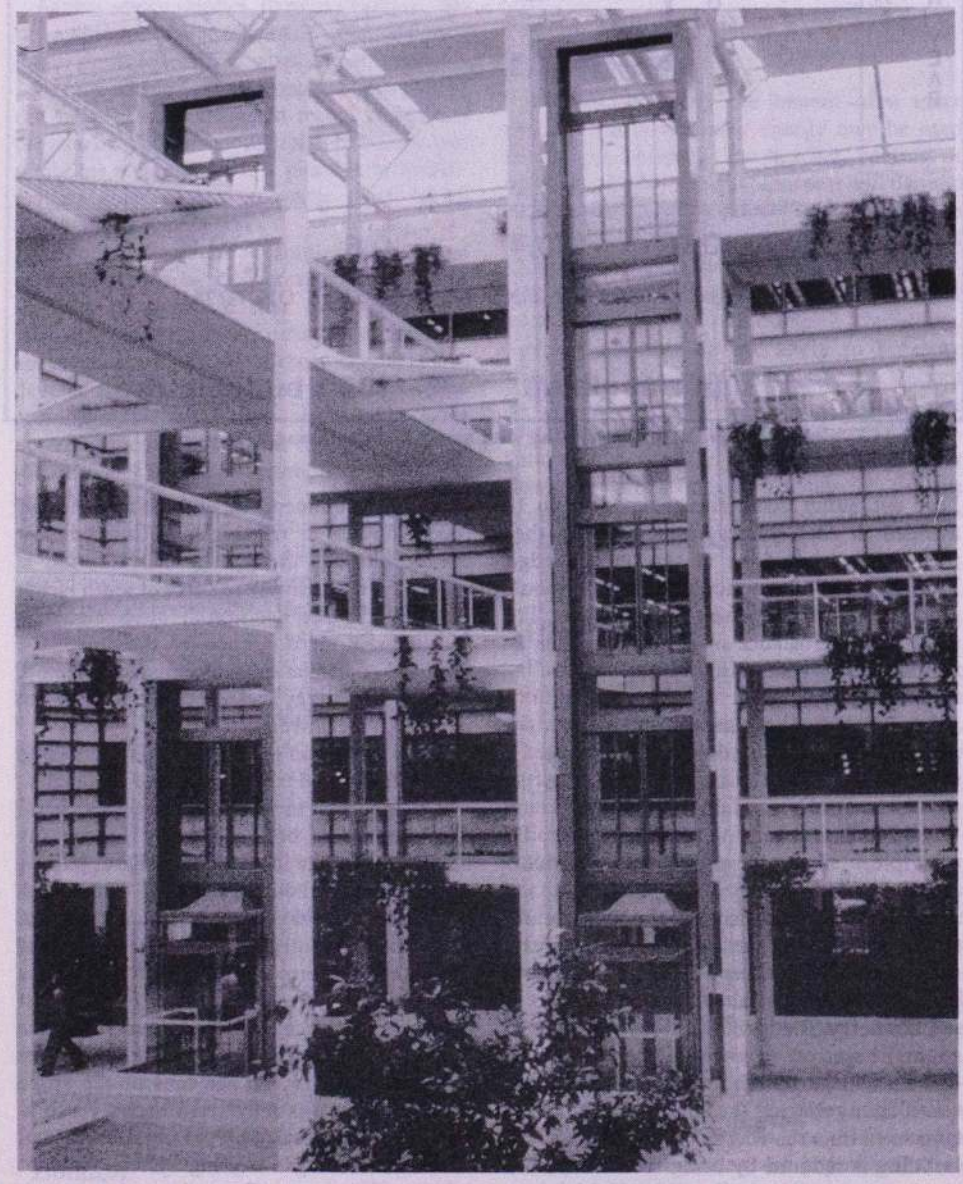

Fig 2: Inside the atrium of Gateway 2.

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Acknowledgement

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Putting renewable energy equipment to the test

*by Bruce Cross MSc, CEng, MIMechE**

The development of new renewable energy conversion systems such as wind power and solar energy devices and their increasing use around the world, has led to a requirement for an accredited testing facility to test components and complete systems. The Energy Equipment Testing Service at the University of Wales College of Cardiff, established in 1979, is almost certainly the most experienced testing service of its kind in the world. The following article reviews the range of services provided by the centre and describes some of the work undertaken to date.

THE ENERGY Equipment Testing Service is an independently accredited test house for many types of renewable energy equipment. The service began in 1979 to make available the SERC Solar Simulator facility to the then blossoming solar heating industry. From that beginning, the range of facilities and the types of equipment that can be tested have grown continuously.

Testing is performed in four major facilities: 1, the SERC Solar Simulator; 2, the Environmental Test Laboratory; 3, the Spectrophotometry Laboratory; 4, the Hot Box and Heat Transfer Laboratory.

Field monitoring, installation and inspections are also offered. This summer the test service has moved into purpose built facilities in the new West Building of the Engineering Faculty at Cardiff. These new facilities will enable the service to offer a wider range and faster response to its customers in future. The Energy Equipment Testing Service covers solar heating systems and components, photovoltaic systems and modules, advanced windows and insulation systems, building shading, cladding, fenestration systems, heating and cooling system components and controllers, general energy and environmental instrumentation and metering. An unusual feature of the service's activity is the design and construction of test rigs to customers' requirements.

The testing service also provides input for development of British and international standards in renewable energy, holds a data base on suppliers of equipment and publishes an annual Directory of European Renewable Energy Suppliers and Services.

Prototype testing

The generally increased awareness of the environmental consequences of energy production are leading many traditional energy equipment suppliers to evaluate the renewables for their own products. The testing service has an important role to play in evaluating the effectiveness of prototypes submitted for test, and in feeding back information about earlier studies in similar fields. This helps to reduce the wasted effort in re-inventing products that have already been investigated a decade ago during the previous phase of interest in renewables.

The large area solar simulator is unique in the UK and is ideal for evaluating prototype solar devices. Often an idea existing only on paper is referred to the testing service to build a prototype and evaluate. The 3m×3m illuminated area has been vital in testing devices such as a solar still, solar powered rankine engine, photovoltaic ventilator, solar powered crop dryer, etc.

An interesting example was an energy roof, which formed part of a complex heating system for a house. The system comprised air-heating solar collectors, a heat pump, phase-change storage and an air distribution and return system. Mathematical modelling of such a complex interactive design was not sufficient to fully evaluate the potential and to compare different operating regimes. A full scale roof of 12 m^2 was constructed in the solar simulator laboratory and was tested as a sub-system, thus including in the measurements the array losses and distribution effects. Taken in conjunction with heat storage tests, this enabled the manufacturer to predict the system performance more precisely.

A full size room was built as a passive test cell to operate in the simulator for another project. In this case, the simulator was used to provide a sun-patch in various orientations (as in a normal day) and measurements were made to obtain the inner wall surface heat transfer coefficients. These values have now been incorporated into several passive design models, rather than text book flat-plate values.

Environmental testing

Photovoltaic module manufacturers use the environmental testing facilities to evaluate the durability of their products in accordance with international standards. The tests cover: temperature, humidity, freezing, hail stone impacts, salt mist, vibration and UV-radiation. All of these mechanisms can cause premature failure of a module and special tests are some-

The author

Bruce Cross has operated the Energy Equipment Testing Service since 1980.

He graduated in Mechanical Engineering from Imperial College in 1975. After a year working at a rural development centre in India, he worked for a tube investments company making expansion joints, becoming Technical Manager.

Since joining University College Cardiff (now UWCC), he has contributed widely to the work of the Solar Energy Unit. He serves on the Committee of UK section of the International Solar Energy Society and organises a yearly schools challenge for model solar powered cars. In 1986 he led the "Sunrider" team, which achieved the only crossing of Europe by a solar powered electric car, from Athens to Lisbon.

**Engineer, Energy Equipment Testing Service, University of Wales College of Cardiff.*

times necessary for extreme conditions of installation. Not only the module, but the control system and the load may be subject to severe weathering conditions. A range of extreme weathering tests are performed in our environmental facilities, usually under full load operating conditions, to verify a system's suitability. The client's customer may be present to witness these tests prior to shipment.

An interesting example was a photovoltaic remote telemetry station for transmitting flow and temperature data from an oil pipe line in the Middle East. In order to verify that the system would operate satisfactorily in extreme desert conditions, the control system was placed in the environmental chamber with full solar radiation temperature and humidity control to simulate daily cycles of worst case weather. The control system was under load during the cycle to demonstrate performance of all fault monitoring and operational conditions. A 100 per cent test sample was necessary for this application, since the cost of repair at such sites would be extremely high.

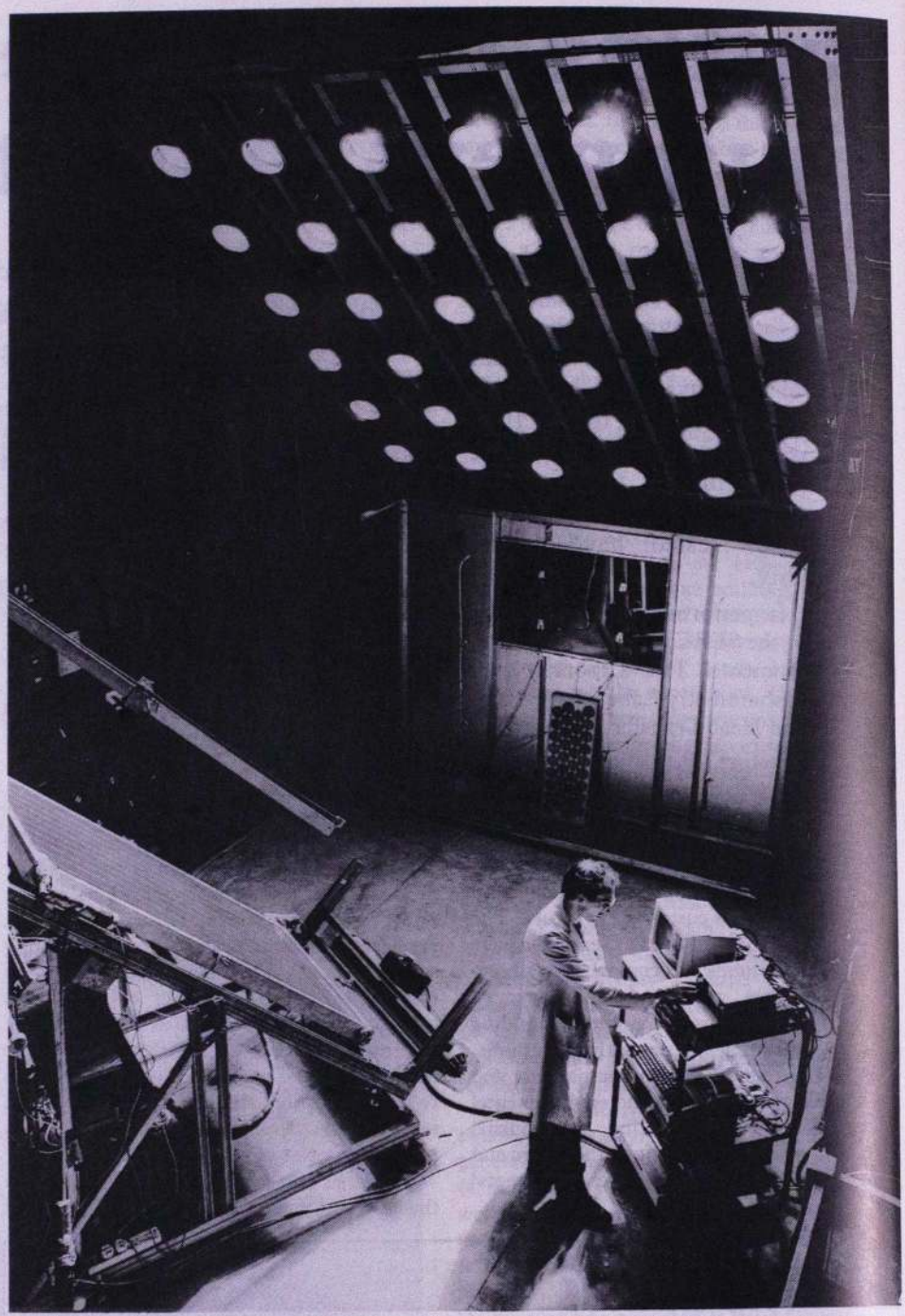
The output of a PV module varies with the intensity and spectrum of the solar radiation and with the temperature of the module. A mobile spectral analysis system can measure the incident radiation and the module performance can be corrected to any conditions. The EETS also builds special purpose test equipment for manufacturers and users.

Building systems

The design of fan-coil units for heating and air-conditioning modern commercial buildings is sometimes a 'black art'. A specially sized unit may depart significantly from the thermal characteristics of the verified standard range. A manufacturer submitted a range of special units for cooling an office block to be tested at design conditions and witnessed by their customer. A rig was constructed to supply controlled warm humid air and chilled metered water to the unit. The thermal performance was then measured in the water circuit and air flow system at a series of operating points including those causing significant condensation. A precise measurement of the unit's performance allowed the customer to reduce his factor of safety in sizing, and this cut the capital cost of the system.

As quality requirements in industry generally improve, there is a need for regular quality testing of goods inwards. The testing service provides an independent check of parameters such as solar absorptance, transmittance and thermal emittance for absorbers and glazings. A regular sampling of batches as received can prevent costly remedial work after manufacture.

The major peak load for electricity in many countries occurs during the summer months for air-conditioning. To help reduce this load, a company developed a highly solar-reflective coating for use on roofs. In order that the performance claims of this coating could be verified, it was necessary to measure the solar reflectance, and to re-measure samples which had been exposed to normal weathering, and to calculate the reduction of heating load achieved. A computer model was necessary for the third objective in order to calculate the air-conditioning load for typical roof structures in the largest countries, compared to traditional roofing surfaces. Some in-situ measurements were provided to validate the model. This allowed the company to obtain approval for its products as energy efficiency devices, thus qualifying for local tax incentives.



The SERC solar simulator at the University of Wales College of Cardiff, a unique simulator for testing all types of solar energy conversion devices.

On-site inspection — monitoring is frequently requested to provide an independent assessment of the state of an installation for legal or refurbishment requirements. A range of equipment is available from simple temperature probes to infra-red, thermography and laser Doppler anemometry. However, the greatest benefit usually obtained by the client is the wealth of experience brought by a professional engineer from this specialism. The comments at the end of our report are generally the most significant part.

For instance, a hot water storage tank was not performing in accordance with its design specification and so a computer data acquisition system was installed to monitor the temperature changes over a period of several days. The outcome was to identify that poor insulation around the tank was the problem, rather than unsufficient input as had been suspected.

Another instance involved assessing the condition of a non-functioning solar heating system to allow an estimate to be made of the cost of refurbishment. Since the installers had gone into receivership some years previously, the client could not find anyone else prepared to undertake this work. One day of our engineer's time was adequate to establish the system condition and to recommend remedial action for the trivial sensor failure which had

caused the system to be shut down by maintenance staff. The payback time for such an inspection was probably a matter of months rather than years.

Special purpose testing

Special purpose test equipment is designed and built by the testing service for supply to other institutes overseas. For instance, solar collector test facilities have been built for clients from the Caribbean to Central Asia. This has enabled them to perform high quality testing of their indigenous renewable energy products. A purpose built facility, with associated operator training can accelerate the development of improved products, without further call on expensive foreign expertise. Small instrumentation and logging systems have been designed and supplied to developing countries for many applications.

The operation of the testing service has generated a large data base of contacts with renewable energy companies. This list was provided to enquiries on an ad-hoc basis for several years, and was formalised in 1984 to become the UK Directory of Renewable Energy Suppliers.

With the approach of the European market in 1992, the Directory has been expanded to cover the whole of Europe. The first European edition last year was well received and a larger more comprehensive publication will be produced at the end of this year. It is supplied free to a controlled circulation list and may be purchased by others.

The fan-coil test facility, used for testing all fan-coil heating and cooling units under both design and worst case conditions of temperature and humidity.

With the quality assurance provided by NAMAS accreditation, the Energy Equipment Testing Service provides a striking example of how the specialist facilities and expertise of a university research unit can be made available directly to industry with immediate impact on design, performance, durability and customer satisfaction. □

READERS' LETTERS

The debate continues . .

Sir,

If Julian Taylor (*Energy World*, July/August 1990) will re-read my viewpoint article in *Energy World*, February 1990, and especially the longer version in the journal *Energy Policy*, March 1990) he will find that I have not missed the points he says I have missed, or advanced the invalid claims he attributes to me.

In particular, my main theme does not equate to saying that money saved on energy conservation will be spent on goods which require energy in their manufacture (this was a garbled version of something I said about *final* consumers only). Neither did I miss the importance of the relationship between energy prices and other prices. On the contrary, my main arguments — and those that underlie the work of the eminent economists I quoted — are all about this relationship.

Way back in 1865, Stanley Jevons argued that using energy more efficiently increased the demand for it because it reduced its implicit price, making energy-dependent goods and services more attractive items in everyone's shopping list. I agree with him subject to one proviso: over zealous pursuit of energy efficiency to the point of pre-empting economic resources that could be more profitably employed in other ways might reduce total energy consumption. But it would do it by making us poorer and less able to afford so much fuel.

Writing in the *Financial Times*, 13 August 1990, Anthony Harris discussed the results of American action to reduce dependence on imported oil. The US Government decided to enact anti-gas-guzzling regulations rather than risk losing votes by increasing taxes on motor fuel. The effects were a dramatic improvement in fuel efficiency of American cars and a countervailing steep increase in car ownership and use.

In *Energy World*, April 1990, Mr P H Spare pointed out that wide bodied jet aircraft, far from reducing take offs and landings at major airports, resulted in more congestion because the more efficient large jets led to lower fares and a sharp increase in demand for air travel. There were many benefits in the shape of wider enjoyment of private motoring and air travel but the results were not what the planners expected. They were what Stanley Jevons would have expected.

I know of no economic, environmental or other purpose that would best be served by a policy of maximising energy efficiency. The best course is always to allocate all resources to best effect subject to all the constraints that beset us. To put all the emphasis on one resource, energy, would be to bias options and this must be sub-optimal. A tax on fuel (and I agree with Mr Allan, *Energy World*, July/August 1990, that his is the right way to deal with fuel-based environmental problems) simply alters the constraints.

Finally I cannot accept Mr Taylor's call for self flagellation for sinful waste of energy. The world is a nicer place and we are all richer for cheap and abundant fuel and for rising to the opportunities it presented.

L G Brookes *(Fellow)*
Bournemouth

Commercial approach

Sir,

There is much current debate about the future of the Institute. In my view there has been a failure so far to take the bias away from energy supply, to the demand related problems of conservation and management.

In addition, the Institute must grasp the opportunities to expand into areas such as training, recruitment and advertising to secure its own future.

A more commercial approach is necessary.

Ian McKay *(Associate)*
Kettering, Northants

It is always interesting to receive members' suggestions on the way forward for the Institute. What may not always be easily apparent to the members not directly involved in the management of the Institute's affairs is that some of the concerns expressed by Mr McKay have been actively addressed for some time and a more commercial approach is being taken— Ed.

A controversial view

'Carbon Dioxide and Global Change: Earth in Transition'
by Sherwood B Idso
IBR Press, 1989
292 pp. $19.95

The general public has very recently come to be aware of a fact that some of us have been saying for many years, that man's technology and particularly his enormous use of fossil fuels is having a very serious effect on the ecology of the Earth. This realisation is polarising people sharply into two groups: first there are those who pooh-pooh the danger and believe that 'it will come right in the end' or that 'clever scientists will find a way out of the mess'. They are totally opposed to the second group: those who feel strongly that man must cease, as a matter of urgency, to put pollutants such as CO_2, acid rain, chlorine compounds and artificially radioactive elements into the environment.

The author of this book is an extreme member of the first group, as far as concerns the CO_2, which he considers a desirable additive to the atmosphere.

When I was asked 'are the recent weather oddities, such as hurricanes, heat and droughts, caused by the greenhouse effect?' I say: 'I don't know, but that it will be a very good thing if people think so, because then they will be prepared to accept the genuine fuel economy which is essential if our descendants are to have a hope of living in a decent stable world.' The author however tries hard to show that the weather oddities are not due to the rise in CO_2 in the atmosphere, although he is prepared to admit that acid rain and the hole in the ozone layer caused by CFCs are harmful.

He accepts an optimistic proposal that the Earth's maximum "carrying capacity" for humankind is somewhere in the range 40-50 billion people, and expects this number to be reached by the year 2100. The CO_2 in the atmosphere will have increased to 1000 ppm and the mean surface temperature will have risen by nearly 2°C. This rise in CO_2 will "produce a tripling of the water use of almost all the world's vegetation", which will be further enhanced by the temperature rise "if the planet does warm (which it may not due to the competing effect of the likely concurrent tendency towards glaciation)".

"Mankind's flooding of the atmosphere with CO_2 may be the only realistic means we have of accomplishing the task of preserving the viability of the Earth for generations yet unborn" (p 128). To invert a popular expression, 'I couldn't agree less'!

Although the book cites 100 pages of references, I personally do not feel happy to entrust the fate of my descendants to the evolution of the author's prophecies. He takes no account of:

1 the ever-increasing gap between rich and poor which is causing increased world tensions and violence,

2 the enormous areas of the Earth's surface which are being denuded of plant and tree life every year,

3 the exhaustion of some of the most easily won fossil fuel resources, as we take carbon out from its multi-million year old strata.

I think it is doubtful if the Earth can support a population of even 10 billion, and at present the governments of the rich countries are concerned almost entirely with increasing their own GNP and are hardly helping at all to develop machinery and agricultural systems which will improve the ability of, for example, Africans to grow their own traditional food.

I agree with one of his final conclusions that "soil is where the action is" but not with another: that we must do much more research before we take any action.

Prof M W Thring

A wide survey

'Back End of the Nuclear Fuel Cycle: Strategies and Options'
International Atomic Energy Agency
669 pp. 1340 Austrian schillings (approx £70)

The International Atomic Energy Agency here publishes the proceedings of a symposium organised jointly by IAEA and the Nuclear Energy Agency of OECD and held in Vienna in May 1987.

The diagram on the cover crystallises the options for dealing with nuclear fuel elements after they have finished their useful life, producing energy. After removal from the power station, the fuel can be stored indefinitely, which is an option chosen by Sweden, Spain, the USA and Canada, or stored for some years before processing if this appears feasible or economic, one of the options for Finland.

Processing can take place soon after despatch from the power station which is the route selected by the USSR, Japan, France and the United Kingdom. The uranium then may be sent to an enrichment plant to be used in new fuel elements and the plutonium either stored to make fuel for future fast breeder reactors or used as enrichment for current thermal reactors.

The papers presented cover the economic and political background to all these options as well as the principal technical features of the processes. There are papers from all major nuclear power countries and contributions from other nuclear nations. The summary section at the back of the volume written by R H Flowers, Fuel Reprocessing Directorate, Harwell, provides a competent guide to key points that arose during the week's proceedings.

Although developments described in the symposium are leading to improved plant reliability and reduced maintenance costs, spent fuel reprocessing is expensive. Certainly, the economics of setting up a new plant are not attractive. However, if the British Government thinks that the funding of the Sellafield reprocessing plant can be cut, the symposium papers suggest that to switch to long-term storage offers only a small economic incentive once a reprocessing plant is operating, when allowance is made for the use of plutonium for thermal fuel enrichment and of the depleted uranium as part of the feed in an enrichment plant. However, the continuing availability of low price uranium and the rapid capital repayment and high interest charges also do not help the economics of reprocessing. Some cost benefit assessment of safety and radiation restriction measures is also needed.

As so many countries are using the 'OTTO' fuel cycle, there is much work on radioactive material disposal. This is also relevant to the high level waste from reprocessing. Most advanced are investigations into the use of deep salt caverns where the Dutch and Germans are working together. In Sweden, where they are planning to phase out nuclear power, investigations into leaching from fuel elements have shown that the solubility of uranium and plutonium in typical groundwaters is much lower than earlier safety studies assumed.

The Americans presented a paper on novel developments in the extraction, transport and removal of radioactive fuel from the damaged Reactor 2 at Three Mile Island. Here, instead of robotics, manual defuelling was employed and operated from behind a shielded rotating platform above the reactor. The wide range of the forms of material to be removed required a diversity of handling and storage equipment. The paper, however, provided only general information.

Although the symposium was held a year after the Chernobyl Reactor 4 accident, it is unfortunate that there is no Soviet paper here on the collection and disposal of radioactive debris scattered on and around that site. Another omission which affects the ease of using the volume is the lack of a subject index.

Whatever happens to nuclear power in various countries in the future, waste disposal remains as an essential area for decisions and technical development. The papers published in this symposium have therefore a current and long-term relevance as they provide a state-of-the-art survey over a full spectrum of topics and countries. The symposium will be a standard reference source in this field for many years.

N G Worley

Recently published

'Infield Worldwide Offshore Field Prospects to 1995'
Edited by Peter Harrison
Hollobone, Hibbert & Associates, 1990, *circ* 450 pp. £990.00 (incl postage).

'Thermophysical Properties of Refrigerants'
by B Platzer, A Polt and G Maurer
Springer-Verlag, 1990, 488 pp. DM 360.00.

'Managing the Environment: The Greening of European Business'
by Nick Robins
Business International, 1990, 209 pp. £295.00.

1,000th engineer joins 'updating' pilot scheme

A PILOT scheme to help engineers and technicians to keep up to date and develop their careers has taken on its 1000th participant.

Miss Rosie Brookes, 23, from Sutton, Surrey, a marketing executive for Dowty Maritime, Command and Control Systems, and student member of the IEE, has joined the scheme, which is organised by The Engineering Council.

To mark the occasion Miss Brookes was presented with a copy of an organiser-style 'career manager' by Mr Derek Kingsbury, Chairman and chief executive of the Fairey Group and Chairman of The Engineering Council's Continuing Education and Training pilot scheme steering committee. The 'career manager' is a personal planning book acting as a record of her programme of development.

The pilot scheme was introduced as a result of a continuing education and training consultative document published by the Council in 1988. This suggested a national system of continuing education and training for engineers and technicians based on individuals taking responsibility, in partnership with their employers, for planning their continuing education and training needs.

More than 70 companies are now involved in the pilot scheme, which has received £170,000 funding from the Department of Education and Science Professional Industrial and Commercial Updating (PICKUP) initiative.

The 'career manager' is designed to help engineers examine what new learning they need to do to improve their present job performance, to define their ambitions for two to five years ahead and draw up a career action plan of how to realise them.

A variety of learning methods can be built-in, including open learning, in-house training, work experience, professional institutions' learned society activities and courses at further and higher education institutions.

The Engineering Council sees the potential benefits to individual engineers as increasing their job satisfaction, career advancement and earning power, while employers have a workforce that will be more capable, both technically and managerially. Education institutions will benefit by greater demand for their services and professional engineering institutions by an increased and better qualified membership.

The untapped resource

A ROLE-SWAP plan that could combat the skills shortage in high-tech jobs was put to a London conference investigating the recruitment of women into technology.

So that women could pursue careers in computer-based jobs companies should allow fathers time off work to care for children, said The Baroness Platt of Writtle, a member of The Engineering Council's Women Into Science and Engineering (WISE) National Co-ordinating Committee.

The conference, *Women in Technology — The Untapped Resource*, was organised by The Engineering Council, the British Computer Society and Women into Information Technology and sponsored by IBM UK Ltd.

Lady Platt told delegates: "It is important for companies to see that leave for domestic responsibilities is available to fathers as well as mothers. Jobs should be available either part-time, or perhaps flexitime. Fathers can be enabled to leave early and mothers to take children to school, and vice versa, after work."

Such an arrangement should in no way be a "second rate existence," added Lady Platt. Benefits should be proportionate to full-time work, particularly in such things as leave and pension contributions and benefits.

She said that too many firms regretted losing a valuable woman employee when she goes on maternity leave, but make no effort to retain her. The onus to set up an interview should not be on the employee — leavers should be interviewed with a view to encouraging them to participate in a career break re-entry scheme, to the mutual benefit of employer and employee in retaining valuable and experienced skills.

The conference was also told by Steve Shirley, President of the British Computer Society, that "far too few women are grasping the enormous opportunities" available in the information technology industry.

"Government should do more to encourage women by offering tax allowances for childcare so that women who want to return to work don't feel the world is organised to make life difficult."

There is now a growing awareness of the need to attract women into the engineering professions. The Institution of Electronics and Electrical Incorporated Engineers (IEEIE) have recently up-dated and reprinted a booklet aimed at encouraging women to choose a career in engineering. *Tales of 12 Women — who are glad they chose Engineering* contains information about the winners and finalists of the Young Woman Engineer of the Year Award. The publication is freely available to schools and colleges.

Engineers' blueprint for environment

ENGINEERING solutions to environmental problems could win the United Kingdom a substantial share of the market for environmental products and services, The Engineering Council has told the Government.

In a submission to the White Paper on the Environment, the Council, which represents 300,000 professional engineers and technicians and has 300 leading industrial companies affiliated to it, says that engineers and industry must take a lead if environmental problems are to be tackled effectively.

Long-term engineering solutions — preferably with stimulation and promotion from the Government — should be developed to ensure companies obtain a major share of the "environmental market".

The Council highlights five key areas for action:

- The efficient use of all energy sources
- Safe waste management
- Recovery and recycling of materials
- Repair of existing environmental damage
- Environmentally sound design of all future technology

It was vital, said the Council, for the success of any lead taken by engineers and industry that Government give a commitment to invest in exciting technology and the development of new technology.

Successive governments have had an inconsistent approach to long-term policy in environmental programmes — an attitude which must change if environmental damage is to be halted and the trend reversed, says the Council.

Director General, Mr Denis Filer FEng, said: "Solving the many environmental problems is the key to maintaining or improving our high standard of living, so it is essential that engineers and industry should take the initiative by proposing sound engineering solutions."

Pollution 'greater threat' than nuclear risk

IF BRITAIN is to make a real and significant contribution towards helping reduce the effects of environmental pollution and global warming, we must press ahead with new plans to introduce and develop our skills in nuclear power technology, said The Engineering Council in June.

The Council went on to say that the Government was right to remove nuclear power from the electricity privatisation plans on temporary fiscal grounds, but it would be wrong to call a halt to the continuing and progressive development of Britain's civil nuclear power programme. The Council said: "If we do not press ahead with nuclear power we risk losing vital expertise in nuclear power engineering which in itself may add to the future cost of generating nuclear energy, deny us opportunities to aid developing countries and risk worsening the greenhouse effect."

The Government decision has also, already, put thousands of jobs of highly trained professional engineers under threat — in addition to job losses recently announced — as our nuclear-experienced industrial companies start to review their positions, and with no new nuclear building prospects on the horizon further job losses are inevitable. In addition, specialists will be drifting away and thus be lost to the industry.

Failure to continue with our nuclear programme may eventually make electricity more expensive, warned the Council. Britain is already being left behind in its use of nuclear power, which contributes to only 18 per cent of the electricity generated in the UK. Much of East and Western Europe — including Czechoslovakia, France, Belgium, Finland, Germany, Spain and Bulgaria and the Far East — all use a higher percentage of nuclear power than the UK. Britain, however, has so far failed to produce sufficiently attractive economic results from nuclear power.

Title: **Energy management.**
Location: Portsmouth Polytechnic.
Duration: 3-6 terms, ½ day per week.
Starting: 1 October 1990.
Content: Fundamentals of energy usage. Computer-aided energy management and optimisation systems. Energy audits. Energy accounting.
Contact: Dr M E Horsley on 0705 842330.

Title: **Understanding heat treatment.**
Location: Aston University, Birmingham.
Duration: 3 days.
Starting: 2 October 1990.
Content: Basic metallurgical theory of heat treatment. Quenching principles and practice. Surface hardening theory and practice. Furnace types, materials and heating methods. Salt bath heat treatment. Atmosphere theory, production and control. Temperature measurement and control. Quality control, specifications and defects in heat treatment. Laboratory testing of heat-treated materials.
Contact: Wolfson Heat Treatment Centre, Aston University on 021-359 3611 x5212.

Title: **Designing for optimal heat recovery.**
Location: Institution of Chemical Engineers, London.
Duration: 3 days.
Starting: 2 October 1990.
Content: Methods for the integrated treatment of process heating, cooling and power requirements, using "pinch technology" concepts where relevant.
Contact: Conference Section, Institution of Chemical Engineers on 0788 78214.

Title: **Safety in process plant design.**
Location: Research Laboratories, Health & Safety Executive, Sheffield.
Duration: 1 day.
Starting: 8 October 1990.
Content: The course identifies the interaction between process design and hazard identification. It examines ways for improving the safety of the plant at the process design stage. The various methodologies used for hazard identification are described and applied to chemical processes. Corrective and contingency methods are examined with emphasis on the consequences of failure and damage to the environment.
Contact: Conference Section, Institution of Chemical Engineers on 0788 578214.

Title: **Energy efficiency in buildings.**
Location: CIBSE, London.
Duration: 1 day.
Starting: 23 October 1990.
Content: Limited resources. Global warming. Green labelling. Potential areas for future energy legislation. Practical aspects of applying various parts of the building energy code to different building and system types.
Contact: Member Services Department, CIBSE on 081-675 5211.

Title: **Safe handling of industrial chemicals.**
Location: Research Laboratories, Health & Safety Executive, Sheffield.
Duration: 1 day.
Starting: 29 October 1990.
Content: Toxicity and toxicology. Epidemiology and target organs. Non-ionising radiation. Combustion reactions and explosions. Fire and explosion characteristics. Prevention of combustion and explosion suppression. Dust explosions and their initiation by static electricity.
Contact: Conference Section, Institution of Chemical Engineers on 0788 578214.

Title: **CHP — the application of small scale heat and power in buildings.**
Location: CIBSE, London.
Duration: 1 day.
Starting: 30 October 1990.
Content: The current technology and principles behind CHP.
Contact: Member Services Department, CIBSE on 081-675 5211.

Title: **Preventing mechanical failure and electrical hazards.**
Location: Research Laboratories, Health & Safety Executive, Sheffield.
Duration: 1 day.
Starting: 12 November 1990.
Content: Mechanical aspects of stress, stress concentration and the measurement and analysis of service loads. Mechanical properties and the principal modes of failure. Corrosion minimisation and prevention. Electrical hazards.
Contact: Conference Section, Institution of Chemical Engineers on 0788 578214.

Title: **An appreciation of modern developments in airport fuelling operations.**
Location: Egham, Surrey.
Duration: 2 days.
Starting: 19 November 1990.
Content: Tracing the development of aviation fuelling equipment, much of which is coming to the end of its economical life since its introduction with jet aircraft, the course covers the impact of small computers enabling sophisticated developments in many areas of fuelling operations that will improve safety, speed data flow, reduce costs and increase efficiency.
Contact: Dr E M Goodger, RouteSouthWest Ltd on 0908 582120.

Title: **Understanding heat treatment.**
Location: Aston University, Birmingham.
Duration: 3 days.
Starting: 27 November 1990.
Content: Basic metallurgical theory of heat treatment. Quenching principles and practice. Surface hardening theory and heating methods. Salt bath heat treatment. Atmosphere theory, production and control. Temperature measurement and control. Quality control, specifications and defects in heat treatment.
Contact: Wolfson Heat Treatment Centre, Aston University on 021-359 3611 x5212.

September 1990

Investing in Innovation
A series of five seminars to be held during September in London, Edinburgh, Warrington, Birmingham and Bristol.
Details from CBI Conferences, Centre Point, 103 New Oxford Street, London WC1A 1DU.

Design Tools and Energy Models
One day seminar, 27 September, Norwich, UK.
Details from Robert Bilbie on 0603 629571 or Rex Bowen on 0992 555120.

October 1990

Pollution Management
Two day conference, 2-3 October, Birmingham, UK.
Details from Caroline Hurley, Financial Times Conference Organisation, 126 Jermyn Street, London SW1Y 4UJ, tel: 071-925 2323, telex: 27347: FTCONF G, fax: 071-925 2125.

Risk Analysis in the Offshore Industry
Three day workshop, 2-4 October, Aberdeen, UK.
Details from Natalie Cox, IBC Technical Services Ltd, Bath House (3rd floor), 56 Holborn Viaduct, London EC1A 2EX.

The Environmental Impact of Buildings
One day conference, 9 October, Watford, UK.
Details from the CIBSE Member Services Department on 081-675 5211.

Information Support for the Energy Industries
One day conference, 9 October, London.
Details from Miss Caroline Little, Conference Officer, The Institute of Petroleum, 61 New Cavendish Street, London W1M 8AR.

Communications Standards for Building & Energy Management Systems
One day technical colloquium, 10 October, Solihull, UK.
Details from the BEMS Centre, BSRIA, Old Bracknell Lane, Bracknell, RG12 4AH. Tel: 0344 426511.

Energy, Environment and Climate
Symposium, 15-16 October, Stuttgart, Germany.
Details from IER, Institute of Energy Economics and the Rational Use of Energy, Stichwort EEC 90, Heßbrühlstr 49a, D-7000 Stuttgart 80, Germany.

Condition Monitoring
3rd international conference, 15-17 October, Windsor, UK.
Details from the Conference Organiser, Condition Monitoring, BHR Group Ltd, Cranfield, Bedford MK43 OAJ.

Intelec 90
International Telecommunications Energy Conference, 21-25 October, Florida, USA.
Details from Orlando Marriott, 8001 International Drive, Orlando, Florida 38219-9312. Tel: (407) 351-2420, fax: (407) 345-5611.

Coal quality and assurance in power generation
Conference, 24 October, London.
Details from the Conference Section, The Institution of Chemical Engineers on 0788 578214.

Emergency Planning
One day conference, 29 October, London.
Details from Liz Hide, IBC Technical Services Ltd, Bath House (3rd floor), 56 Holborn Viaduct, London EC1A 2EX.

November 1990

Gulf Energy Convention
Conference & exhibition, 4-8, Dhahran, Saudi Arabia.
Details from London, tel: 071-486 3741.

Improving efficiency of energy use in commercial refrigeration
Four workshops, November, Nottingham, Birmingham, Manchester, Edinburgh.
Details from Simon Burgess at ETSU on 0235 432034

Engineering Energy Efficiency
Conference, 22 November, London.
Details from Krysia Budzynska on 071-836 8366.

Chaos and the Danger of Unpredictable Failure
Lecture by Prof J M T Thompson FRS (University College London), 26 November, London.
Details from Helen Bisson, The Fellowship of Engineering, tel: 071-222 2688.

Installation and Maintenance of Security Equipment
One day symposium, 27 November, Solihull, UK.
Details from The Conference Organiser, IEEIE, Savoy Hill House, Savoy Hill, London WC2R OBS. Tel: 071-836 3357, fax: 071-497 9006.

The Institute of Petroleum: Luncheon Meeting
Speaker: Mr Robert Horton, Chairman, The British Petroleum Co plc, 27 November, London.
Details from Caroline Little, The Institute of Petroleum, 61 New Cavendish Street, London W1M 8AR.

December 1990

Energy India 90
Exhibition, 7-16 December, Bombay, India.
Details from IBPL URJA Research Foundation, 701-C, Poonam Chambers, Dr Annie Besant Road, Worli, Bombay, India.

Robotics in the Power Generation Industry
Two day conference, 11-12 December, London.
Details from Louise Coote, IBC Technical Services Ltd, Bath House, 56 Holborn Viaduct, London EC1A 2EX.

January 1991

EIA Trade Mission to the Netherlands
27 January-1 February, Rotterdam.
Details from EIA, 16 Dartmouth Street, London SW1H 9BL.

February 1991

3rd National Conference on Plant Engineering & Maintenance
Two day conference, 19-20 February, Bristol, UK.
Details from Rosemary Wood, CMC, Bankside, Hollybush Lane, Frensham, Farnham, Surrey GU10 3BN. Tel: 025 125 4702, fax: 025 125 4808.

March 1991

Management of In-Service Inspection of Pressure Systems
Conference, 12-14 March, London.
Details from Alison Elgar, tel: 071-222 7899 ext: 208.

ETEX 91
Environmental technology exposition & conference, 13-15 March, Las Vegas, USA.
Details from The Interface Group, tel: (617) 449-6600, fax: (617) 449-6600, fax: (617) 449-6953.

Civil Engineering in the Nuclear Industry
Two day conference, 20-22 March, Windermere, UK.
Details from The Conference Office, Institution of Civil Engineers, 1-7 Great George Street, London SW1P 3AA.

EPRI-EPA Joint Symposium on Stationary Combustion NO_x Control
25-28 March, Washington DC, USA.
Details from Electric Power Research Institute, Attn: Maureen Barbeau, Conferences and Exhibits, 3412 Hillview Avenue, Palo Alto, CA 943304, USA.

April 1991

International Symposium on Radon and Radon Reduction Technology
2-5 April, Pennsylvania, USA.
Details from Pat Heightchew, CRCPD, 205 Capital Avenue, Frankfort, KY 40601, USA.

1st Environment Technology Expo
Exhibition, 8-11 April, Chicago, USA.
Details from EIA, 16 Dartmouth Street, London SW1H 9BL.

June 1991

25th Unichal Congress
Congress and Exhibition, 4-6 June 1991, Budapest, Hungary.
Details from UNICHAL, International Union of Heat Distributors, Bahnhofplatz 3, CH – 8023 Zurich. Tel. +41/1.211-3635, fax: +41/1.221-0442.

INSTITUTE OF ENERGY CONFERENCES

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

For further details please contact Judith Higgins or Jill Leigh on 071-580 0008.

In 1990

31 October
ELECTRICITY FROM GAS
Venue: The Royal Garden Hotel, London W8
Chairman: Mr J Masters (British Gas)

In 1991

February
MANAGING LONG TERM RISKS IN THE ENERGY BUSINESS
Venue: to be confirmed
Chairman: Mr D M Willis (Institute of Energy)

13 March
WHERE ARE WE NOW ON NUCLEAR POWER?
Venue: to be confirmed
Chairman: Mr C E Pugh CBE (Institute of Energy)

30 April-1 May
FIRE & EXPLOSION HAZARDS: ENERGY UTILISATION
Venue: Fire Service College, Gloucestershire
Chairman: Mr P G Redpath (British Steel)

17-19 May
THE INSTITUTE OF ENERGY ANNUAL CONFERENCE
Venue: Bournemouth
Chairman: Mr D M Willis (Institute of Energy)

Autumn
ENERGY FROM WASTE (provisional title)
Venue: to be confirmed
Chairman: Mr B Lees (Institute of Energy)

Autumn/Winter
5th International Fluidised Bed Combustion Conference:
FBC TECHNOLOGY TO MEET THE ENVIRONMENTAL CHALLENGE
Venue: to be confirmed
Chairman: Mr J S Harrison (British Coal)

Conferences co-sponsored by The Institute of Energy

In 1990

10 October
Interconnection of Renewable Source Generators with a Public Utility
Contact: Institution of Electrical Engineers on (071) 240 1871

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

24 October
The Implications of Coal Quality in Power Generation
Contact: Institution of Chemical Engineers on (0788) 578214

4-5 December
National Energy Management Exhibition & Conference NEMEX '90
Contact: Energy Systems Trade Association on (0453) 873568

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- ☐ Incorporated Engineer or equivalent.
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- ☐ Engaged on a relevant course of study (Student applicant).

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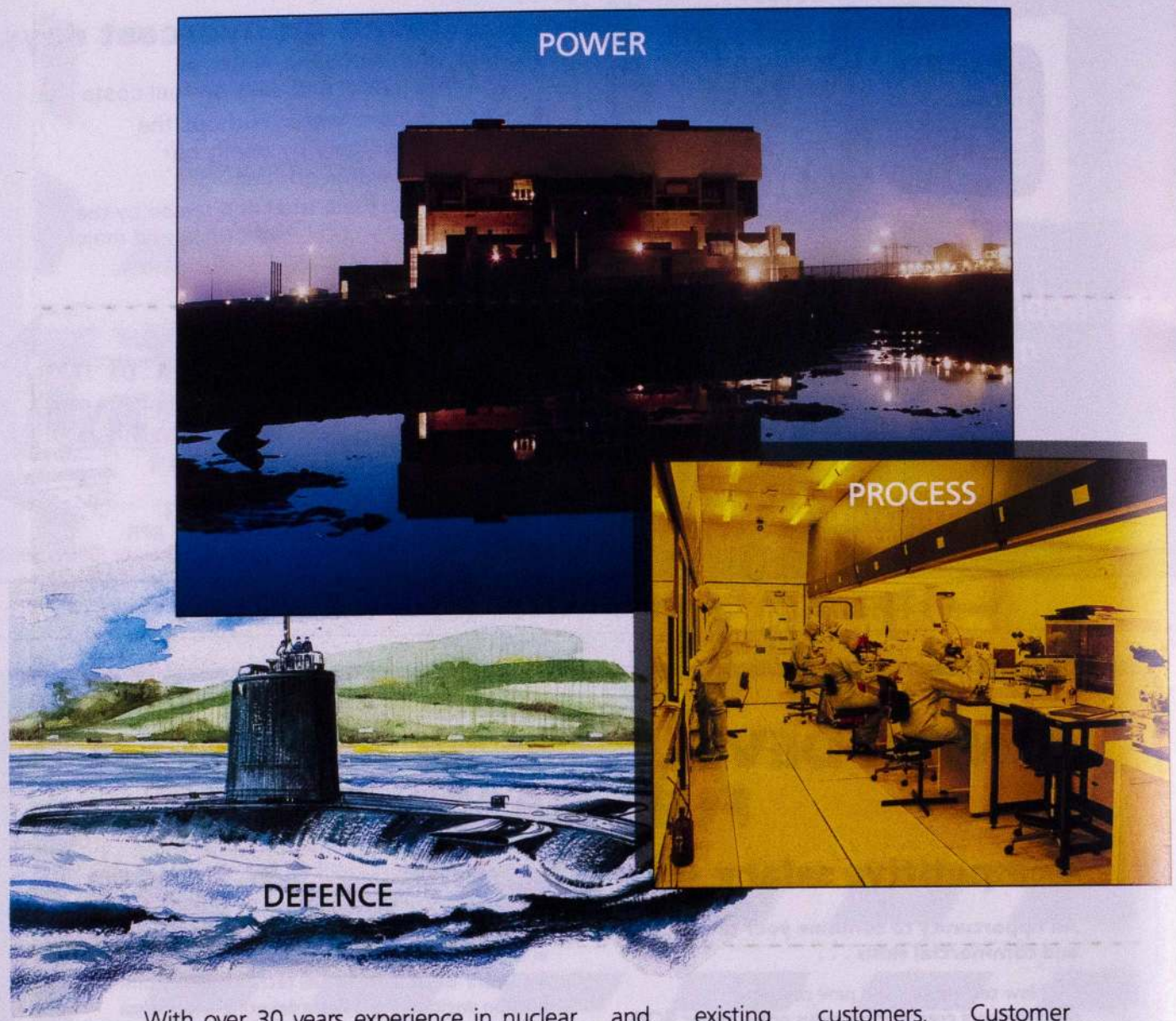

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