ENERGY WORLD

The magazine of The Institute of Energy

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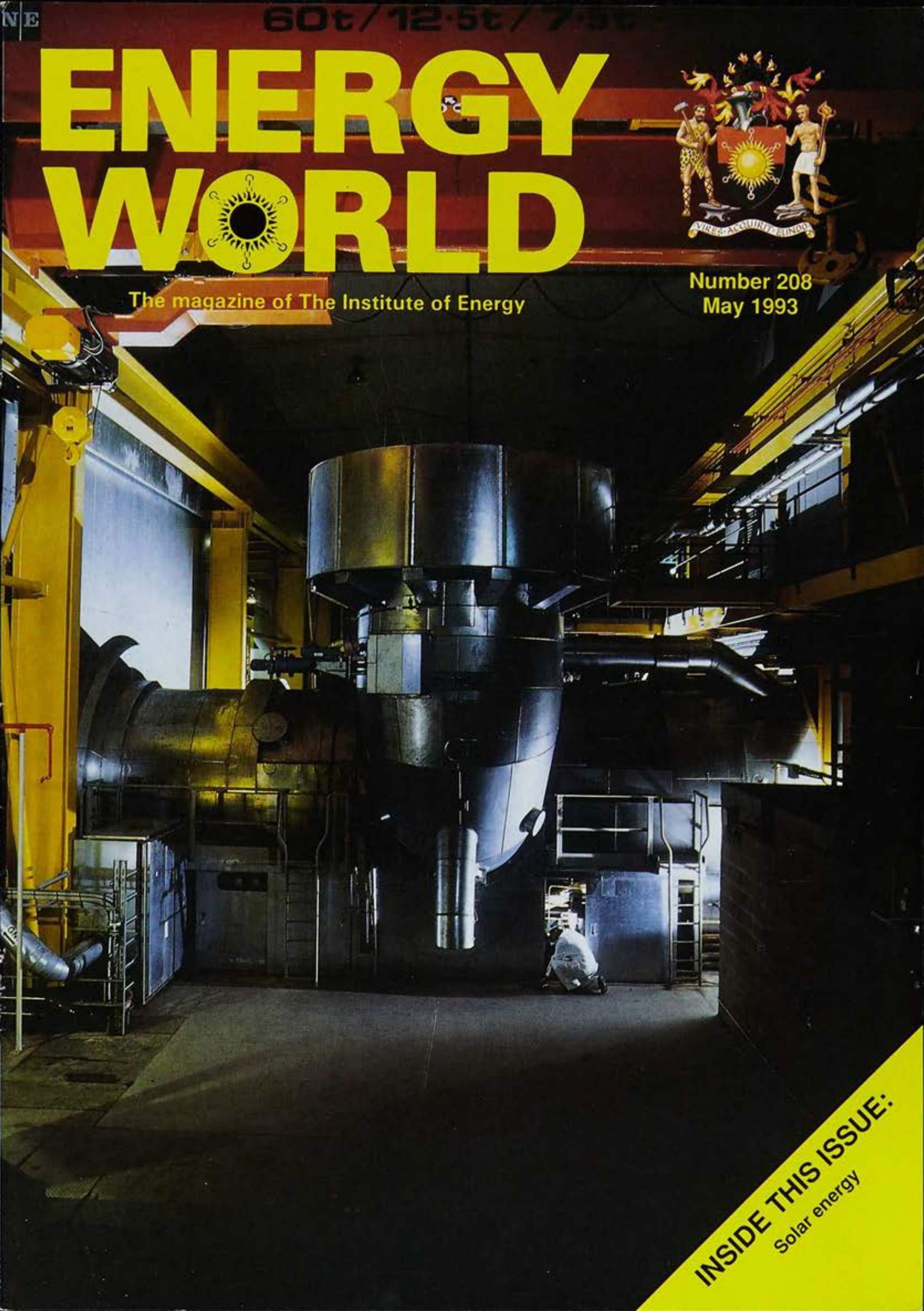
May 1993



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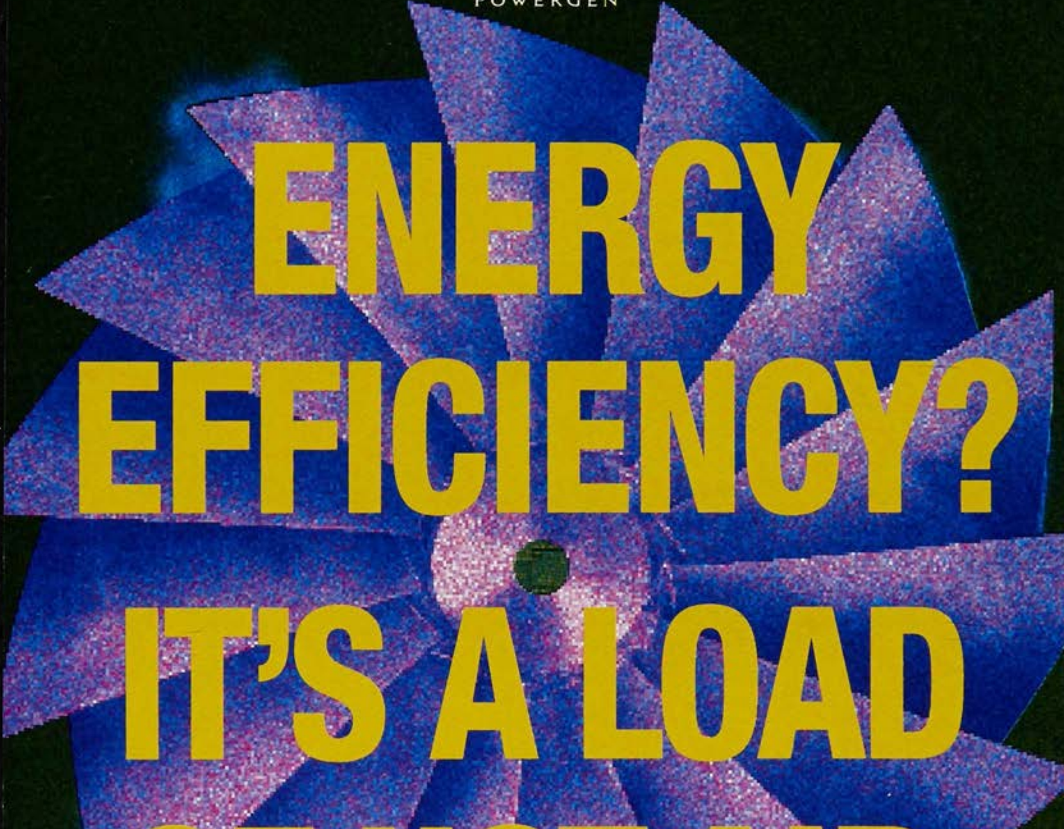
Solar energy

POWERGEN



A lot of hot air is talked about energy efficiency. We decided to use it. For instance, at Killingholme power station we actually use our waste heat to drive an extra turbine. Increasing efficiency by 30 per cent. And helping to keep down the cost to our customers. Because we believe that energy efficiency isn't just about ecology, it's also about economy. Hot air? It's a load of electricity, as we say at PowerGen.

THE ENERGY COMPANY WITH ENERGY.

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**The magazine of
The Institute of Energy**

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COVER

PowerGen's Killingholme power station, (this month's front cover shows a view of one of the four gas turbines) was officially opened in April.

The 900 MW combined cycle gas turbine (CCGT) has been generating at full power since December 1992, and is the first CCGT station to feed into the nation's main 400 kV electricity grid. The station is fired by gas from the Pickerill field via the gas terminal at Theddlethorpe, and a 50 km gas pipeline installed by Kinetica, a joint venture company formed between PowerGen and Conoco to transport and market gas. *(See p5)*

Power without pollution

IS IT possible to harness energy without harming the environment? The recent Braer oil disaster which spread 84 000 tonnes of oil into an environmentally sensitive area highlighted just one of the problems of our dependence on oil. Tanker routes and double hulled ships are smoke-screen 'solutions'. Nothing short of phasing out our use of oil can *guarantee* an end to such spills.

But while the world can witness some of the devastating effects of oil spills, it is a more insidious environmental risk which must ultimately prompt the phase-out of oil and other fossil fuels. Global warming, say the world's leading climate scientists, is set to bring massive and damaging changes to our climate unless we stem production of the major greenhouse gas — carbon dioxide.

Since we started mass burning of fossil fuels we've added around 170 billion tonnes of carbon to the atmosphere, helping it trap heat which would otherwise escape. We continue to add 6 billion tonnes a year just by burning fossil fuels.

Now, according to the United Nations Intergovernmental Panel on Climate Change (IPCC), it will take a cut of 60-80% in human-generated emissions of carbon dioxide and other greenhouse gases to stabilise the world's climate. Without such action the IPCC predicts a 3°C rise in average world temperatures within the next century — an increase unprecedented in recorded history.

Continuing 'business as usual' for just another 50 years could, they say, bring us to a point of no-return where we would be unable to stop worldwide climate crises. Even before that, temperature rises will put animals, plants, even whole countries in danger. Seven of the past 10 years have already been the warmest ever recorded. Coral reefs are bleaching, sea levels rising, and the world's insurance industry testify to a huge increase in claims related to extreme weather conditions. These and other events have led the Chair of the Enquete Commission, a prestigious body set up by the German Bundestag to investigate climate change, to write in a recent report that 'our planet is already warming at an increasing rate. The first signs of climate change are already measurable and noticeable.'

Yet despite these indications that action is vital, most energy and climate studies suggest that fossil fuel use is likely to double in less than 40 years — with an even bigger increase in nuclear power. This is not surprising when the debate on future energy use is dominated by those with the greatest financial resources — the oil, coal and the gas industry, the nuclear lobby and the industrialised countries of the north. All assume the continued dominance of fossil fuels.

But if fossil fuel use increases as projected, carbon dioxide emissions could increase by 400% by the end of the century. The world would warm up at a faster rate. Sea levels could rise by 66 cm, with the result that people would be forced to leave their homes by rising seas, floods and desertification. Forests would die, with increases in acid rain and smog of up to 500% in some regions.

Presently, the continued large-scale allocation of R & D funds to fossil fuels and nuclear power diverts money from energy practices that would alleviate not only global warming, but also a host of other environmental disasters. Renewables, such as solar and wind power, biomass, have enormous technical potential which has so far been barely tapped. Given the right level of political support, renewables can provide all our energy needs in future at a reasonable cost. The biggest obstacles to a clean energy future are not technical but political.

In a recent report* Greenpeace has directly contradicted the message from the fossil fuel industries and some governments that future energy security is dependent on a continuing increase in the use of oil, coal, gas and nuclear energy. The report shows that the phase out of fossil fuel use is not only possible, but also achieveable in a relatively short timescale. Applying energy efficient measures, coupled with clean renewable energy sources, including hydro and geothermal power, (all of which currently deliver 14% of the global energy supply) could provide all the world's energy needs by 2100.

In the next few decades new policies are needed to set us on the path of a clean-energy future. A driving force for these would be strong international agreements to protect the climate. Although an international climate convention has been signed by more than 150 nations, it is weak and should be amended to commit signatories to reduce CO_2 emissions. There should be strong protocols on energy efficiency and renewable energy which set ambitious targets for signatory countries as well as providing funding to allow the south to participate effectively.

Governments should introduce energy taxes to reflect the economic costs of environmental damage caused by fossil fuels and nuclear power. Germany, UK, Italy, the Netherlands, Denmark and several states in the USA have already introduced financial incentives for renewable energy developers. There should also be encouragements to utilities to buy clean renewable energy, and changes in regulations which remove financial incentives to sell more gas or electricity. Fossil fuel and nuclear subsidies should be ended, as should tax breaks for oil and gas exploration. R & D funding for fossil fuels and nuclear power should also end, unless related to safety or decommissioning.

With rapidly deteriorating ecosystems, disappearing resources, and skies accumulating pollution at an alarming rate, even without the possibility of climate change, there are compelling reasons for moving away from fossil fuels and nuclear power. We cannot afford to take the risks of continuing along our present energy path. A clean energy future is now a real possibility, and an imperative for the protection of the planet.

Sue Cooper
Greenpeace UK

* *Fossil Fuels in a Changing Climate — How to protect the world's climate by ending the use of coal, oil and gas* available from Greenpeace International, Keizersgracht 176, 1016 DW, Amsterdam.

Biomass-fired CHP in Sweden

A CHP plant, fuelled by biomass is to be built in Kristianstad, southern Sweden. Power from the plant will meet baseload demand for heat and electricity for a population of around 72 000.

The town's municipal utility, Kristianstad Energiverk, has placed an order for a 15 MW medium pressure steam turbine and ancillary equipment with ABB STAL AB, of Finspong, Sweden, for whom the order represents a breakthrough in the area of medium-pressure turbines in small biomass-fired power plants. The biomass fuel will consist mainly of wood chips.

Joint venture in India

A JOINT feasibility study is to be undertaken to look into the building of a 300 MW coal-fired power station in India.

Jaiprakash Industries Ltd (JIL) and National Power signed an agreement in March, as the first step towards establishing a joint venture company that would build, own and operate the proposed station.

The power station at Mangalore, Karnataka, would be next to a planned steel plant, to whom it would supply power, as well as to other major companies in the area. The station would have two 150 MW generating units, and the cost is currently estimated at around £260 million.

National Power would operate the plant, and be a major shareholder, along with JIL, a large civil engineering and manufacturing company, and a third joint venture partner. Opportunity would be given in due course to other Indian investors to acquire shares.

National Power International (NEI) is at present reviewing a number of opportunities in India, but the Mangalore plant is seen as their lead project in that area. "India is an important target market for us," said NPI's Graham Hadley.

New policy for World Bank loans

THE WORLD Bank is changing its criteria for loans on energy projects, according to two reports published by the Bank recently.

In future lending the Bank plans to increase its efforts to achieve fundamental requirements in the provision of public power. These include more transparent regulation and greater openness to private investment. They hope this will create greater energy efficiency, in both production and consumption.

The reason for its change of policy stems from the deteriorating performance of many power utilities in developing countries.

In future lending for power projects will focus on countries who are clearly committed to improving power performance in line with the new principles of the Bank. Total lending on power projects by the Bank to 1991 totals $40 billion. Future lending will be more selective, and support will not continue for energy supply projects where public energy enterprises have performed poorly, and their governments are unwilling to carry out fundamental structural reforms. In order to receive lending in future, governments will have to show that they are setting up structural incentives that lead to the more efficient production and use of energy.

The World Bank also hopes to improve end use of power by promoting demand-side management, as well as less-polluting technologies.

A few countries have improved their energy efficiency, according to the reports. These include Korea, Malaysia and China. But most developing countries could make improvements of between 20-60% in their energy efficiency.

The Bank claims its new policies are in line with calls from the UN Conference on Environment and Development in June 1992.

Multilateral fund for CIS

A MULTILATERAL fund for nuclear safety assistance to central and eastern Europe and the former Soviet Union has been set up, with a £8.25 million contribution from the UK.

The UK contribution was announced in February by Energy Minister, Tim Eggar, who reaffirmed UK commitment to the call by G7 at the Munich Summit last year to set up a fund to address the immediate operational and technical safety improvement measures in Eastern Europe's aging nuclear plant.

The fund will concentrate on urgent safety improvements on RMBK and VVER model 230 nuclear reactors, supplementing bilateral assistance efforts which are already in place.

The multilateral fund will be managed by the European Bank for Reconstruction and Development.

Combined cycle power plant at Simmering, near Vienna is claimed to be the most modern in Europe. The plant, which went on line in April, uses hot exhaust gases from the gas turbine as combustion air in the steam boiler. District heat is also supplied to the city of Vienna, bringing the efficiency of the plant up to a staggering 80%. Electrical output is 380 MW in winter, when it provides a further 350 MW of district heat. In summer the power generation capacity increases to 440 MW. Pictured above is the Siemens/KWU gas turbine, fitted with low-pollutant hybrid burners used for Unit 3 of the power station.

Prosecution of UKAEA

THE UKAEA pleaded guilty to two charges brought by the Nuclear Inspections Inspectorate of the Health and Safety Executive, in April.

The prosecutions were made under the provisions of the Ionings Radiations Regulation 1985, following an incident involving the release of the radioisotape tritium.

The incident took place in the Active Handling Bay of the PLUTO reactor building at Harwell in Oxfordshire in April 1992 during decommissioning operations. Approximately 10 tera becquerels of tritium were released to atmosphere, and some members of staff received radiation doses of up to 12% of the annual statutory limit

This was a joint prosecution between HSE and HMIP. The UKAEA was fined £3000 with over £10 500 costs.

Fuel tax debate continues

A BOOK published in April by the New Economics Foundation suggests ways of helping both the environment and the economy through fuel taxes, without penalising the poor.

Energy efficiency policies by Victor Anderson argues for a 'progressive carbon tax' as a far more effective tool to achieve an increase in energy efficiency than the imposition of VAT on domestic fuel, which is to be introduced from April 1994.

"The Government have failed to produce a thought-out package to reduce carbon emissions and at the same time protect the poor," claims Victor Anderson. "My book advocates a form of carbon tax that would be zero rated for the quarter of the population using the least fuel, and spending the money raised to improve energy efficiency in homes, industry and transport."

Energy Efficiency Policies by Victor Anderson, senior researcher with the New Economics Foundation, is published by Routledge.

Pressure to streamline further

BRITISH Coal chairman, Neil Clarke warned that further streamlining would be necessary to allow time for a number of deep mines to become competitive with coal imports.

Mr Clarke was speaking at The Institute of Energy's annual luncheon at the Grosvenor House Hotel in April.

Existing impediments such as constraints on developing more efficient working practices would have to be removed, as the only way to give collieries the best chance of survival. "I look forward to early action to allow us to organise our productive capacity so that we can get the very best from our mines," said Mr Clarke, adding that this could mean further job losses and an increase in the flexibility of labour.

Mr Clarke went on to point out the productivity had risen by 20% in the past year, demonstrating British Coal's determination to meet the commercial challenge.

British Coal must alter its fundamental perception of the market, he said, as it would no longer be able to rely on the security of long-term contracts for the bulk of its output.

Cutting Kent's energy bill

A TOTAL of £380 000 has been sliced off energy bills for schools, offices and other Kent County Council buildings.

The County's commercial services department manages LASER, the local authorities south east region energy efficiency consortium, which was set up in September 1991. The savings have been achieved by searching for the best deal from a gas supplier for a specific site.

LASER has helped local authorities achieve savings in excess of £1.2 million since 1991. Energy contracts have been negotiated for more than 700 sites so far. The consortium aims to reach its total savings target of £2.5 million within the next 18 months.

10% renewable by 2000

UP TO 10% of energy used in Humberside could be drawn from renewable sources by the year 2000, according to a report for Humberside County Council.

The eight-month study analysed and set targets for a number of potential sources of renewable energy, including waste, wind, geothermal, and biomass. Despite the financial barriers in terms of capital costs, the report links their development to finding solutions to wider environmental problems, and recommends 20 points for action.

"Our favoured technologies not only offer Humberside cleaner energy, but they can also help tackle other issues, such as waste management, and the need to contribute to national CO_2 targets," said Ray Tompkins of Environmental Resources Ltd, authors of the report.

HSC proposes IAC for coal

SIR John Cullen, chairman of the Health and Safety Commission has written to interested parties in the coal industry seeking views on the Commission's proposal to establish an industry advisory committee (IAC) for the underground coal industry.

The hopes the IAC will give attention to promoting an industry-wide safety culture; identifying and disseminating best practice; and advising the Commission on other matters involving health and safety in underground coal mines.

Consultation will continue until 28 June, and it is hoped that the committee will have its inaugural meeting in the autumn of this year.

"The Commission has long felt that there is a need for an IAC for underground coal mining," said Sir John.

Union report gives different picture

A REPORT produced by the NUM in conjunction with the pit deputies union, NACODS, argues that the ten pits chosen for closure by the Government in October 1992, have economic reserves, and could make valuable financial contributions in the future.

The report *The case for the 10 pits* was welcomed by the Coalfield Communities Campaign's chairman, Cllr Hedley Salt, who said "this study confirms yet again that the decision to close a large part of Britain's coal mining industry is ill-founded. Given the opportunity to compete on a fair and equal basis, evidence proves that coal is both economic and viable."

The report argues not only for the 10 doomed pits, but also for Britain's deep mine coal industry as the only long-term energy resource in Britain.

OFTEC launch

LORD EZRA formally launched the oil industry's industrial oil burning training and registration scheme at the Energy Efficiency Office in London in April.

He emphasised the importance of training if essential improvements were to be made to the UK's standards of combustion efficiency, and fully supported the Oil Firing Technical Association for the Petroleum Industry (OFTEC) scheme.

Technical adviser to the scheme, Colin Sutherland, outlined its method of operation. Experienced technicians should register, he said, to put pressure on those who were less skilled to submit themselves for training.

The Oil Firing Technical Association for the Petroleum Industry has drawn up a scheme for technicians to complement its existing training activities. The new scheme complies with the OFTEC Code of Practice in Training Standards and with the rules of the registration scheme.

Killingholme on line

POWERGEN's first combined cycle gas turbine (CCGT) to come on line was officially opened on 19 April, by chairman Sir Graham Day.

The opening ceremony took place at the beginning of a week of open days and official visits. More than 300 guests, including MPs, councillors, contractors and many others associated with the station, heard speeches by PowerGen's chief executive Ed Wallis and Juergen Gehrels of Siemens plc, the turnkey contractors for the station.

The 900 MW CCGT is fired by natural gas supplied by Kinetica Ltd, a gas transportation and marketing company jointly owned by PowerGen and Conoco (UK) Ltd. The high pressure, underground pipeline stretches 52 km, from Theddlethorpe in Lincolnshire to Killingholme, South Humberside and is 50 cm in diameter. Approval to build the pipeline was received in March 1991. Less than two years later it is providing up to 160 million cubic feet of gas each day, despite diversions *en route* to avoid significant archaelogical sites and even a badger sett! The £20 million pipeline has spare capacity to supply other industrial and commercial users in the Humberside area.

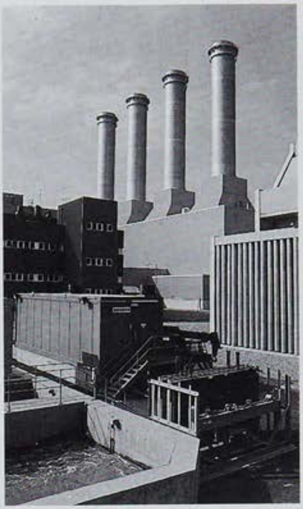
The power station itself has been a success story for all companies involved. Turnkey contractor Siemens secured the contract in January 1990, it was the first to be awarded by a UK privatised utility for a major power station, and was worth in excess of £290 million.

Siemens has built many power stations using CCGT technology throughout the world. The largest in Europe being the Ambarli plant in Turkey, which generates in excess of 1350 MW.

Killingholme was built in less than 900 days — ahead of time and to cost, and is the first major non-nuclear plant in the UK for a decade. It comprises four gas turbines and two steam turbine generating sets, driving six electrical generators — essentially two generation modules, each with a gross capacity of 470 MW (450 MW net). Each module has two 150 MW German built gas turbines, and one 170 MW steam turbine, constructed at Siemen's plant in Mulheim. The first module was commissioned in September 1992, the second in December.

Siemens is currently building a slightly smaller CCGT plant at Rye House in Hertfordshire, with a rated capacity of 680 MW. The plant is scheduled on go on line in early 1994.

The Killingholme plant has a rapid start-up time, with 300 MW available in just 15 minutes. Full module capacity of 450 MW can be achieved within one hour. The control room is split into various duty centres. The centre desk provides communication links to the National Grid, PowerGen's Energy Management Centre at Solihull and the gas suppliers. Computers monitor and display gas consumption and electrical output.

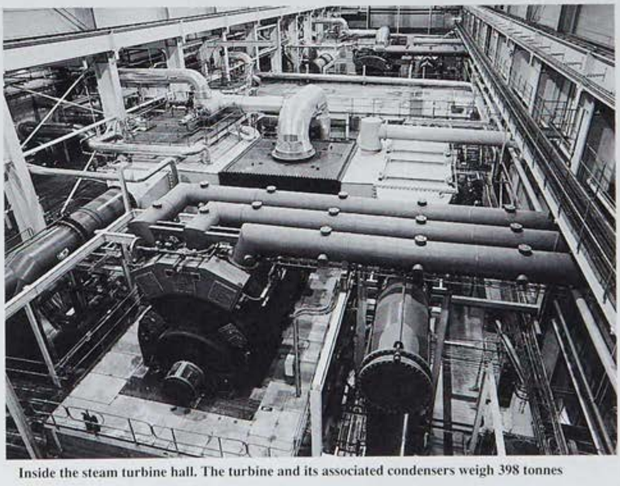


Killingholme CCGT — 6000 tonnes of reinforcing steel has been used in the structure.

Each module has a separate control desk and panel, managing start-ups, shut-downs, load changes and alarm systems. A common service panel controls connections to the grid, river water extraction, gas supplies to the station and fire and gas leakage alarms. The 'back panel' has a mimic diagram of the plant, including controls, indicators and alarms, providing another back-up facility to the main system.

The station works to a 'paper free' philosophy, and has one tenth the staff of a conventional power station. Rigid work practices and demarcation are a thing of the past, with teams of multi-skilled workers performing a variety of roles. PowerGen feels these flexible working practices create greater productivity and higher job satisfaction for the workforce.

As part of the opening celebrations, a local school girl planted a five-year old horse chestnut tree, which she had grown herself from a conker, in the grounds of the power station. PowerGen have been keen to involve the local community. To this end they have also commissioned a sculpture by Julie Edwards, from the nearby Grimsby School of Art and Design, which will also stand in the grounds of Killingholme. Appropriately, the piece is made from 60 pairs of turbine blades taken from one of PowerGen's redundant power stations. The blades form an arc, which surrounds a sphere, symbolising the precious power of energy, locked away at its core. ❑



Inside the steam turbine hall. The turbine and its associated condensers weigh 398 tonnes

Museum of power — one man's vision

by Johanna Fender

Senior engineer, David Lindsley, is anxious that the derelict power station at Kingston upon Thames should not become 'another Battersea'. His imaginative ideas for a new future for the redundant plant are outlined here.

A POWER station has stood on the site of the now derelict Kingston upon Thames plant for the past 100 years. Kingston power station finally closed in 1980, since which time the building has stood redundant.

The site is overdue for redevelopment, on that all parties seem agreed. The Borough Council has produced a Unitary Development Plan, which has the approval of site owners, PowerGen. But there is another interested party, who has put forward its own proposals for the derelict power plant: the Kingston Power Station Preservation Trust.

The Trust has been set up by David Lindsley, a senior electronics engineer, whose vision for the power station site constitutes a cultural and scientific centre. The project also has the enthusiastic support MEP Anita Pollack.

David Lindsley's proposals centre around a Museum of Power, situated inside the plant itself. The power station is of particular interest: it was the first to come on stream, in 1948, after nationalisation of the Generating Board, although an interruption by the war meant that proposals were already somewhat out of date by the time the plant was commissioned.

However, the plant was built with a surprisingly high degree of consideration for the environment, given that pollution did not attract serious attention until the Clean Air Acts in the 60s. Its tall stacks and efficient electrostatic precipitators minimised local atmospheric pollution during the lifetime of the plant, and several measures were taken to reduce thermal disturbance of the river water. Attempts were made to help the massive building blend into its surroundings, with a screen of large poplars, gardens, a park and sports facilities. The structure of the building remains strong due to the high standard of construction, and far from being just a 'shell', it still contains six stirling boilers, probably the sole survivors of their type.

The point on which all parties concur is that the power station could not be re-commissioned: it could never meet today's environmental or efficiency standards. In David Lindsley's view there are three possible redevelopment options. First, conversion to a more modern design of power station, possibly CHP plant providing heating for nearby residences. The second option, along the lines of the plan proposed by the Borough Council, is complete demolition and redevelopment for non-power purposes. Third is the Preservation Trust proposal, which advocates a conference and hotel complex on the site, in addition to the museum.

Asbestos

The major reason for the plant lying idle for the last thirteen years is the presence of asbestos in the building. Virtually all the machinery and connecting pipework were originally lagged with asbestos, whose dangerous properties were not recognised until long after the power station was commissioned. Removing asbestos is a time consuming and expensive process. If the plant were to be demolished all the asbestos would have to be removed and taken to a place of safe disposal. David Lindsley argues that if the plant were to be left substantially intact, it may be possible to seal hermetically some installations, negating the need for complete asbestos removal. The building would then have to be monitored to ensure the long-term integrity of sealed installations.

The demolition and redevelopment option, preferred by the local authority and site owners PowerGen, presents the lowest financial risk. But David Lindsley points out that the massive machinery still in situ must be removed; and the foundations, currently riddled with a network of underground tunnels, would have to be made good before any new construction work could begin. A further fly in the ointment for PowerGen is contained in the electricity privatisation act, which states that in the event of a power station site being sold, half the capital gain would revert to the Government. David Lindsley is proposing that PowerGen retain ownership of the site, thus avoiding this financial stumbling block.

The Trust's plan envisages the museum being housed within the power station itself, with the old coal stockyard converted into a 150-bedroom hotel with space available for ground-level car parking, and the rest of the building used for a conference centre. In order to meet planning objectives, the Trust has included some residential accommodation in their proposal.

But it is the museum which remains a priority for Mr Lindsley and the Trust. It is seen as a potential showcase for the UK energy industries, and this particular plant is perceived as having advantages over other redundant power stations. The site has good access for both central London and Heathrow airport, making it easily accessible to both UK and overseas visitors. In addition Kingston's small boilers and turbines provide the opportunity to illustrate the power generating process in terms comprehensible to the general public.

With the help of a team which includes quantity surveyors, structural engineers, architectural consultants and a property surveyor, the Trust has produced detailed plans, which include the provision of low-cost heat and power for the complex. The retention of the power station building should enable the incorporation of a gas-fired CHP unit, which could have the potential to earn additional revenue for the energy centre. In terms of the museum itself, with careful planning the new plant could provide a working display of a modern power plant.

Education and training

The training potential provided by the Energy Centre is given particular emphasis by the Trust. In the first instance it would provide the general public with a chance to learn about the energy industries, but Mr Lindsley envisages a greater training potential. Existing workshops on site and some of the offices could be used to provide training for process engineers, and the Centre could exist as a satellite of Kingston University. Students would have the advantage of working in classrooms and laboratories adjoining full-scale examples of plant, some of which would be fully operational.

For the Museum itself the Trust proposes full-scale models (eg, wind generators, gas turbines) in the entrance hall, which would be surrounded by exhibition rooms, relating to specific areas of interest. For these smaller rooms several potential topics have been suggested, such as an energy and the environment display. This would show how acid rain is formed and explain the greenhouse effect, as well as demonstrating practical methods for reducing pollution. Other areas of possible interest could be a renewable energy sources exhibition; modern power systems, and control of power.

Observation gallery

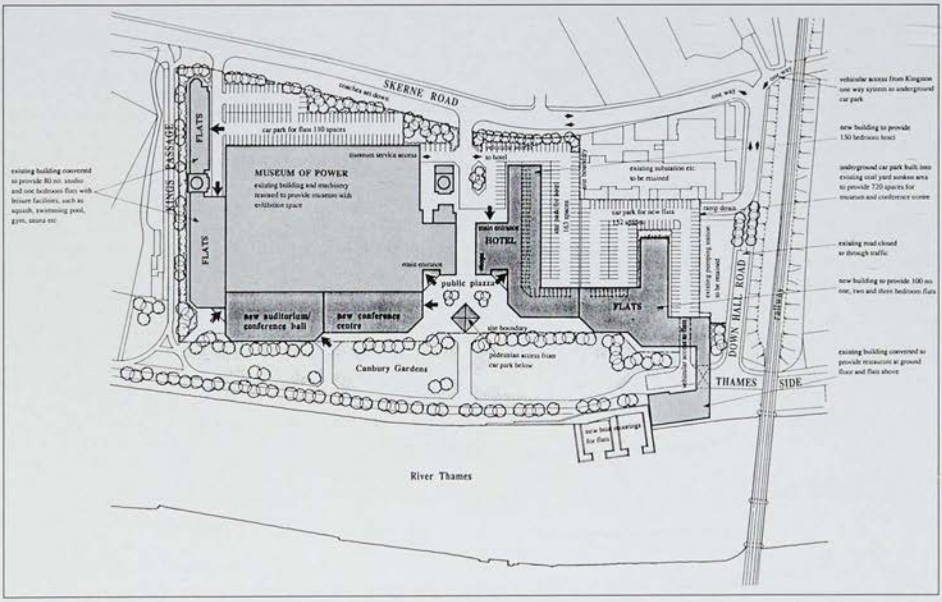
A moving walkway would carry visitors through the turbine hall, where they could observe the machinery at close hand. A lift in one of the stacks would take members of the public to an observation gallery which would give stunning views over the surrounding countryside towards London, with views of such landmarks as Windsor Castle and Heathrow airport.

Site owners PowerGen have expressed their support for the local authority's plans for developing the site, which involve demolition of Kingston power station so that the area can be redeveloped. "The site is of no great architectural merit," said a spokesman for the company. "Had David Lindsley gone ahead with his plans when the plant first became redundant, back in 1980, the scheme may have been a realistic possibility. But it has degraded to such a point in the last 13 years that such a plan is now unworkable." Since 1980 PowerGen have carried out basic maintenance, but inspite of this internal fittings have degraded, and there is considerable water penetration and pigeon infestation. They have also pointed out that the power station was not designed or built to allow public access, and the site is inappropriate for large numbers of visitors.

Kingston power station as it is today, viewed from Kingston Bridge.

Costs

The Kingston Power Station Preservation Trust has produced an estimated cost for the proposed project, put at £38 800 000. This ball-park figure does not include professional fees, VAT planning-submission and building regulation fees, abnormal ground conditions or the fitting out of pubs and restaurants on the site, although it does allow £2 million for asbestos treatment. The assumption is made that PowerGen would undertake the project on their land, or lease it to the developer, avoiding the need to include the cost of land purchase in the estimate. PowerGen, on the otherhand, do not believe that the scheme will provide enough revenue to cover the costs, and are therefore unlikely the undertake the project in any form. ❑



The feasibility layout plan for Kingston power station, drawn up by the Preservation Trust, but rejected by site owners PowerGen.

Prospects for photovoltaics

*by Professor Robert Hill**

The 1990s are the decade in which photovoltaics will make the transition from an important to a major technology. It is a transition which will be sustained long into the 21st century, maintains Professor Hill.

SOLAR cells convert light directly into electrical power via the 'photovoltaic effect'. Modern cells are efficient, long-lived, low-cost devices resulting from the enormous theoretical and technical advances made since the 1970s. The advances expected in the next 10 years will equal, if not exceed, those of the past decade, bringing about a major increase in the use of photovoltaics (PV).

Solar cells are electronic devices and are made from semiconductors such as silicon, usually in the form of thin slices (wafers) about 0.25 mm thick. The positive contact is a layer of metal on the back of the wafer, whilst the negative contact on top of the cell must collect the current, but also allow as much light as possible to enter the device. The top contact is usually made in the form of a grid.

In bright sunlight, a 10 cm square cell will give an output of about 0.5 volts and 3 amps, ie about 1.5 watts of power. Manufacturers quote the output of their cells for a sunlight intensity of 1 kW per square mile (similar to that of the Sahara desert at noon). This standard output is labelled 'peak watts' or Wp and is measured at a standard temperature of 25ºC. The power output of a solar cell varies with the intensity of light falling on it. The current output will halve if the light intensity is halved, but the voltage will drop only by a few percent. The power output also depends on the temperature of the cell and decreases by about 1 part in 200 for every degree Celsius rise in temperature above 25ºC.

Single solar cells give only a small amount of power. They are usually used in 'modules', which contain 30-36 cells connected such that the top of each cell is connected to the back contact of the preceding cell in the series (series connected). This ensures that the output will exceed 12 volts even in moderate sunlight and, hence, charge a 12 volt battery.

The module must provide mechanical strength for the cells to withstand wind loads, hailstorms etc, and protect the cells and their electrical contacts from environmental attacks by moisture and atmosphere pollutants for the 20/30 year lifetime of the module. Cell temperature can vary from -20ºC on a cold night to +60ºC on a hot day, so the thermal expansion of the cells must be allowed for. The string of interconnected cells is usually encapsulated in the layer of soft plastic, with an upper layer of glass to let in the light, and a back protective layer of plastic, metal or glass. A metal framework around the edges provides additional mechanical strength and the means of fastening the modules to a structure.

Typically, a module will give a power output of 50-70 Wp. When more power is required, modules can be connected together in series (positive to negative) to increase the voltage or in parallel (negative to negative, positive to positive) to increase the current. The modules are fastened to a secure structure, which holds them in the correct position to receive the maximum energy from the sun, and which can withstand the wind loads and so on. These 'arrays' of modules can be fixed or they can be driven to constantly face the sun. Arrays vary in size from a few modules, for telecommunications, say, to hundreds or thousands of modules, for large grid-connected utility supplies.

Electricity is rarely useful in itself — it must be used as the input onto some system which provides a useful service such as lighting or water pumping. The parts of the PV system, other than the modules, are known as the balance of system (BOS) and can be a significant or even major part of the total cost.

Commercial cells for most power applications are made from wafers of single crystal or multicrystalline silicon. There have been enormous advances in the efficiency of these cells and in reducing the cost of both cells and modules. The records set for small cells by the research laboratories are important in pushing forward our understanding of the science and technology, but of greater importance to the use of PV are the advances in the efficiency and cost of the commercial products.

The cost per peak watt of PV modules depends on the cost of silicon wafers, the cost of cell fabrication and the efficiency of the cells, as well as the cost of module fabrication and efficiency. One of the most significant recent advances has been the introduction of wire sawing, which has about doubled the number of wafers which can be obtained from each boule or ingot. The growth of multicrystalline ingots has also seen great strides in the rate of growth, ingot size and material quality, all of which serve to reduce costs and increase cell efficiencies.

The design of silicon cells for commercial production is changing, with the incorporation of features from the high efficiency cells developed in the research laboratories over

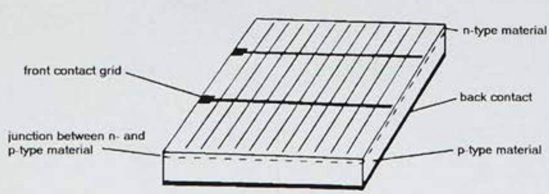


Figure 1: Top contact is usually made in the form of a grid.

**Photovoltaics Applications Centre, University of Northumberland*

the past decade. The buried contact grid and efficient optical design have been used to give commercial cell efficiencies of 17.5-18% with good yields. A pilot line at University of New South Wales produces 7 x 7 cm cells in the 19.5-20% range, with yields of around 70%. These exciting results suggest that commercial cell efficiencies over 20% should be achievable in the next few years.

The production cost of PV modules depends on the scale of production. New production facilities are now often in the 5-10 MWp per annum range. As markets expand, the size of the production facility also expands bringing with it cost reductions which open further markets for additional expansion. Photovoltaics companies are now changing prices to reflect their production costs, which was not always the case in the past. This benign cycle of larger markets, increased production, lower costs, larger markets, is thus leading to a more secure foundation for the photovoltaics industry, and a profitable future.

The optimism on the thin film solar cells has been somewhat dampened in recent years. Amorphous silicon still suffers from light-induced degradation, although the efficiencies at which the modules stabilise has increased to 5-6%, particularly for the p-i-n/p-i-n structures. Plans for large scale production in Europe seems to be on hold, but a 10 MWp per annum has opened in the USA producing 5ft x 2ft modules, at low cost.

The polycrystalline materials are still in the pre-commercial stage. Copper indium diselenide seems to have problems in obtaining high yields in production. Small defects at the substrate interface grow to large shunting defects in the final cell. Electrodeposited cadmium telluride appears to be rather more 'production friendly', but final decisions on commercial production are still awaited. It has been possible for some time to buy small cadmium telluride cells made by screen printing, and there are now 30 cm x 30 cm modules available made by screen printing and spraying. Cadmium telluride thus seems to be winning the race into commercial production and is likely to be widely available by the turn of the century at about the same cost per unit area as amorphous silicon, but at around double the efficiency.

Two other technologies seem promising for commercial production in the next few years. The micro-sphere and the thin silicon film technologies both promise lower costs, and the latter promises high efficiencies, theoretically even higher than silicon wafer cells.

The efficiencies and the estimated costs of the various PV technologies at different production rates are shown in Table 1. It should be noted that the production costs quoted in Table 1 do not include distribution costs or retail profit margins, which must be added to estimate prices.

Table 1: Materials and efficiencies of devices available through the 1990s, with module costs estimated for different annual production rates.

cell material	c	M	module costs ($Wp⁻¹ 1992) 1 MWp pa	10 MWp pa	100 MWp pa
Silicon					
single crystal	24	16	4.5	2.3	1.5
polycrystalline	20	14	4.5	1.8	1.2
(1) amorphous	14	6	3.0	1.5	0.6
(2) Copper indium diselenide					
	14	>10	3.0	1.5	0.6
(3) Cadium telluride					
	14	>10	3.0	1.5	0.6
(4) Concentrator cells					
silicon	27	15-19	6.0	2.3	1.2
gallium arsenide	29	-	4.5	1.8	1.1
multijunction	35	-	6.0	1.5	0.8

c = best cell efficiency achieved in research laboratories
M = standard commercial module effcieicies

Table 1 includes estimates for concentrator cells, ie, those used in sun-tracking devices, where the direct component of solar radiation is concentrated by a mirror or Fresnel lens by a factor of between 50 to a few hundred on to a small solar cell. The cost of this cell can be quite high, provided that its conversion efficiency is high. In hot areas, including those in Europe, the economics seem quite promising for utility-scale applications, where the increased maintenance requirements of tracking arrays can be accommodated cost effectively.

Applications

Photovoltaic power supplies have no moving parts, no fuel costs, no waste products and are completely silent. They can be designed to supply any range of power from miliwatts to multimegawatts. These are unique characteristics which make them ideal power sources for many applications, and the steadily increasing efficiency and decreasing cost is continually widening the range of cost effective uses.

The first contact with solar cells for most people is the 'solar-powered' calculator. Modern electronic equipment requires little power, so that generated by small solar cells even in room lighting (about 10 000 times less intense than Sahara sunlight) is enough to power a calculator. The cells used in these products are usually made of amorphous silicon, which responds better to room lighting than wafer silicon. Over 100 million solar calculators are sold each year, plus hundreds of thousands of other products such as clocks, battery chargers, radios, torches and garden lights. The range of consumer products which can be solar powered is limited only by the imagination and ingenuity of manufacturers, and the range will expand greatly over the next few years.

Perhaps the most worthwhile use of photovoltaics is the provision of power in remote villages and refugee camps, in the developing countries. No other power source is so reliable or so cost effective in providing lighting, medical refrigeration, water pumping and similar services in those conditions, and many thousands of these units are in operation around the world. Photovoltaics is a major tool for the social and economic development of the third world, and is playing an ever-increasing role in the welfare of people in rural areas.

Although it has been the case for some years that PV is the most cost effective option in remote rural areas, on a life-cycle cost basis, it is only recently that it has begun to be widely used, and still only in a few developing countries. The non-technical factors which influence dissemination are now the major determinants of the penetration of PV in the market place. The two major factors are the availability of PV systems to potential purchasers and the ability to finance the initial cost of PV, which appears high in comparison to kerosene lamps or a small diesel generator. In fact the repayments on loans to purchase a PV system are about the same as the recurrent costs of running a kerosene lamp or small generator, so providing the financing mechanisms are in place, PV is a very attractive option for private purchase. Commercial markets for solar home systems exist in Namibia, Indonesia, Philippines and some other countries, without government support. Rural electrification schemes to provide lighting and battery charging use PV because it is the cheapest and most reliable option. Major programmes exist in Mexico and are beginning in Brazil and other Latin American countries and in many of the countries in Asia. The establishment of the GEF and FINESSE funding programmes greatly assists governments and electricity utilities to expand these projects to bring social and economic development to remote rural areas.

The continued improvements in performance and reductions in price of photovoltaics have brought the technology to the point where major electrical utilities can now consider it for power into their grid systems. The first applications were in the southern USA where the peak loading is due to air conditioners, and power is required when the sun is at its hottest.

In the past few years, there have been important developments in identifying cost-effective applications within utility systems. Where utilities have long distribution lines, the power quality at the end of the line can become poor as demand increases. PV arrays at the ends of such lines can provide voltage support, and harmonic and power factor correction more cheaply than an upgrading of the power lines, transformers and switches. Embedded PV generators at critical points of a utility distribution system are cost effective now in some instances, in both developed and developing countries, and will become increasingly so during this decade. PV systems of 0.5-1 MWp operating at 11kV or 13kV into utility feeder lines are likely to be common around the turn of the century. The key to opening up this market is to produce good simulations of the utility distribution systems to identify the critical points in the systems where PV can provide the support needed.

Distributed generation refers to electricity generated at many points with a distribution system, and in this case particularly to PV systems installed on buildings in urban environments. In Germany, Netherlands, Switzerland and the USA there are programmes to study PV roofs on domestic houses. Technically these PV roofs work well, but the output is not in phase with the demand which, at least in Europe, increases in the evening. A better match between supply and demand, and more attractive economics, is found when PV is used as a cladding on the facades of commercial buildings. The cost of conventional cladding is partly offset by the use of PV laminates in the cladding and the BOS costs are greatly reduced, which brings down the overall price of the system. For high latitudes the vertical orientation can be advantageous in enhancing winter/summer output ratio, although for modern offices, a major electrical demand is for air movement and cooling, which rises in summer to match the average PV output. Even in a northerly maritime climate, such as that of the UK, PV cladding of commercial buildings could begin to be cost effective around the turn of the century. In a continental climate, PV cladding is likely to become a commercial option before the end of the century.

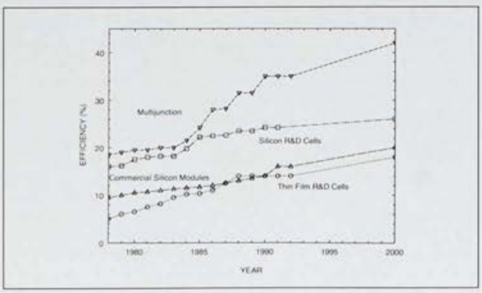
There are many applications in the 'professional' market — for cathodic protection systems, remote silent power, transport lighting, warning signs, telecommunications, and many others where fuel-free, maintenance-free systems are required. This market is growing as more users become familiar with the operation and benefits of PV, and incorporate it into their routine operations as a standard engineering solution to specific problems.

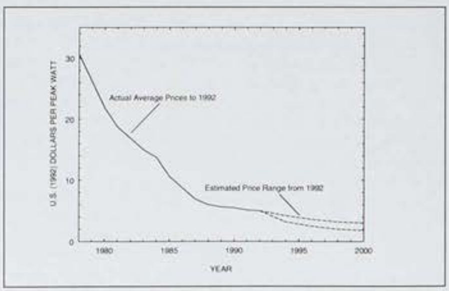
Projections of the total market for PV at the turn of the century range from around 250 to 1000 MWp per annum. The projections by the major PV companies tend to be around 300 MWp per annum, equivalent to a 25% constant yearly growth rate. This has been the rate of growth for the past 10 years or so, but in the difficult conditions of 1992, only the European companies maintained this rate. It is hoped that the new political climate in the USA will bring about a resumption of growth in the PV market there. The growth of the PV market is important in that it allows larger production plant and hence lower costs, as pointed out earlier.

The growth of the PV market, as with other commodities, depends on the state of the world economy and on political will. For PV, the utility applications would be more attractive economically if the environmental and social costs of fossil and nuclear fuels were taken into account. This is now becoming politically possible. The electrification market in the third world is potentially huge, but depends on the availability of international funds, and there are hopeful signs here too. The PV companies must operate in conditions of much uncertainty. At worst the industry will limp along growing slowly, and not very profitably to about 100 MWp per annum by 2000 AD. At best there will be a well-ordered, steady expansion of 25-35% a year to 300-400 MWp per annum. If the world's political leaders become seriously concerned about climate change and the alleviation of poverty the industry could be swept into a rapid expansion up to 1 GW or more a year by 2000.

What is more certain is that technical progress will continue to be made both in the research labs and in industry, and that the unique characteristics of PV will be increasingly recognised and applied. PV is an important technology. It will become a major technology. The 1990s are the decade in which this transition begins, but it will continue well into the 21st century. ❑

This article is based on one that originally appeared in the 'European Directory of Renewable Energy Suppliers and Services' published by James & James Science Publishers Ltd, London, and reproduced with their permission.





Great advances have been made in cell efficiency and reduced costs. Fig 1: (left) Variation of efficiency over time. Fig 2: (right) History of module costs.

If we haven't convinced you about the advantages of PFBC have a word with some of these companies.

AEP

"We are pleased with PFBC and expect continued testing will result in continued improvements in environmental performance, cost savings and reliability." *James Markowsky, Senior Vice President, American Electric Power Services Corporation.*

STOCKHOLM ENERGI

"We are confident we have invested in the best technology for our site, a technology that will be regarded as modern with respect to the environmental impact throughout its lifetime." *Tomas Bruce, Executive Vice President, Stockholm Energi.*

でんぱつ

"The choice of PFBC is based on its high efficiency combined with low emissions – the two most important features for the next century." *Yasuyuki Nakabayashi, Executive Director, Electric Power Development Co., Japan.*

Endesa

"The evaluation of the results obtained to date, with high-sulphur, high-ash coal, is positive. This technology is a clear option for the future." *Pedro Martinez Crespo, Director of Electrical Production, Endesa, Spain.*

KYUSHU ELECTRIC POWER CO.,INC.

"The proven demonstration of the smaller modules has strengthened our belief in our decision to build a 350 MW PFBC." *Mr. K. Ishi, Director, Kyushu Electric Power Co., Japan.*

PFBC is no longer at the experimental stage

It is the new generation of clean-coal technology that has been proven in commercial operations around the world.

The PFBC (Pressurised Fluidised Bed Combined-cycle) system already gives thermal efficiency gains of 10-15%.

These higher operating efficiencies lead, not only to cost savings, but also to lower emissions.

In fact, pressurised combustion releases so few pollutants that PFBC not only meets the most stringent emissions regulations today, but is also the natural choice to meet all future requirements.

Clean Coal Power

PFBC is a simple, one-step process for turning coal into electrical power.

And although the technology is new, many of the components are familiar.

A fluid bed boiler, a gas turbine and a steam turbine.

Unique to PFBC is the integration of the pressurised fluid bed into the combined cycle. Cleaning, during combustion, eliminates the need for add-on equipment.

The limestone which is added during combustion captures up to 99% of sulphur released by the fuel.

Coal of any quality can be used.

Together with the limestone the coal is crushed and fed into the fluid bed where it burns suspended in air streams.

This suspended mixture of coal and limestone forms a "bed" and appears "fluidised", hence its name.

The fluidisation allows for effective combustion at 800°C–1000°C, well below the conventional flame temperatures at which thermal NO_x is formed.

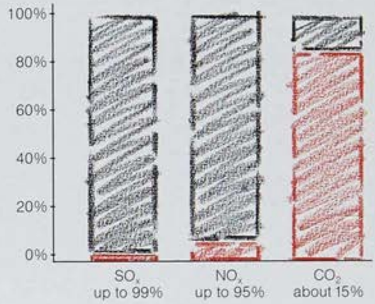
The very low inherent NO_x emissions can be further reduced by non-catalytic measures.

PFBC's high efficiency is such that the amount of CO_2 released into the atmosphere, in relation to the power generated, is lower than with any other coal-fired technology.

Solid waste, in the form of ash, is both benign and, potentially, a useful material.

When mixed with water it sets like concrete, and can be used directly as a filler, or crushed to make synthetic gravel.

In fact, by whatever criteria you care to mention, PFBC has minimal environmental impact.



Combined-cycle efficiencies

The linking of a gas turbine with a steam turbine is a major factor in the high efficiencies of the PFBC system.

And in designing a gas turbine that runs off coal, ABB have made a breakthrough.

The turbine's unique twin shaft configuration makes it capable of sustaining optimum plant performance throughout the load range.

It is also highly efficient with low inlet temperatures. And therefore has the potential for increased efficiencies when future higher temperatures are applied.

The turbine has been ruggedised and is protected by two stages of cyclones which remove 98% of particulates.

The combined cycle reduces fuel consumption by 10-15% in comparison with conventional coal-firing technologies.

PFBC is available in two modules. The P200 which can be configured singly or paired to produce up to 170 MW of power. And the P800 which is available at 350 MW or paired to give 700 MW of power.

A new option for utilities

PFBC is a milestone in coal-fired power generation.

Besides combining low emissions with improved efficiency it has many practical operating advantages.

It is a significant new option for utilities.

It is compact, simple, easy to permit and provides a low-cost route to generating electrical power from coal.

Its flexibility enables fast plant start-up, rapid load changes and low minimum load.

It is also a proven technology.

But more importantly, PFBC is a growing technology. Further refinements and advances will improve its already impressive performance and efficiencies, ensuring its position as the technology of the future.

If you'd like to know more about PFBC...

Call or fax Lynne Anderson at the address below for an introductory brochure entitled "PFBC clean-coal technology".

It is a detailed step-by-step guide to PFBC technology, including data from pilot plants in operation and current commercial applications.

One day seminars

ABB is also offering, one-day seminars for utilities and others interested in PFBC.

These seminars are a unique opportunity for engineers, management and other specialists to form a detailed appreciation of the system.

The programme which includes discussion periods covers present technology, operating experience and future developments.

Seminars can be arranged at your own facilities, at a PFBC site, or at the ABB premises. If this unique learning opportunity would be of value to your organisation, contact Lynne Anderson at the address below.

Name ____________________

Company ____________________

Title ____________________

Address ____________________

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☐ Please send me details of the one-day seminars

☐ Please send me details of the step-by-step guide to PFBC clean-coal technology

ABB Carbon AB
Marketing Department
S-61282 Finspong
Tel.: +46 122 81 700
Fax: +46 122 15 820

ABB
ASEA BROWN BOVERI

A way forward for coal

Increasingly stringent environmental standards have served to make conventional coal-fired plant progressively less economically viable. Clean coal technology, developed in the UK, but so far undemonstrated in this country, could hold the key to the future of coal-fired power generation.

A COMMERCIAL clean coal power plant which also demonstrates a key element of the topping cycle can be built in the UK within the constraints of the recent Government White Paper *(The Prospects for Coal*, March 1993), according to ABB Carbon of Sweden.

As identified in the White Paper (article 15.20) the partial gasifier is a key element for second-generation clean coal plants. ABB has developed a concept for a commercial 165 MW, clean coal, pressurised fluidised bed combustion (PFBC) plant enhanced at low risk by the addition of a partial gasifier developed at the Coal Research Establishment (CRE) and now awaiting demonstration. No government grant is required except for the R & D portion. The size of the demonstration gasifier to be 'added on' to the PFBC plant could be chosen within the financial constraints set by R & D funds available. Ideally this gasifier would be sized at 24 MW (thermal).

It would need Government support only in the form of a deferred but fully commercial, long-term loan for about 20% of the investment for the project to meet the investment criteria likely to be applied. Such a loan could be seen as being in return for the use of a commercial project as the vehicle for the demonstration and would not be in conflict with the policy set out in Article 15.18 of the White Paper. Moreover the Government loan could be made on the condition that if successful demonstration of the gasifier leads to increased project revenues — due either to improved plant flexibility or to credits for environmental costs avoided at other stations — then repayment would be speeded up.

ABB Carbon believe that a new clean-coal plant in the UK today would not lose money. The analysis of a 165 MW clean-coal plant shows that a return of over 8% (deflated) on equity and about 7% for the project can be expected over a project life of 30 years. These returns require no financial support apart from normal commercial loans. Cash flow is negative only for the first two years of operation. The project breaks even after 11 years of operation. However, in the economic climate existing in the UK today, such an investment in a new coal-fired plant is not considered an attractive proposition for two reasons. First, the project needs to be evaluated over a 25-30 year project life, but the future for UK coal is very uncertain over such a term. Second, the rate of return offered — while not unattractive over the long term — is modest in comparison to the returns offered by other projects when evaluated over shorter periods.

ABB Carbon suggest that 'encouragement' to overcome these barriers is possible if the Government's commitment to the long-term future of coal could be convincingly shown to potential investors, by funding the demonstration of a key element of second-generation clean-coal technology. They propose that this demonstration be of a small gasifier 'added on' to a commercial PFBC plant, without endangering commercial operation of the plant, yet at a meaningful size to be valid as a commercial demonstration. An additional encouragement would be for the project to receive support (repayable, at commercial interest rates and not a grant) during its early years. While a number of alternative ways of structuring such support could be devised, the simplest would be if the project could receive a commercial loan of perhaps 20% of the total investment, but with repayment deferred for 10 years. Equity payment could then be delayed until the end of the construction period, and the rate of return on equity would rise to over 11% (deflated). Cash flow would always be positive. Early repayment could be triggered if the project benefits from the demonstration aspects.

The economics of clean-coal power generation are considered here. The plant is a 169 MW PFBC plant using UK coal. The plant is enhanced by a small partial gasifier. The gasifier is taken to be a technology under demonstration and is therefore not allowed to either burden or benefit the basic economic analysis.

The plant investment cost assumes that a site is available. No land cost is therefore included. It is also assumed that the basic infrastructure for supply of coal and cooling water to the site, and transmission of electricity away from the site (road, rail) are existing. In all other respects the site is considered to be a greenfield site. Plant cost is estimated to be £180 million (10% accuracy). The construction period is taken to be 34 months.

Plant size, MW	168.8
Net Efficiency, LHV %	42.3
Coal consumption, t/h	58.3
Limestone consumption, t/h	c. 3
Construction time, months	34
Plant cost, £Million	180
Price level	January 1993
Interest rate, % (real)	5
Financial costs - construction period, %/year	1.5
Financial costs repayment period, %/ year	1.0
Taxation, %	33
Equity / debt	20% / 80%
Electricity price, p / kwh	2.9
Operating hours (full load equivalent)	7200
Coal price (unwashed, delivered), £/ton	30
Limestone price (delivered), £ / ton	11
Fuel oil price, £ / ton	70
Personnel, £/ man-year	35000
IDC + financial costs, £ Million	23

Basic assumptions for a demonstration PFBC plant.

Coal supply is taken to be slightly higher than world market prices, at 30£/ton, and is assumed to follow world price development through the life of the project. The plant itself is designed for a 30-year life.

The project is credited with an electricity price of 2.9p/kWh, with no credit for any extra revenues that may result.

The analysis of the base case shows that the project's net cumulative cash flow reaches break-even 11 years after operation. The rate of return (deflated) is 6.8%, while the rate of return on equity (deflated) is 6.8%. The minimum annual cover ratio is less than unity only for the first two years of operation.

From an analysis of the base case it appears that improving the cash flow in the first few years of the project, and/or improving the internal rate of return could provide the necessary stimulus for the investment. Forms of support which could improve the project include: a Government grant, which would improve both parameters but would be considered fundamentally unsound; a reduced coal price to be recovered later would help cash flow and the cover ratios; or a reduction in equity from, say, 20% to 15% would improve the internal rate of return but would reduce the cash flow. ❑

Contemporary passive solar developments

by Brian Norton

Professor Norton looks at recent developments in passive solar design, giving examples of their applications, and commenting on their effectiveness in given situations.

SOLAR gains contribute, at least part of the time, to the heating of virtually all buildings. Although it is obviously difficult to generalise, solar gains can often contribute 30% or more of a building's annual requirement for heating. In a passive solar design opportunities are taken, from conceptual stages of design onwards, to maximise the appropriate use of solar energy to provide heating, daylight and ventilation together with enhanced amenity. The latter can range from the additional space provided by a conservatory to the creation of a bright light working environment.

As justified concern has increased in regard to the environmental impact of the unnecessarily profligate use of fossil fuels, passive solar concepts have become established in the mainstream of design approaches leading to energy-efficient domestic and non-domestic buildings. Both the selection of the most appropriate approach to harnessing solar gains in a particular building and the detail of subsequent design, depend on the prevailing climate, the use and diurnal occupancy of the building, its site, and the relative and absolute magnitudes of the energy associated with meeting the likely requirements for lighting, indoor comfort and ventilation.

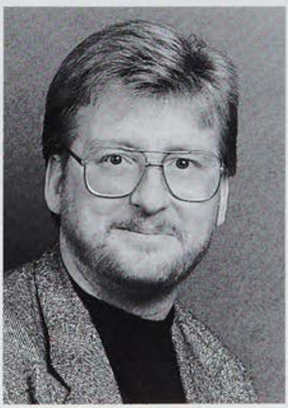
The most obvious method of capturing solar radiation in a room is through a window oriented at any angle from east to west through south. Heat stored within the building fabric ameliorates temperature fluctuations resulting from casual and incidental gains, and also may avoid overheating during particularly sunny periods. Windows facing north gain little in the way of heating from solar radiation. However, as designers of artists' studios have known, at least since the renaissance, useful, usually glare-free daylighting is provided through north-facing windows by diffuse radiation.

The influence of the sun and of solar motion on building design and urban planning, either fortuitously or by design, is, of course, nothing new. It probably pre-dates even the earliest archeological remains of buildings. Coming closer to home, and in time, in primary schools, for example, classrooms facing south or south east have been favoured, for the psychological advantages of the early morning sun, while avoiding overheating and glare in the late afternoon. However, other orientations can be employed to equal effect, for example non-domestic buildings with a majority of rooms which accept direct gains facing south west can be successful with the inclusion of overhangs and/or windows set well back.

The carry over of heat absorbed in a building's fabric from one day to the following morning is relatively small, even in fairly massive buildings, and the rate of heat loss is particularly high where there is a large amount of glazing. Excessive thermal mass also increases the demand for auxiliary heating on cold mornings, before the sun can have any effect. The mass provided normally is usually sufficient to prevent overheating in rooms which are not affected greatly by the sun. In atria and conservatories, additional thermal mass may be necessary to counter overheating. Ventilation is also used in such situations to keep temperatures down to acceptable levels.

For most of the UK heating season, air recirculated via a conservatory contributes very little to reducing the heat load. In contrast, if ventilation air for the building is prevailed upon to enter through the conservatory by wind-induced effects, natural buoyancy or fans, it will be heated by passive solar gains before passing to the rest of the building. With 0.5-1.5 air changes per hour, the ventilation heat load is of a similar magnitude to the conduction heat loss. This has been put into practice in a school in Hampshire, where it contributes 28% of the total heating requirements.

In the UK there are a diverse range of



Professor Brian Norton

The author

Professor Brian Norton is Head of the Department of Building and Environmental Engineering at the University of Ulster, and directs 'PROBE', the centre for Performance Research On the Built Environment.

A Fellow of the Institute of Energy, he is currently chairman of the Institute's Northern Ireland branch.

Professor Norton is the author of numerous research papers in the field of solar energy. His most recent book *Solar Energy Thermal Technology* was published by Springer-Verlag in 1992.

Nazeing County Primary School in Essex, left prior to refurbishment. This was a typical system-built school in urgent need of improvements in the weatherproofing and thermal performance of the building fabric. Right, the school after refurbishment. Thermosyphoning air panels providing solar heated air were incorporated as part of the curtain walls. They can be seen as the opaque elements which alternate with pairs of windows.

examples of successful, and indeed not so successful, passive solar dwellings and school buildings. Many dwellings have employed direct gain, often with conservatories. Issues that have been addressed, particularly in the higher density passive solar developments that have been built in Milton Keynes, include the privacy of occupants and the 'kerb appeal' of the design to potential purchasers. With notable exceptions, in domestic architecture passive solar design has not generally led to radical new forms.

The adoption of passive solar design in schools predates the use of the term. The desire for light and air has long had profound influences on school architecture. In schools, there has also been more willingness to include specific elements to facilitate the collection of solar gains rather than solely seek to optimise the size and orientation of conventional features such as windows and conservatories. The architects in two local education authorities producing buildings that are very highly regarded internationally, despite their often modest scale and the tight budgets within which they were built.

A Trombe-Michel wall consists essentially of a glazed cavity fronting a wall. The wall absorbs short-wave radiation and re-emits it as long-wave thermal radiation, which, together with a layer of immobile air, is effectively trapped in the cavity. The temperature of the air and the wall rise. Because the wall has a high thermal mass, there is a considerable time delay of several hours between the absorption of the solar radiation and transmission of the heat through the wall to the room behind. Vents may be provided at the top and bottom of the cavity to allow air to pass between the cavity and the room, thus reducing the time lag. The wall is also then operating in a thermosyphoning mode with heat flow to the room via convection. The normal mode of operation is to open the vents only when heating is required in the room. As most non-domestic buildings are only used during the day, the availability of heat late in the afternoon and evening is not of particular advantage. More importantly, in the UK climate, very sunny days followed by severely cold nights are not common. It is for such conditions, in the Pyrenees, that the Trombe-Michel wall was originally devised. The use of Trombe-Michel walls in the UK has thus been limited. However a school in Looe, Cornwall, incorporates 'mini Trombe walls', topped by a concrete bench, to moderate temperature fluctuations and take advantage of solar gains. This feature has been estimated to contribute approximately 2-4 kWh/day towards the auxiliary heating of the school.

In St John's School, Clacton, Essex, completed in 1980, special lightweight external cladding was designed in the form of vertical ducts with glass external and steel internal layers. As with a Trombe-Michel wall, solar

Houses in Milton Keynes with, on the right, a roof-space collector, and on the left without. Both have most of the windows on the south side.

gain is collected in the space between the glass and the inside wall, but in this case the heat is not stored but is passed directly to the inside, or vented to the outside when not required. As with many of the concepts and devices in this field, this is an idea of long standing. This concept was first patented in the USA in 1881, It has been developed further at a school in Nazeing in Essex, where such devices, being a component of modular commercial curtain-walling system, were used , in 1988, to replace disintegrating facades.

A roof-space solar energy collector is essentially a glazed roof into which fresh air enters at the eaves and is heated by solar energy before being conveyed by fans to occupied areas. It may provide a preheated supply to a warm-air heating system. Return air is recirculated to the heaters or vented at the roof ridge, possibly via a heat recovery unit.

Roof-space collectors in schools have certain advantages over atria and conservatories, as they leave the internal layout unaffected.

The high ratio of roof to floor area especially for single storey primary schools provides a large potential for solar energy collection, and the system can be less prone to summer overheating. The relatively rapid thermal response is compatible with occupancy patterns.

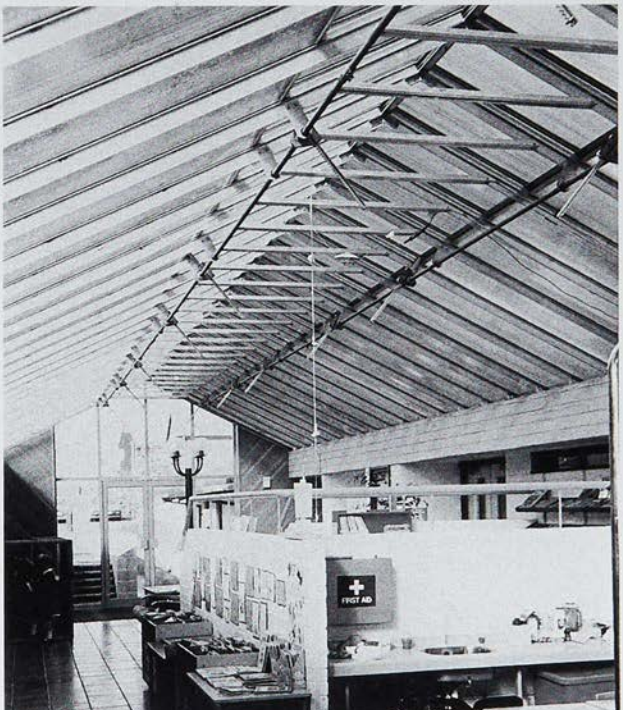
As with conservatories, the roof-space collector need not be at a temperature above that of the building to provide a beneficial effect, assuming it is above ambient, since any warming of the air passing through roof space will provide some reduction in the ventilation heat load.

Green Park School, Newport Pagnell, Buckinghamshire, incorporates three roof-space collectors providing ventilation air preheat to gas-fired warm-air heaters, as well as optimised fenestration to enhance daylighting. This building has been very popular with its occupants whilst also being energy efficient.

Despite the long history of solar energy heating buildings, it is only recently that significant changes in the nature of typical building fabrics have began to emerge. In particular advanced glazing systems to deflect daylight deep in rooms have been developed. An example of such a system was used in the re-modelling of the old Billingsgate fish market in London. In laboratories worldwide, research is underway to develop windows that, by including aerogels or a vacuum, exhibit very low rates of heat loss. Significant advances are being made in the development of large-scale 'switchable' windows that change, with an electrical, thermal or light stimulus, from transparent to opaque.

Considerable information is available to designers seeking to know more about passive solar design. Practical design support is now also available in the context of the Energy Design Advice Scheme (EDAS) organised by the Building Research Energy Conservation Support Unit based at the Building Research Establishment at Watford. EDAS regional centres have been established to date in London, Scotland and Northern Ireland. In EDAS advice is provided on the most appropriate and coherent measures to adopt to achieve, in a particular context, an energy-efficient design. ❑

Green Park School, Newton Pagnell, showing roof space collectors for preheating air before it enters a gas-fired warm air heating system.



Internal view of the atrium at Barnes Farm School, Chelmsford, Essex, built between two blocks of classrooms.

Exporting power from Iceland to the UK

*by Halldor Jonatansson**

THE IDEA of exporting electricity from Iceland to the UK or the continent of Europe was first discussed publicly in Iceland some 40 years ago, at a meeting of the Icelandic Electrical Engineers' Association. Since then high voltage direct current technology has advanced to such an extent that transmission of electricity through HVDC submarine cables is becoming more and more common. In the past six years this favourable development has encouraged Landsvirkjun, the National Power Company of Iceland (NPC), to study increasingly the feasibility of exporting electricity from Iceland to the UK and/or the continent.

Icelandic export of electricity is recognised as one of the two main means to the large-scale utilisation of Iceland's hydro and geothermal power potential. The other means being the power-intensive industrialisation of the country. The power is certainly there, since Iceland has harnessed about 10% of its potential, or 5 TWh per year out of a possible 50. This is in spite of the fact that Iceland is fully electrified, where practically all its inhabitants have access to electricity, and the consumption of power per capita is one of the highest in the world, second only to the Norweigians.

UK import of electricity from Iceland would constitute increased use of non-polluting renewable energy sources at the cost of the polluting and risky use of fossil fuels and/or nuclear power. Such imports would therefore be environmentally beneficial to the UK, and in line with the objective established by the EC of achieving a considerable reduction in sulphur, nitrogen oxide and carbon dioxide emissions in the near future.

Renewables provide the answer to many of our global energy problems, but the potential in the UK is somewhat limited. In this article the author suggests importing power from a country rich in renewable sources of energy.

Export of electricity from Iceland to the UK would furthermore be in the spirit of the report of the United Nations' Commission on Environment and Development, the so-called Brundtland Report, which encourages us to think in global terms about the earth's energy sources, to use environmentally friendly energy sources instead of polluting ones, and to do this without regard to national boundaries.

In the past few years extensive changes have taken place in the UK electric power industry with its privatisation. Similar development is taking place in Norway, Sweden and Finland. The EC has submitted ideas of increased freedom in the electrical industry and taxation of polluting suppliers of electricity. In order to diversify their energy sources and be less dependent on more polluting energy sources like coal, countries in Europe, and the UK in particular, aim at vastly increased use of natural gas for the generation of electricity. In north and central Europe, plans for the building of nuclear power plants have been shelved and numerous nuclear power plants will probably be decommissioned during the next decade. One of the consequences of this development is that power companies in Europe currently seek new ways in electricity production and interconnections with other electric power systems. In 1994 we will see the completion of a 600 MW submarine cable between Sweden and Germany. Recently, Statkraft of Norway took up cooperation with Siemens, ABB and Alcatel to study transmission of electricity via submarine cable from Norway to the Netherlands or the UK. A group of Norweigian power companies and the Dutch company EDON are also investigating the possibility of importing electricity from Norway to the Netherlands. The Dutch companies EPON, PGEM and NKF, in cooperation with Icelandic engineering companies, and the City of Reykjavik, are likewise studying the possibility of exporting electricity from Iceland to the Netherlands.

**General Manager, Landsvirkjun*

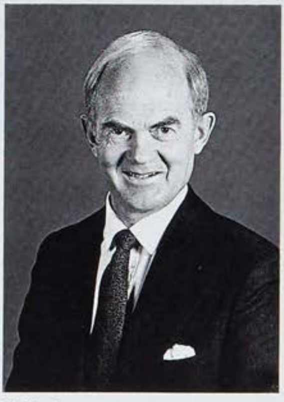
The author

Halldor Jonatansson, a law graduate, began his professional career with the Icelandic Ministry of Justice in 1957 after completing his MA at the Fletcher School of Law and Diplomacy, Medford, Massachusetts. From there he went on to become division chief in the Ministry of Commerce.

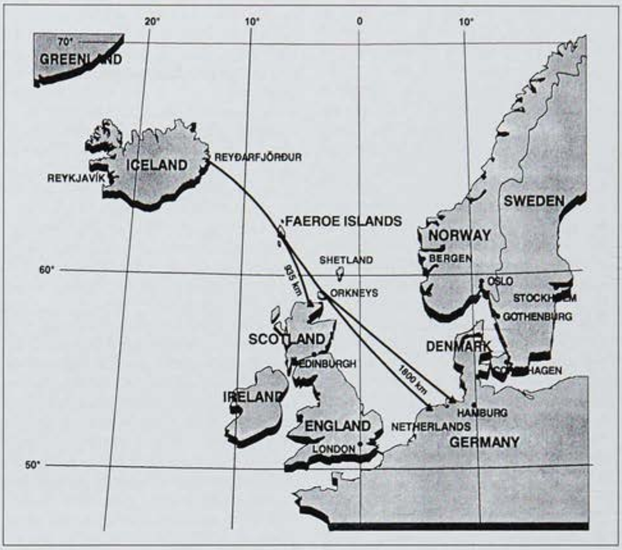
Mr Jonatansson joined Landsvirkjun as office manager in 1965. In 1971 he became deputy general manager, taking over the post of general manager in 1983.

In addition he is deputy chairman of Icelandic Electric Utilities, a board member with both Nordel and the Iceland National Committee of the International Chamber of Commerce, and a committee member of UNIPEDE.

He has published numerous articles.



Halldor Jonatansson



Possible submarine cable routes: Iceland — Scotland — mainland Europe.

Furthermore, the German power company Hamburgische Electricitats-Werke AG has shown a growing interest in the import of electricity from Iceland. Turning finally to the UK, informal discussions are already taking place between NPC and Scottish Hydro-Electric concerning the possibility of such import to Scotland. This possibility has also been introduced to several other UK power companies, with alternative sites for landing the cable on shore.

Feasibility studies

The competitiveness of Icelandic power costwise, and the environmentally friendly aspect of export of electricity from Iceland call for the feasibility of such exports to be scrutinised. Accordingly, NPC has recently obtained a pre-feasibility study report from Pirelli Cables, UK, which was recruited by NPC a year ago to carry out such a study. In these investigations, NPC is also relying on services rendered by Vattenfall Engineering AB, Sweden, the Icelandic engineering company Afl Ltd and UK consulting firm Caminus Energy Ltd. The Icelandic Energy Marketing Unit, owned by the Ministry of Industry and NPC, is also participating in the study as far as the marketing is concerned. The conclusions of these studies so far are that export of electricity from Iceland to the UK through a HVDC submarine cable is not only technically feasible but most probably also economically.

The principal conclusions of these studies and estimates to date are in general terms as follows:

- there are no major technical problems attached to the manufacture and installation of a HVDC submarine cable from Iceland to the UK or the continent of Europe;
- in recent years, advances in the manufacture of submarine cables have resulted in increased transmission capacity and lower transmission costs. This development will most likely continue in the near future;
- presently, NPC is studying the possibility of exporting electricity through one or two cables from Iceland. Net power transmission to north Scotland over a single 550 MW submarine cable is estimated at about 4400 GWh/year on average;
- considerable preparation work and further research has to be carried out for five to six years before a decision to go ahead with the project can be taken. When such a decision has been taken it will be possible to complete tendering, sea trials, type tests, manufacture and installation of the first cable over a period of four to six years, depending on whether two or four factories manufacture the cable. For two cables the estimate is six to 10 years;
- the Pirelli report presents a technical feasibility study of the manufacture and installation of the submarine cable. A corresponding study must be undertaken with regard to other technical premises, such as converter stations and the operation of the DC link. Simultaneously, studies must be carried out regarding other aspects of the project such as marketing, financing and ownership;
- it is clear that the installation of a submarine cable from Iceland to the UK or the continent is technically possible. Such an installation also appears to be economically feasible. All studies hitherto therefore recommend further investigation of this possibility.

Cable technology

In light of current cable technology and foreseeable advances in the next few years, a submarine cable between Iceland and the UK or Europe will have a copper conductor and insulation of oil-impregnated paper which has been used with favourable results for decades, both with AC and DC, and with ever higher voltages. A double steel armouring will give the cable the necessary strength and protection against external damage.

The most likely cable route between Iceland and Scotland lies from the east coast of Iceland, travelling in an easterly direction, then southeast along the northern sector of the ridge between Iceland and the Faroe Islands at a depth of 500-700 m. In order to facilitate location of the cable faults and supervision, it is proposed to take the cable ashore on the Faroe Islands. The deepest portion of the route is between the Faroe Islands and Scotland, the Faroe-Shetland channel, with a maximum depth of 1100 m. From the Faroe-Shetland channel to the north coast of Scotland the depth is about 100 m or less. Landing in Scotland is scheduled near Dounreay. The length of the cable is estimated at 935 km.

In order to reduce the probabilities of the cable sustaining damage caused by wave actions, fishing gear and anchors, it will be necessary to bury it 1.5-2 m into the sea bed down to a 10 m depth, thereupon one metre to a depth of 200 m and finally 0.6 m down to a depth of 500 m where necessary. In the North Sea, cables are generally buried 0.6 m into the sea bed, which is considered sufficient protection against fishing gear.

Converter stations where AC is converted to DC and vice versa will be of a conventional type. The length of the cables creates certain difficulties due to the large electrical capacitance which, however, can be overcome with present technology and only a minor rise in costs.

The operational security of the submarine cable has considerable influence on its profitability, as the volume of power transmitted as well as its market value is reduced through decreased operational security. The operational security of converter stations is generally well known, but it is necessary to conduct a special study of whether operational conditions of very long submarine cables result in inferior operational security of the stations. Despite the fact that numerous cables have been installed in many parts of the world in recent years, there are only a few which are of a similar type and protected to the extent proposed for a cable from Iceland. According to Pirelli's assessment, there are only 11 comparable cables in the world, eight of which are across the English Channel. The operational time of these eleven cables ranges from five to 14 years, and only a single breakdown has occurred in one of them. Special attention is aroused by the six years' experience of the English Channel cables where no breakdown has occurred, despite enormous traffic of ships, but much care was taken in the burying of the cables into the sea bed.

On the basis of available statistical data from the operation of existing cables and converter stations it is estimated that the average availability of a DC connection between Iceland and Scotland could be about 96%.

The investment cost of two submarine cables from Iceland to north Scotland, including converter stations and DC high tension lines, amounts to about £1.2 billion.

The estimates made by Pirelli apply to a submarine cable to north Scotland and are based on conditions on that route. Costs of converter stations, overhead lines and other relevant items are estimated by NPC's consultants. Operational costs have been assessed on the basis of the estimated number of breakdowns, repair costs and the operation and maintenance of converter stations. Assessment of repair costs is provided by Pirelli, but other operational costs are based on information from Vattenfall.

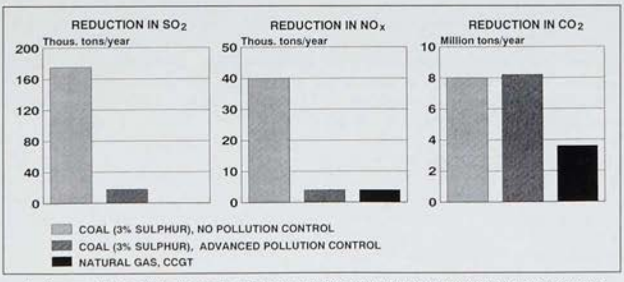
Investment in one 400 kV submarine cable transmitting 550 MW from Iceland to north Scotland is estimated at £0.6 billion and the transmission cost 1.1-1.3 p/kWh, depending upon interest rates. Adding this cost to the estimated electricity generation cost of 1.4 p/kWh, the cost price in Scotland would be 2.5-2.7 p/kWh, depending upon interest rates, compared to 2.7-3.1 p/kWh, which is the estimated cost price of electricity from natural gas plants in the UK, and to 3.5-4.0 p/kWh from new UK coal plants. These figures neither include an export charge on electricity from Iceland, nor carbon taxes on electricity from natural gas or coal plants.

The power projects which will undoubtedly be most economical for export of electricity, in view of their size, location and the cost of power, are major projects situated near the east coast of Iceland and have a total generation capacity of 11 000-12 000 GWh/year. However, environmental issues remain to be solved, and solutions are being sought in close cooperation with the Iceland Nature Conservation Council.

One may influence the time it takes to manufacture a submarine cable and install it by applying variable numbers of factories, but it is more difficult to expedite the construction of power projects. According to a time schedule for research, manufacture and installation of a single submarine cable to Scotland, about 12 years will pass until the first submarine cable could be brought into operation, around the year 2005. On this assumption, the final decision on the manufacture of the cable would have to be taken in the year 2000. It should then be possible to take the second cable into operation in 2010.

I shall not deal here with the important aspects of the project such as marketing, ownership and financing, as their preparation is not sufficiently advanced. The respective authorities in Iceland have not yet formulated important items of their policy with regard to the export of electricity. In order to clarify their position in this matter, the Minister of Industry has recently appointed a committee intended to prepare a White Paper on the formulation of policy by the Icelandic Government concerning the export of power. The committee is due to complete its work in early 1993.

Conclusions arrived at in the studies made so far regarding the possibility of exporting Iceland's electricity are, in the opinion of the NPC, promising enough to warrant a continuation of various relevant technical studies and appraisals, such as studies of electrotechnical joint operations of power systems and preparatory design of converter stations and DC overhead lines. More accurate studies and research must also be conducted on the cable route, the manufacturing capabilities of cable factories, the development of trenching equipment for extensive depth, cable joints, methods and equipment for fault location, technique for cable repairs at great depth and techniques for crossing of submarine installations. Primary assessment of environmental effects is also pending.



Environmental benefits of imports of clean electricity from Iceland compared to electrcity production based on fossil fuels, and two 550 MW submarine cables to Scotland.

The environment

It is a well known fact that producing electricity in hydro electric power stations is generally the most economical means of producing electricity and does not create any pollution. This clean form of electricity production is therefore most desirable with regard to the impact on the environment, at least wherever such power stations can be constructed in reasonable harmony with their natural surroundings.

The total consumption of electricity in the world today is around 11 000 TWh/y. Of this only 20% is produced by hydro, despite the fact that the potential worldwide for electricity production from hydro has been estimated to lie between 10 000-15 000 TWh/y. This stems partly from the remote nature of the majority of harnessable hydro sites in the world from the markets for electricity. This may be changing, however, because of advances made in transmission techniques. The environmentally friendly effects of electricity production by hydro must lead to ever increasing efforts to harness this great source of power for our already overpolluted world.

The possibility of transmitting electricity produced from hydro from Iceland to the UK seems to be within practical limits in respect of technology and economy. Besides introducing a new dimension to the UK electricity market, this undertaking would also alleviate the pollution problems of electricity production from fossil fuels that otherwise would have to take place. At present, it is foreseen that it might be practical to export approximately 1100 MW, corresponding to about 9 TWh/year, via two cables to the UK, resulting in a considerable reduction of greenhouse gases. Although such reduction would only constitute a small contribution to the solution of the global pollution problem, it would still be a step forward in restoring the atmosphere.

The export of electricity from Iceland to the UK and/or the continent is an exciting possibility and all studies so far make it a most promising one. ❑

Institute participates in DTI conference workshops

AS PART of a Department of Trade and Industry conference *The global technology partnership*, The Institute of Energy was asked to run one of 15 workshops, to run in simultaneous sessions in the afternoon slot, following the morning's conference speakers.

The conference was the result of the Prime Minister's commitment to the idea of technology partnerships between nations of the developed and developing world, expressed at the Rio Summit last year. *The global technology partnership* launched the Technology Partnership Initiative, which sets up a network of non-governmental organisations, such as the International Energy Agency, to advise countries wishing to take part in technology transfer. It was organised to coincide with the Environmental Technology 1993 exhibition at the NEC in Birmingham, and was held in the adjoining Metropole conference centre.

An impressive line-up of speakers, including Prime Minister, John Major, Michael Howard QC MP, Jacqueline Aloisi de Larderel (director of UN Environment Programme) and Santos de Sampaio Nunes of DG XVII, spoke to a large audience, comprising delegates from all over the world, with a particularly high proportion from developing countries.

Workshop sessions took place on a wide range of subjects, including waste management (organised by AEA Technology); the role of the scientific community (organised by NERC and SERC); recycling (organised by Proctor & Gamble), and transport, organised by the Transport Research Laboratory.

The subject chosen for the Institute's workshop was 'Sustainable energy generation'. Six presentations covered the entire area of intermediate-scale power generation, and included a paper which examined the mechanisms for successful technology transfer and partnerships. The Institute produced a bound copy of more detailed versions of the presentations for each delegate attending the workshop, so interested parties could study their areas of interest in greater depth at their leisure.

Senior Fellow, Eur Ing Brian Locke started the session with an overview of his paper on mechanisms for technology transfer. As an energy engineering consultant he has had much experience of technology transfer in developing countries, and was acutely aware of the problems likely to confront UK companies unused to dealing with third world countries: religious holidays and different working practices are good examples of cultural differences which must be taken into consideration if a technology transfer is to be successful.

The second presentation was based on work carried out at British Coal's Coal Research Establishment, and sought to inform delegates about clean coal technologies. This is of particular importance in developing countries, where coal is often cheap and readily available, making it imperative that clean methods of burning fossil fuels are in place if the associated environmental problems are to be avoided.

Tony Marshall of Babcock Energy Ltd gave a synopsis of his paper which concentrated on energy recovery from biomass and other waste materials. Again this was of particular relevance to developing countries, for whom a cheap source of fuel is vital.

The use of internal combustion engines and steam turbines, which operate on all types of fuel, was the subject of a paper by W H Allen's Bill Page. He summarised the challenge to engineers, who must improve both efficiency and cleanliness of such machinery, whilst maintaining the reliability and economy of operation.

British Gas' Jim Liptrot gave an overview of the work of the Global Gas division of the company. Again the emphasis of the presentation was on the environmental aspects, about which delegates showed a high level of concern.

The workshop concluded with a joint presentation on renewable energy by Professor Peter Dunn, of the University of Reading and Anthony Derrick of IT Power Ltd. It was this final presentation which attracted the greatest interest from third world delegates, who, despite the high capital costs, found the notion of a free fuel supply most interesting. Professor Dunn and Mr Derrick were able to tell the audience of applications, both in the UK, and in developing countries, where IT Power have carried out a number of successful projects.

The three sessions were ably chaired by Professor James Harrison, President-elect, who congratulated the speakers on their performance of the difficult task of condensing complex papers into 10 minute slots.

A display at the back of the workshop area, comprising many free leaflets and publications, as well as Institute publications for sale at drastically reduced prices, created much interest, and provided a contact point between delegates and speakers.

Copies of the papers from the *Sustainable energy generation* workshop are available from the Institute, tel: 071 580 0008, fax: 081 580 4420, priced £5 inc. p&p (UK).

Excellence rewarded

INSTITUTE Fellow, Dr Jasper Mardon, pictured above, has been elected an Honarary Life Member of the Canadian Pulp and Paper Association. He was the 39th member of the technical section of the association to receive this honour since its foundation 78 years ago.

In addition, Dr Mardon was awarded the R S Jane Memorial Lecture Award by the Canadian Society for Chemical Engineering.

He was born in Exeter, Devon in 1921, and moved to Canada in 1950, since when he has worked on all aspects of papermaking.

Institute events

South Wales & West of England branch annual lunchtime lecture and luncheon. *The Environmental Protection Act: its Implementation and Implications for UK Energy Usage* by Dr D Slater, director & chief inspector, Her Majesty's Inspectorate of Pollution (HMIP). At British Coal's Coal Research Establishment, Stoke Orchard, Cheltenham, Gloucestershire. Reception at 11.15 am, 18 June. Lunch after the lecture, courtesy of British Coal. Please contact Bob Wardell on 0242 873861 if you wish to attend.

The Combustion Engineering Association has organised a conference & exhibition *Oxygen for Clean Combustion* on 8 June at Forest of Arden Hotel, Coventry, starting at 9 am. The seminar will focus on the use of oxygen in combustion to provide both process benefits and viable, environmentally acceptable solutions to new and emerging legislation. Whilst traditional oxygen applications will be discussed, the emphasis will be placed on more recent and current applications, particularly in the copper, glass, non-ferrous metals, municipal waste, steel and power industries. The papers will focus on combustion engineering issues which are technically and environmentally challenging. For more details, tel David Suthers on 0685 879119.

Good news, bad news

'Renewable energy' edited by Johansson, Kelly, Reddy and Williams.

Published by Earthscan Publications Ltd, London, 1993, 1200 pp, £30.00 P/B, £60.00 H/B.

RENEWABLE energy is free! and in some cases (such as landfill gas or waste combustion) people will even pay you to take it away! That is the good news. The bad news is that this means the renewables are capital intensive, even more so than nuclear power. So the renewables are finding it difficult to compete economically with subsidised coal and cheap gas turbines.

Nevertheless, renewable technologies are clean and some of them are reasonably cheap. The future looks bright for those fortunate ones in certain situations. After all, hydro power provides nearly 15% of the world's electricity (550 GW in 1989), geothermal provides 6 GW of generating capacity and twice that amount of heat, while winds farms add a few more GW. So there is a lot of it about! In my view, this volume does not make enough of these existing and successful installations.

In capital-rich countries real progress is being made, and there are substantial plants operating on a fully commercial basis — or at least as commercial as any other source of energy. Subsidies are endemic across the whole of the energy field, and many of them are well hidden. As the editors explain "the merits of renewable energy are often masked by national policies that subsidise fossil or nuclear energy technologies." They might have said more about the subsidies that are often received by the renewables.

In capital-starved developing countries, such as India, this book points out: "high interest rates should be used for investment decisions". That being the case, they are not going to find many situations which are right for the renewables. The editors have tried hard to find practical and economic applications in the third world, but they are few and far between.

The material for this book has a sound pedigree. It was put together for the 1992 UN conference in Rio by the United Nations Solar Energy Group for Environment and Development. The overall balance of the book reflects this solar energy interest. Wind power, which is in widespread use, gets no more space than the highly speculative topic of solar hydrogen. Other solar energy topics receive even more attention, although they are not economic. Hydro power on the other hand, gets only half as much space as wind. Geothermal gets nearly as much attention as hydro, while tidal and wave power have to share a brief chapter with ocean thermal energy conversion and salinity gradients.

With this bias towards solar, there will no doubt be many enthusiasts who feel their particular renewable technology does not get a proper share of attention or appropriate emphasis. Even if they are right, I do not think they can claim that their technology has been unfairly or inadequately treated. As far as I can see, each individual topic is quite soundly and carefully analysed, with enthusiasm and optimism held tightly in check in most cases. Each chapter has evidently been subjected to critical peer group review, and this shows in the careful wording that is generally used.

"It seems implausible that integration difficulties will significantly constrain the use of wind energy in most regions" and "Wind power is already cost competitive with conventional modes of electricity generation under certain conditions", we are told. Such statements seem rather cautious when wind turbine capacity in the UK has jumped from 21 MW to nearly 100 MW in the last six months. So those interested in the renewables will find a considerable amount of carefully edited information collected together in this volume.

There are many who are suspicious about the renewables. They want to know what all the fuss is about. If the renewables are so attractive, why are there not more of them? This book provides plenty of information to answer that question. It gives many and various individual insights into the reasons for lack of success — and most of them are financial. "Private sector discount rates are unfavourable to most ... projects" (hydro); "deployment will depend on the availability of capital at modest discount rates (tidal); "commercialisation of the process is hampered by the need for substantial capital investments" (geothermal); "the major barrier to wide-spread adoption ... is its high cost" (photovoltaics); "although proven at a small scale, the technique is ham-strung by poor economics" and "the market ... will be greatest wherever fossil fuels are most expensive" (ocean thermal).

Evidently those renewables that are making the grade are doing well to overcome such difficulties: "Ethanol can be expected to compete directly with oil derivatives in the near future", "wind power is already cost competitive", "the cost advantage of biogas-based electricity ... increases with interest rate", "the intermittents can be treated as completely reliable plant with a capacity equal to the average annual output" — there is no doubt that more of the renewables are coming. This book will help the professional energy engineer to understand them.

Prof D T Swift-Hook

13th edition

'Engineering Reference Book on Energy and Heat'

Published by VDI-Verlag, Dusseldorf. 180 pp, 30.00 DM.

THIS is the 13th edition of a reference book first published in Germany in 1934. Although many of the references, which are the source of the charts and equations, date from the 1960s, all of the material is given in SI units for this edition, and the scope of the book has increased.

There are 14 chapters, covering heat transfer, combustion, steam generators and water quality, steam turbines, cooling systems, pipework, energy storage, compressors and pumps, cogeneration and gas turbines, and temperature measurement.

Clearly the reference book has been successfully used by engineers for 60 years, and this English version is most welcome.

This is not a text book, and there is no information on design. There are a series of nomographs, many of which have to be pulled out, which makes them difficult to use as they do not lie flat thereafter. The labelling of the lines is often confusing, and in some diagrams there are areas where the lines run into each other — omission of some lines in that area would have enabled the user to obtain a better answer. Also in the drafting the use of heavy and thin lines would help the user to follow the line he is using across the page.

This is a reference book so there is no background information on the charts or equations. A more serious omission of practical importance to the engineer using the book is the lack of indication of the level of accuracy to be expected. The reviewer worked on committees for the Engineering Sciences Data Unit in London, and the question of the likely accuracy of the numerical answers and the conditions and areas covered by the experiments (eg, heat transfer) gave the user a feel for how much he could rely on his arithmetic. The 'average' figure is not suitable for all engineering purposes.

Whilst noting the limitations of the reference book, it is surprising to see that in the heat transfer section, data are given for heat transfer to tube banks in cross flow, but the engineer will search in vain for a chart or reference by which the pressure loss across the bank can be assessed, an essential ingredient of a tube bank evaluation.

However, these are detailed points, and I suspect the English reader will welcome a book which draws from the central European tradition, rather than the Anglo-American work, so often the main source for our own reference and textbooks. Particularly useful are the tables outlining the emission standards in Germany.

N G Worley

The other half

A ONE-DAY conference to investigate the recruitment of women is to be held this month, on 19 May, in Edinburgh.

The conference is targeted at careers representatives in secondary schools, further and higher education; science and technology advisers; industrialists and industrial liaison officers.

The *Women Into Science and Engineering — The Other Half* conference is organised by the Engineering Council and the Teaching Company Scheme, and sponsored by NCR (Manufacturing) Ltd.

Speakers will include Jim Adamson OBE, of NCR, Helen Liddell of the Business Venture Programme; Marie-Noelle Barton of WISE at the Engineering Council, and John Monniot, deputy director at the Teaching Company Scheme.

The conference is free of charge, and will be held at the Caledonian Hotel, Princes Street, Edinburgh. Applications for admission should be directed to Sarah Goodyear, The Teaching Company Scheme, Hillside House, 79 London Street, Faringdon, Oxon SN7 8AA.

Partners in science

A LEAFLET encouraging partnerships between scientists and schools was launched at the Edinburgh Science Festival in April.

Sir Francis Graham-Smith of the Royal Society and the Committee on the Public Understanding of Science (COPUS), said at the launch: "Structured partnerships between scientific institutions and schools can significantly enhance public understanding and awareness of science, mathematics and technology."

The leaflet, the second of a series, forms part of COPUS's wider programme to encourage scientists and engineers to recognise their responsibility and take part in heightening public awareness of science and technology. It explains why communicating science is so important, and how scientific bodies and schools can work together, and how to set partnerships going, as well as listing useful organisations already active with schools.

It also calls for the active support of the senior management in scientific institutions and departments for structured and flexible partnerships with schools developed in close collaboration with local teachers.

Now have your say

ENGINEERS throughout the UK will soon be given the opportunity to discuss the Fairclough Initiative report.

The report's contents were still unknown at the time of going to press, but they will deal with the future of the engineering profession and are due for publication imminently.

Starting later this month a series of 20 meetings will be organised in major centres throughout the country. These meetings will be open to all engineers, and should allow the widest possible discussion, with individual engineers able to get their views known.

Setting seal on engineering careers

TWO leading bodies promoting engineering as a career, the Engineering Council and the Engineering Training Authority (EnTra), have signed an agreement to work more closely together.

The two organisations will collaborate to ensure that the regional delivery of engineering careers information to young people becomes more efficient and effective.

A key feature of the agreement is for EnTra's careers information service to provide the Council's Neighbourhood Engineers scheme and the regional organisations with free literature for use in secondary schools. The Neighbourhood Engineers will also ensure that school careers libraries carry up-to-date EnTra literature.

The formal accord was signed by Denis Filer of the Engineering Council, and Ken Jones of EnTra, who said "Greater coordination and cooperation among careers providers is a key part of EnTra's strategy for supporting companies in the engineering sector in their task of attracting the most able young men and women into the industry."

Promoting staff development

A NATIONAL conference is to be held in London to highlight how staff can be technically and managerially updated through continuing professional development (CPD), enabling them to enhance the performance of their companies or organisations.

Making CPD work for you will be held on 7 June at the Institution of Civil Engineers' headquarters in London. The aim is to share good CPD practice and expertise, and it is aimed at senior management, recruitment, personnel and training staff, as well as individual professionals concerned with developing their careers and staff in education and professional institutions.

Keynote speakers will include Ken Burrage, director of Engineering Standards, British Rail; Derek Bradbeer, past president of the Law Society and John Steele, group personnel director of British Telecomminications.

The conference will offer a range of workshops, offering a practical opportunity to explore issues in depth. There will also be a series of professional development sessions to allow participants to focus on issues central to their work.

The Engineering Council operates a national system calling on engineers and technicians to carry out a planned programme of CPD with their employers. Support for the system has included £450 000 in funding from the Department for Education's Professional, Industrial and Commercial Updating (PICKUP) initiative.

Interested parties should contact Careers Research and Advisory Centre (CRAC) on 0223 460277. Other CRAC initiatives involving career development, education and training, help education to structure its involvement with industry, and help employers to develop their relationships with education.

Guide available

The Ivanhoe Guide to the Engineering Profession 1993 is available, priced £9.95, from Public Affairs, The Engineering Council, 10 Maltravers Street, London WC2R 3ER. Tel: 071 240 7891.

The Lord Mayor of London, Sir Francis McWilliams presents the Robert Blair Fellowship Award to Avril Blackmore, an engineering graduate of the University of Cambridge, now studying for her PhD at Imperial College, London. She is currently engaged in research on the buckling of oil pipes beneath the ocean. The award will enable her to spend six months at the University of Queensland, Australia.

May 1993

Asian Electricity: the growing commercialisation of power generation
Conference, 25-26 May, Singapore. Details from FT Conference Organisation, 102-108 Clerkenwell Road, London EC1M 5SA. Tel: 071 814 9770; fax: 071 873 3969/3975.

26th International Symposium on Automotive Technology and Automation
31 May - 4 June, Florence, Italy. Details from ISATA Secretariat, 42 Lloyd Park Avenue, Croydon CR0 5SB. Tel: 081 681 3069; fax: 081 686 1490.

June 1993

Indoor air quality
Conference, 8 June, London. Details from Conference Dept C3, Mid Career College, P O Box 20, Cambridge CB1 5DG. Tel: 0223 880016; fax:0223 881604.

Oxygen for clean combustion
Conference & exhibition, 8 June, Coventry. Details from The Combustion Engineering Association, P O Box 15, Farm Road, Aberman, Aberdare, Mid Glamorgan CF44 6YZ. Tel: 0685 879119; fax: 0685 879119/878104.

Current developments in North Sea drilling operations
Conference, 8 June, London. Details from Miss Caroline Little, Conference Officer, The Institute of Petroleum, 61 New Cavendish Street, London W1M 8AR. Tel: 071 636 1004; fax: 071 255 1472.

Foundation course in Rheology
Three day course, 8-10 June, Stevenage, UK. Details from Miss P Madhvi, Warren Spring Laboratory, Gunnels Wood Road, Stevenage, Herts SG1 2BX. Tel: 0438 741122, ext: 2366; fax: 0438 360858.

Thermal comfort: past, present and future
Conference, 9-10 June, Watford, UK. Details from Patricia Rowley, Building Research Establishment, Garston, Watford, Herts WD2 7JR. Tel: 0923 664488/664765; fax: 0923 664099.

Business transformation through electronic trading
Conference, 9-10 June, London. Details from Nikki Newman, tel: 0932 776259.

The environmental agenda: how will it affect the ESI?
Conference, 10 June, London. Details from European Study Conferenes, 16 Church Street, Wantage, Oxon OX12 8BL. Tel: 0235 770200; fax: 0235 771073.

EC emissions regulations and CHP: the way forward
Workshop, 11 June, Lincoln, UK. Details from Pamela Rudolph, Wren Business Service Ltd, tel/fax: 0403 785409.

ENERGY
Conference & exhibition, 22-24 June, Lo9ndon.
Details from Energy, Philbeach Events Ltd, Earls Court, Exhibition Centre, Warwick Road, London SW5 9TA. Tel: 071 370 8238; fax: 071 370 8143.

Risk in the local environment — setting priorities for action
Workshop, 23 June, Birmingham. Details from NSCA, 136 North Street, Brighton BN1 1RG. Tel: 0273 326313; fax: 0273 735802.

Materials aspects of CAD in magnetics
Seminar, 23 June, London. Details from Margaret Swadling, The UK Magnetics Club, Wantage Business Park, Wantage, Oxon OX12 9BJ. Tel: 0235 770652; fax: 0235 7711144.

19th World Gas Conference
23 June, Milan, Italy. Details from 19th World Gas Conference, c/o Studio EGA Professional Congress Organisers, Viale Tiziano, 19, 00196 Roma, Italy.

Quality and the environment
Seminar, 23 June 1993, London. Details from Amanda Wright, IBC Technical Services Ltd, tel: 071 637 4383; fax: 071 631 3214.

Pipeline Management '93
3rd international symposium & exhibition, 23-24 June, London. Details from The Conferences Manager, IWEM, 15 John Street, London WC1N 2EB. Tel: 071 831 3110; fax: 071 405 4967.

Explosion prediction and mitigation: congested volumes and complex geometrics
Short course, 28-30 June, Leeds Details from Miss Julie Charlton, Dept of Fuel & Energy, The University of Leeds, Leeds LS2 9JT. Tel: 0532 332494; fax: 0532 440572

July 1993

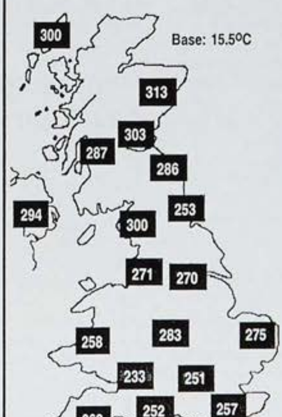
Gas Turbine Combustion
Short course, 5-9 July, Bedford, UK. Details from Mrs M Howard, School of Mechanical Engineering, Cranfield Institute of Technology, Cranfield, Bedford MK43 0AL. Tel: 0234 754644; fax: 0234 750728.

October 1993

Environmental analysis & risk assessment
MSc course, Imperial College, London. Details from The Registrar (Admissions), Imperial College of Science, Technology & Medicine, London SW7 2AZ.

DEGREE DAYS: MARCH 1993

Source: **Degree days direct**



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

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

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

© Vilnis Vesma, 1993. Because different observing stations are used, the figures given here will not necessarily agree exactly with those from other information providers.

INSTITUTE OF ENERGY CONFERENCES

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

How Climate Change Will Change Your Business

Government Strategy & Practical Responses

7 July 1993, London

in association with ETSU on behalf of the Department of Trade and Industry

Speakers include: The Rt Hon Michael Howard QC MP, Secretary of State for the Environment; Professor James Harrison, Institute of Energy; Peter Bach, Ministry of Energy, Denmark; John Collins, Advisory Committee on Business & The Environment; Professor Peter Jones, University of Westminster; Paul Davidson, BRECSU; Andrew Warren, Association for the Conservation of Energy.

International Conference on

Combustion & Emissions Control

21-22 September 1993, Cardiff

Keynote speeches from international figures will precede contributions on the following subject areas: Boilers and Furnaces, Emissions Reduction — Gas & Oil Systems, Emissions Reduction — Solid Fuels, Waste Utilisation and Combined Cycle Power Generation.

Making Energy Privatisation Work

The Future of Regulation

17 November 1993, London

Speakers include: Tim Eggar MP, Minister for Energy; Professor James Harrison, Institute of Energy; Professor Nigel Lucas, Imperial College; John Baker, National Power plc; Malcolm Chatwin, Yorkshire Electricity Group, plc; David Jefferies, National Grid Company plc; Cedric Brown, British Gas plc; Alan Marshall, AGAS; Lady Wilcox, National Consumers' Council; Ian Blakey, British Iron and Steel Producers Association; OFGAS speaker to be advised; Richard Caborn MP, Trade & Industry Select Committee. Conference Chairmen: Mr Ian Powe, Gas Consumers' Council and Professor Nigel Lucas, Imperial College.

2nd International Conference on

Ceramics in Energy Applications

April 1994, London

CALL FOR PAPERS

(closing date 30 July 1993)

The conference will consider material solutions to new and existing applications of interest to energy suppliers and users. Important aspects of materials innovation in energy saving will be explored. We would welcome the submission of abstracts on the following areas: New Developments & Applications; Energy Saving & Heat Transfer; Evaluation & Performance; Power Generation; Sensors & Catalysts; Energy Efficiency. For further information please contact Judith Higgins on 071-580 0008.

Events Co-Sponsored by The Institute of Energy

8 June 1993, Coventry, UK

Oxygen for Clean Combustion

The efficient use of oxygen in the process industries to meet environmental standards
Contact: The Combustion Engineering Association
Tel: 0685 879 119 Fax: 0685 879 119/878 104.

January 1994, Calcutta, India
First International Conference on

Combined Cycle Power Generation

General Enquiries should be directed to:
Professor Prabir Basu, Technical University of Nova Scotia, PO Box 1000, Halifax,
Nova Scotia, Canada B3J 2X4, Tel: 1-902-420 7531
Paper Co-ordinator for the submission of abstracts from European Countries:
Dr J R Howard, Tel: 44-21-705 1946

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