

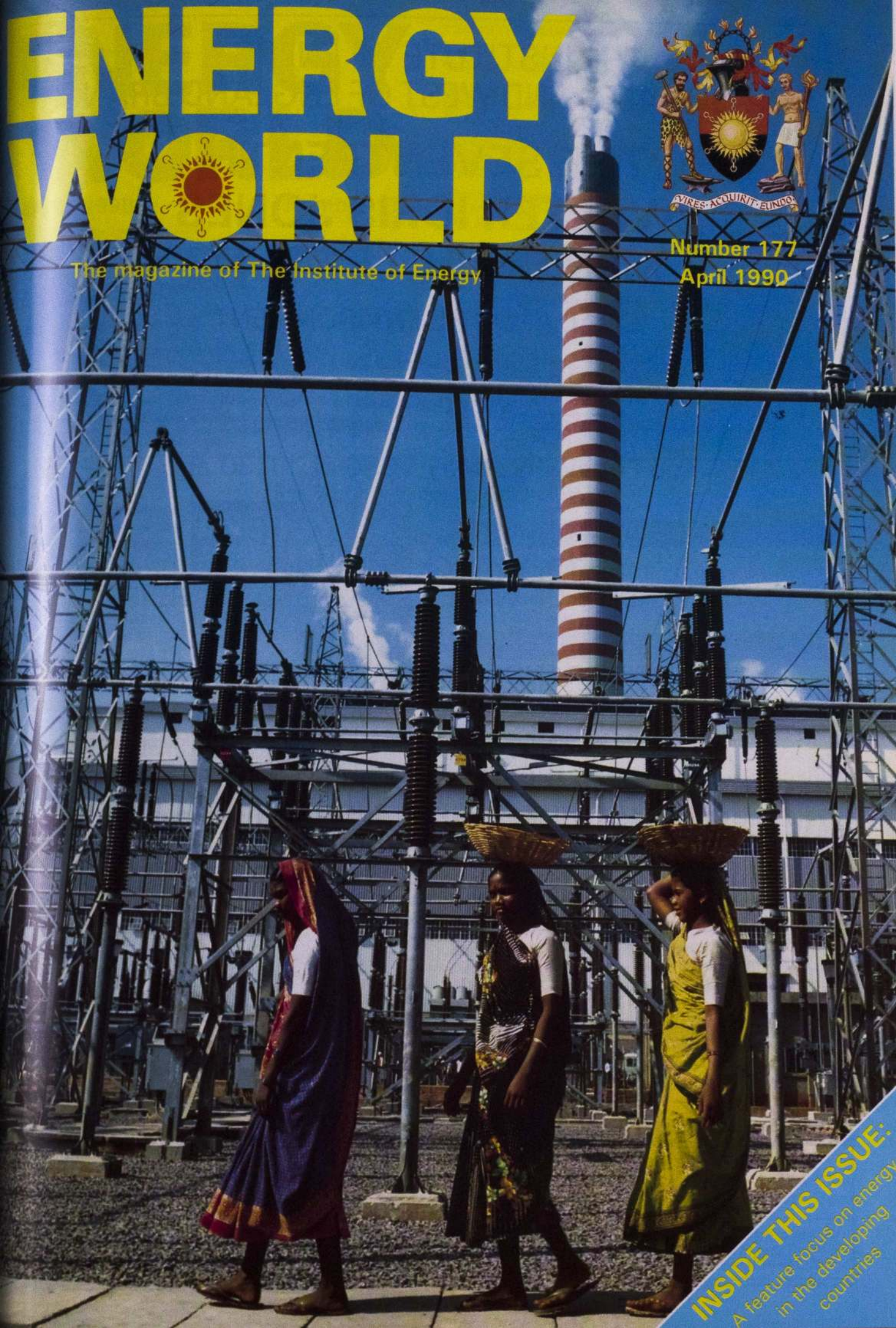
# ENERGY WORLD



Number 177

April 1990

The magazine of The Institute of Energy



**INSIDE THIS ISSUE:**  
A feature focus on energy  
in the developing  
countries

THE INSTITUTE OF ENERGY  
SOUTH WALES AND WEST OF ENGLAND BRANCH

**THE SEVENTEENTH  
WALTER IDRIS JONES  
MEMORIAL LECTURE**

'COAL AND THE ENVIRONMENT'

to be presented by

**Jim Harrison**

(Director, Coal Research Establishment)

on Friday 25th May 1990 at 11.30 am  
(coffee and reception at 11.00 am)

at the

**TREVITHICK BUILDING  
UNIVERSITY OF WALES COLLEGE OF CARDIFF**

to be followed by

**THE BRANCH ANNUAL LUNCHEON**

at 12.30 (sherry) for 1.00 pm (start of luncheon)

Admission to the lecture is free but those wishing to attend should apply for tickets, using the form below.

Tickets for the luncheon should also be applied for, using the form below.  
These will cost £5.00 a head inclusive of sherry and wine.

Early application is recommended as numbers for the luncheon are limited to 100.

Tickets will be sent out in early April.  
**(BCURA are sponsoring this event).**

To: Mr D H Mustoe  
20 Park Court Road  
Bridgend, Mid Glamorgan CF31 HBW

1. Please send me . . . . . tickets (free) for the seventeenth Idris Jones Lecture to be given on Friday 25th May 1990.
2. Please send me . . . . . tickets for the lunch. I enclose a cheque for £ . . . . . (made out please to The Institute of Energy)

Name (block capitals) . . . . .

Position . . . . .

Address . . . . .

. . . . .

Office . . . . . Signature . . . . .

# ENERGY WORLD

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## COVER STORY

Our cover picture shows an unusual view of the new power generation plant owned by the Bharat Aluminium Company at Korba in the state of Madhya Pradesh, India, with three of the local inhabitants and the power plant's switchgear in the foreground.

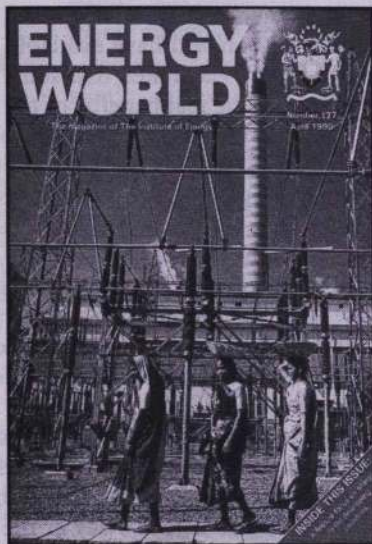
This coal-fired, captive power plant has recently become fully operational, supplying electricity to the company's neighbouring aluminium smelter and the local electricity grid. The plant

was to be turnkey and completely self-contained. This was the result of efforts by the Government of India to overcome power shortages by encouraging large power users to invest in captive power plants.

The power station has been supplied with 4 x 67.5 MW turbine generators manufactured by GEC ALSTHOM of Britain and France, who were also the project managers for the design, construction and commissioning of the station. Site work began in October 1984 and major plant installation was completed by November 1987. Commissioning of the last of the four turbine generators was completed in April 1988.

The cover photograph, reproduced by courtesy of GEC ALSTHOM, reflects something of the growing industrialisation, and hence energy-intensive economies of many of the developing countries.

For a more detailed appraisal of current energy issues affecting the developing countries turn to our series of feature articles, beginning on page 8.



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## TERMS OF CONTROL

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# Energy strategy for equilibrium

OUR CONSCIENCE tells us that we must leave a world for our descendants at least as good as that which our ancestors left to us. Moreover, it is quite certain that, in the long term, our own descendants cannot have a decent life in a world where millions of other humans do not. Technology has shrunk the world so much that we all sink or swim together, and we must seek a long term strategy for the whole of mankind.

Can mankind come into stable equilibrium with the environment or is he doomed to self-destruction? It seems to me that only if we first establish the necessary conditions for such an equilibrium, can we begin to move towards it, and thus ensure that our descendants have a life of higher quality than ours. By quality of life I mean one's gut feeling that one's life is 'worthwhile'.

Many observations indicate that when standard of living rises above a certain optimum level, the average quality of life falls, both because the desire for the acquisition of status symbols begins to replace creativity and caring, and because the earth's resources become overstretched. This is illustrated particularly strongly by the lives of many of the richest people in the world.

There are three kinds of technology:

- Primitive or pre-industrial technology (PT).
- High technology (HT) concerned with perpetual growth, of speed, size, sophistication, number of cars, gadgets etc.

• Technology appropriate for an equilibrium world (AT). AT overlaps the creative parts of PT, and those parts of HT which really contribute to human Quality of Life.

What are the requirements for appropriate technology? I suggest they are:

- The world's population must be stabilised by voluntary means. This necessarily implies making it possible for all potential parents to earn a decent standard of living and to receive a decent education.

- Since world peace is impossible so long as the gap between standards of living in rich countries and in poor ones is so large, this gap must be reduced to the point where it no longer produces dangerous tensions.

- Man's use of energy must not produce any cumulative pollution of land, sea or air.

- Eventually man must use only renewable energy sources.
- Work must be available to all which makes good use of their talents and trained skills both manual and mental.

These conditions lead to the following picture of man's use of

energy in the stable world.

1) To avoid the Greenhouse Effect the total world use of fossil carbon must be one third to one half what it is now. If 10,000 people are to have roughly equal shares this means that there is only two to three barrels of oil or 0.4-0.6 tonnes coal for each person-year. There is no such limit to renewable energy, even biofuels, since these take their carbon out of the air. Also it is necessary to cover as much of the earth's surface with green leaves as possible, and any timber must be grown on a renewable basis. Coppicing will be revived. It will be easier for those countries which have not grown used to energy extravagance to come up to this figure than for the developed ones to come down to it.

2) Fossil fuels must be regarded as a capital resource, ie, a substantial fraction of them will be spent on installing equipment for renewable energy of all kinds except those such as large dams which can have adverse long term environmental results. Thus when the fossil fuels are exhausted our descendants can have as much energy as they need.

3) Each person will have available a few tens of watts of electricity: I have calculated that some 20W would suffice to give everyone all the real benefits of the industrial revolution. This implies small local power stations of less than 1 MW in towns, while rural areas will need ones of a few tens of kW.

4) No combustion will emit detectable quantities of SO<sub>x</sub>, NO<sub>x</sub>, CO, unburnt or partially burnt hydrocarbons, or any other harmful product.

5) No artificially radioactive elements will be around, especially those such as C<sub>14</sub>, I, P<sub>32</sub> or S<sub>35</sub> which lodge in the human body. There will be no stores of radioactive material or sealed reactors left for future generations to deal with, with no benefit to themselves.

At present 'the powers that be' adopt the same attitude to energy matters as Canute's courtiers adopted to the tide: 'let us set up a committee and perhaps by the time it reports the problem will have gone away or the public will have forgotten about it'. I suggest that we need to consider this problem of a stable world for our descendants urgently and that such consideration will lead us to regard energy as being as precious as water in a desert.

**Prof M W Thring ScD FEng** (Senior Fellow and Past President) formerly Professor of Mechanical Engineering and Head of Department, Queen Mary College, University of London.

## The author

Professor Meredith Thring is a Past President of The Institute of Energy (1962-63) as well as a former Professor of Fuel Technology at Sheffield University and Professor of Mechanical Engineering at Queen Mary College, University of London.

His brilliant career in the fuel and energy sector began when he graduated in mathematics and physics at Cambridge and joined the British Coal Utilisation Research Association from 1937 until 1946. His work in this period on the flow of producer gas in mains

gained him the Student Medal of the Institute, then the Institute of Fuel, in 1938.

At the beginning of World War II he led a small research team on the design and theory of small gas producers and on electrostatic precipitators. This led in 1944 to his appointment as Head of the Combustion Research Laboratory.

From 1946 to 1953 he was head of the Physics department of the British Iron and Steel Research Association and was made Assistant Director in 1953. During this period he was closely connected with the setting up of the International Research Project on

Flames.

In 1953 he was appointed to succeed Professor Sarjant as Professor of Fuel Technology at Sheffield University and in 1955 the scope of his Department was extended to include chemical engineering.

He moved on to become Professor of Mechanical Engineering at Queen Mary College, University of London, in 1964, retiring from that position and as Head of the Mechanical Engineering Department in 1981.

During his retirement, Professor Thring has maintained an interest in appropriate technology for energy utilisation in developing countries.



## World Energy Council commission begins work on identifying realistic energy strategies

THE World Energy Council (WEC) has established its new Commission on *Energy for Tomorrow's World* to identify strategies and make recommendations on how adequate, sustainable energy can be supplied worldwide, while achieving an appropriate reconciliation between the needs for environmental protection and global economic development.

A small project management team of experts has been set up in London under an executive director to manage and coordinate the work of the WEC Commission.

The Commission aims to indicate to political leaders and others

involved with energy at the national, regional and global level how the legitimate aspirations for economic growth and their related energy demands throughout the world can be met. These considerations will take account of, and pay particular attention to, the local, regional and global constraints relating to the environment, technology, the economy, finance and social considerations.

A statement issued by the WEC for the Commission's launch says that the WEC, with its Member Committees in 90 countries, is uniquely well placed to undertake such a study as it is the world's only non-governmental, non-commercial, multi-mergency organisation.

It claims that the Commission's report will contain balanced objective fact drawn from energy operatives and from international experts in the fields of environmental protection, energy conservation, energy technology, finance and economics. It will be concluded with an Agenda for Achievement targeted at both national and international energy decision makers.

The WEC Commission will include both regional and global

work in order to ensure that regional considerations are identified before they are aggregated globally.

The Chairman of the Commission is Mr Henrik Ager-Hanssen, Chairman of the WEC Studies Committee, Senior Vice President of the Statoil Group and Chairman of the Norwegian Institute of Energy Technology.

The Executive Director, who will head the London-based Project Management Unit, is Mr Derek Davis, who retired at the end of March as an Executive Board Member of Britain's Central Electricity Generating Board.

In addition to its 90 country Member Committees, the Commission will draw on expertise from such organisations as the Stockholm Environmental Institute, the World Bank, the International Energy Agency, OPEC, the Massachusetts Institute of Technology, the USSR Academy of Sciences, the various United Nations agencies and major international single energy organisations. The findings of the Commission will be released at relevant international conferences, and at the 15th WEC Congress to be held in Madrid in September 1992.

## Europe's clear choices on fast reactors

EUROPE will either be leaders or losers when fast reactors come into their own early next century — and there is a strong case for continuing operation of the UK AEA's Prototype Fast Reactor at Dounreay right through to the year 2005. These were two of the main points made by the AEA to the House of Commons Energy Committee on 17 January.

Appearing before the Committee were AEA Chairman John Collier, Deputy Chairman Brian Eyre, and Tony Broomfield who is head of the AEA's Fast Reactor Programme and who also chairs the European Fast Reactor R&D Steering Committee.

While other types of reactors, mainly PWRs, will continue to be the mainstay of nuclear power programmes in the short term they are rapidly using up known world reserves of uranium — and producing the plutonium and depleted uranium feedstock which is ideal for fast reactors. In Europe alone, 100 commercial reactors will need to be replaced by the year 2030. With improvements in design and engineering, their replacements will have a lifetime of 40 years or more. And before that, economic uranium may already be in short supply.

AEA Chairman John Collier told the Committee, which is studying the fast reactor, that it is essential for the UK to keep the fast reactor option open on the most economic basis for 1994, when the British Government intends to review the nuclear programme.

"Europe will reap the benefit," he said, adding that "recent so-called revelations on nuclear costs and prices in no way alters the economic case for fast reactors. Our assessments indicate that they will be comparable with current PWRs — and independent French and Japanese studies agree."

Mr Broomfield told the Energy Committee that no single country could afford to go it alone — and Europe has a key role to play. "Europe has the most mature developed technology, and will be in a position to lead the market. In the UK we are still playing a major role in the European programme and it makes sense to continue this commitment," he said.

## Major Pakistan hydro project

BINNIE & PARTNERS and Ewbank Preece are the UK members of an international joint venture awarded the feasibility study and tender design contract for the Ghazi Garijala Hydro Power Project in Pakistan. The joint venture will be known as Pakistan Hydro Consultants and based in Lahore.

The Ghazi Garijala Hydro-power Project has been proposed to provide additional power to Pakistan's fast expanding electricity generating system. The study will examine a scheme to divert the River Indus at Ghazi, downstream of the Tarbela Dam. A 50 km power canal would be constructed, taking water to a power station at Garijala and back to the original river course, possibly generating up to 1000 MW.

Funding is being made available by the UNDP and the Government of Pakistan. The World Bank will be executing agency for this project with the Water and Power Development Authority representing the Government of Pakistan.

Binnie & Partners will take overall responsibility for the study. Detailed layout studies for the barrage, power channel and power station are required as part of the feasibility study. Ewbank Preece is undertaking the electrical and mechanical aspects of this project in addition to examining economic benefits from the scheme.

## Statfjord field dispute settled

THE IMPASSE over the redetermination of the equity shares in the Statfjord oil and gas field, which straddles the UK-Norway median line, has been resolved.

Peter Morrison, Energy Minister, has approved the appointment of an expert to settle matters in dispute between the licensees arising from the redetermination undertaken by the operator, Statoil, in 1989.

The UK licensees in the Statfjord median line field (Conoco UK, Chevron UK and Britoil (BP)) have a 15.9 per cent equity share. The Norwegian licensees have 84.05 per cent and Statoil is the field operator. In 1985, the UK group called for a redetermination under the Unit Operating Agreement (UOA) which must be carried out by the operator. Although this should have led to a recommendation within 90 days, it was not until January 1989 that the operator

completed his work and it left outstanding a large number of issues disputed by the field participants.

In April 1989, the UK licensees called for a new redetermination under the UOA, the Government was not convinced, at the time, that the UOA procedures would enable a fair and objective settlement to be reached. It therefore decided in May 1989 to initiate a Government redetermination under the Statfjord Treaty and has been in negotiation with the Norwegian Government over the procedures for conducting such a redetermination. Since then, the Statfjord companies have been able to agree changes to the UOA redetermination procedures, in particular increasing the time allowed for an expert to settle matters in dispute between the companies arising from a redetermination undertaken by the operator.



## Joint venture European gas turbine company created

GEC ALSTHOM and the General Electric Company of the USA have announced the creation of a new joint venture company — the European Gas Turbine Company NV.

The new company, which was announced on 22 February, has been formed to service the growing world market for gas turbine power generation. It combines the turbomachinery businesses and technologies of Alstom Turbines a Gaz SA in France, the industrial aero divisions of Ruston Gas Turbines Limited in the UK, Ruston Gas Turbines Inc, in the USA, and Napier Turbochargers Limited of the UK, which services the diesel engine turbocharger market.

GE, which has a 10 per cent stake in EGT, is providing additional technology through a new long term licence agreement for GE 50Hz large heavy duty gas turbines. This agreement builds on the already excellent relationship between GE and Alstom,

## Spent nuclear fuel storage project

NORTHERN STATES Power Company of the United States has selected Stone & Webster Engineering Corporation to engineer an independent spent fuel storage installation at its two-unit, 1,060MW Prairie Island Nuclear Generating Station in Red Wing, Minnesota. The facility will employ a dry storage technology to supplement the existing spent fuel storage pool capacity, which will be exhausted in 1994.

Northern States Power Company is initiating this project to meet its storage needs beyond 1994 until the United States Department of Energy's high-level waste programme is operational.

## Pumps for Iraq

SULZER (UK) Pumps of Leeds has won a £750,000 contract to export 16 pumps to the new Al Shemal power station north of Baghdad in Iraq.

The order was placed by NEI Parsons of Newcastle-upon-Tyne on behalf of the Ministry of Industry and Military Manufacturing in Iraq.

in the field of heavy duty gas turbines, and between GE and Ruston in aeroderivative and aircraft gas turbines.

The combined experience of the new company includes the sale of 3,300 gas turbines and over 100 million running hours in power stations from 1MW to 1,000MW in 85 countries.

Sales are currently running at £300m annually and are predicted to rise to around £500m annually in the next year or two.

Mr Kelvin Bray CBE, the first Chairman and Chief Executive Officer of the new company said at the inauguration of the new company:

"There have been several major developments in the power

generation industry as key players prepare for the challenges of the new decade and beyond.

"One of the most important developments was the formation last year of GEC ALSTHOM which brought together the activities of GEC and Alstom in energy and transport.

"Now, GEC ALSTHOM has joined forces with GE to satisfy the growing market for gas turbine power generation. Our new company will be competing at the highest level in a number of key markets including large combined cycle power plants, the oil and gas industry, and, of course, in the small aircraft engine sector — a very important new part of our business."

## Call for international action to combat global warming

VIGOROUS international action to tackle the known 'greenhouse' problems, and a blitz of energy efficiency were urged by a senior director of British Coal on 7 March.

Addressing a power generation conference in Washington DC, Mr Malcolm Edwards, Commercial Director for British Coal, said the Greenhouse Effect — a political and public reality if not yet a scientific reality — encompassed a vast array of quite different problems of a scale and extent that governments had not experienced before.

It was clear that the institutions did not exist to deal with the problems — even when they were most clearly recognised and simple to solve. Good examples of this were CFCs and deforestation.

Mr Edwards said CFCs — a major contributor to the 'greenhouse effect' — were created only 50 years ago and 85-90 per cent were produced in the developed world. Yet the Montreal Protocol could still mean a doubling of stratospheric chlorine levels during the next century. The developed world was not moving fast enough to eliminate CFCs and persuade underdeveloped countries to avoid using them, he said.

With deforestation there was clear evidence of the effect on CO<sub>2</sub> levels of major clearance programmes, yet 50,000 square miles of tropical forests were

being cleared each year. The only way of stopping this action was to transfer resources from the developed to the underdeveloped countries to help them achieve a reasonable standard of living.

There were other major but less clearly defined contributors to the 'greenhouse' problem, for example methane — which is 30 times more potent, molecule for molecule, than CO<sub>2</sub> — and nitrous oxide, both long-lived agents. More work needed to be done to further our understanding of these.

Mr Edwards said in simple terms the carbon dioxide element of the 'greenhouse' problem centred on a small imbalance of just 3GT of carbon in the atmosphere. When compared with the natural photosynthesis of the forests, which alone removes 50GT of carbon a year from the atmosphere, it was clear the natural cycle had been only slightly disturbed. A better approach could be to restore that balance.

One way could be to use the sea — a huge carbon sink which already holds more than 11,000 times the annual imbalance of 3GT. "We are not considering here some kind of dumping exercise — just a way of helping the natural process there to work a shade harder," he said. Carbon could be used to enhance the growth of ocean organisms through photosynthesis. Studies into this were just beginning in the UK.

## Combined-cycle power plant with syngas

THE General Electric Company of the USA, Texaco Syngas Inc, a subsidiary of Texaco Inc., and Commonwealth Energy System have begun planning the joint development of an electrical generating facility in Freetown, Massachusetts. The facility would be known as the Freetown Energy Park.

The energy park, which would be located on land owned by a subsidiary of Commonwealth Energy, would generate 440 megawatts of electric power. The electricity would be sold to electrical utilities in New England. Long-term pricing for the power is expected to be competitive with other power alternatives in the region.

The facility would incorporate the proprietary Texaco Coal Gasification Process, which converts coal to fuel gas. This fuel gas would be used in state-of-the-art GE combined-cycle turbine generators to produce electricity.

"Details of the project design are still preliminary," said H Richard Horner, president of Texaco Syngas Inc, adding: "Our goals in this project are two-fold: to construct the cleanest coal-based power plant in the world, and to produce power at competitive rates."

## Malaysian gas plant project

A CONSORTIUM, headed by SWEC Zainal Sdn Bhd and including Hyundai Engineering & Construction Co Ltd, Sumitomo Corporation, and Pemas Construction Sdn Bhd, has been awarded a contract by Petronas Gas Sdn Bhd, the wholly-owned subsidiary of Petronas Malaysia Corporation.

The project, which will involve the expansion of the export terminal and two grass roots gas processing plants (GPP-2 and GPP-3) located at Terengganu, Malaysia, is the second phase of the Petronas Peninsular Gas Utilisation Project. The two gas processing plants will have the flexibility to recover ethane for petrochemical feedstock as well as sales gas, liquefied petroleum gas (LPG) and condensate.



## Government challenged over acid rain

THE PRIME MINISTER has been challenged by the Opposition Spokesman on Energy, Frank Dobson MP, over her Government's decision to go back on her promise to the UN last November on the issue of acid rain.

In November 1989, Mrs Thatcher told the UN in New York of Britain's £2 billion programme to reduce NO<sub>x</sub> and SO<sub>x</sub> emissions from Britain's power stations. This referred specifically to the installation of flue gas desulphurisation (FGD) equipment on 12,000 MW of generating plants.

However, during the run-up to electricity privatisation, plans to import low-sulphur coal and build electricity generating plants fuelled by gas rather than coal, have been outlined as a cheaper alternative to the £2 billion FGD programme.

In a letter to Mrs Thatcher at the end of February, Frank Dobson asked for clarification on the Government's apparent 'U' turn.

So far, FGD work has started on only 4,000 MW of generating plant.

## SLD call for energy policy

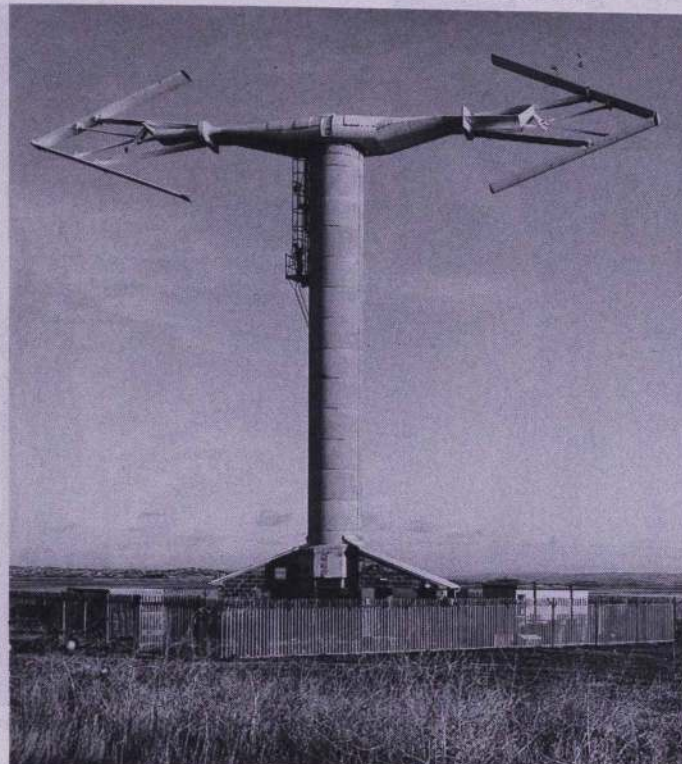
THE SOCIAL and Liberal Democrats have published an integrated energy policy for Britain, entitled *Energy and the Living World*.

In contrast to the Government's policy of allowing market forces to guide the energy sector, the SLD's green paper sets out an energy strategy, taking into account conservation, efficiency and renewable resources.

Amongst other proposals, *Energy and the Living World* calls for a target of 30 per cent reduction in CO<sub>2</sub> emissions from the UK by 2005; the taxation of fuel use, and investment in public transport, and the development of renewable energy sources.

On the issue of nuclear power, the SLD call for an immediate halt to the construction of Sizewell B, no further commissioning of new power stations, and the withdrawal of all UK nuclear power stations from service by 2020.

## Output record for wind turbine



The vertical axis wind turbine generator at Carmarthen Bay.

DURING January this year, the vertical axis wind turbine (VAWT) at Carmarthen Bay broke all records by generating 20,863 kW hours of electricity for the local distribution network. The previous highest output was 19,428 kW hours recorded in January 1988.

Constructed in 1987 by VAWT, a subsidiary of Sir

Robert McAlpine & Sons Limited, the wind turbine has been subjected to an extensive three year research programme to evaluate the use of wind power to generate electricity. During this period it has achieved 94 per cent availability.

A larger, half megawatt, vertical axis wind turbine is currently being constructed on the Carmarthen Bay site.

## BNFL seeks permission for new CHP plant

BRITISH Nuclear Fuels is seeking planning permission to construct a gas-fired combined heat and power plant to safeguard steam and electricity supplies to its reprocessing site at Sellafield in West Cumbria.

A wide-ranging review has been carried out, its conclusion is that a gas-fired plant nominally sized at 160 MWe would give the most economic steam costs and provide significant business opportunities for the sale of attractively-priced 'surplus' electricity, in addition to the output of Calder Hall.

Subject to planning approval, construction of the £100 million plant within the existing Sellafield site boundary could begin this year for operation in late 1992 or early 1993. It is a design which uses combustion gases to drive a turbine for electricity and

also heat a boiler for steam and has a high thermal efficiency.

Although well in advance of any projected closure date for Calder Hall nuclear power station, which has provided site steam and electricity for 33 years, the timing of the development represents insurance against any unforeseen early closure of Calder Hall and takes advantage of favourable commercial terms now available.

BNFL's separate study into the feasibility of eventually building modern nuclear reactors to replace Calder Hall and/or Chapelcross in south west Scotland will continue. One new nuclear reactor, if built at Sellafield, could not guarantee continuous steam production reliability.

## CCGT site studies

NATIONAL Power have announced that investigations are to start shortly into the suitability of three further possible sites for 'environmentally friendly' gas turbine power stations.

The studies — at existing power station sites at West Burton and Staythorpe in Nottinghamshire and Padiham in Lancashire — will cover technical, environmental and local issues. They will centre on combined cycle gas turbine (CCGT) plants of around 400-700 MW.

Fired by natural gas, a CCGT plant emits no significant amounts of SO<sub>x</sub> and produces only about half of the amount of CO<sub>2</sub> of an equivalent coal-fired station.

A gas turbine development at West Burton would not preclude National Power from proceeding with its proposal for a second coal-fired station on the site should that be required in the future.

The investigations are part of an extensive assessment by National Power of potential sites.

## Islay prototype

BRITAIN'S first prototype wave power station, to be in operation later this year on the Isle of Islay, is expected to show that wave power can generate electricity at costs ranging from 7p down to 2p per kilowatt hour, about as cheaply as hydro-electric power.

The claim was made by Dr T Whittaker, manager of the Wave Energy Group at Queen's University, Belfast, in a talk to the Institution of Engineers and Shipbuilders in Scotland (IESIS) in Glasgow.

Shoreline wave power devices use the power of waves concentrated in caves and rock gullies, or in similar man-made structures of steel or concrete, to drive special turbine generators. The stations are economical to build and, unlike offshore wave power devices, are easily accessible for maintenance in any but the worst weather.

There are many sites in Scotland where such stations could be built to produce anything from a few kilowatts to several megawatts of electricity.

After initial testing the Islay unit will supply electricity to the main electrical grid system.



## Parliamentary energy group go 'down below' at Lea Hall



The Institute of Energy's Secretary, Colin Rigg (pictured second from the right), on a visit by the Parliamentary Group for Energy Studies to British Coal's Lea Hall Colliery in Staffordshire in February.

### WANDSWORTH HEALTH AUTHORITY ENERGY MANAGER

Salary scale – £15,278-£18,141 plus a London Weighting Allowance of £1,580.

The Wandsworth Health Authority is looking for an Energy Manager with a proven track record to manage the Wandsworth Health Authority's Energy Conservation Programme, and provide statistical information on the management of energy within the Health Authority for Operational Managers to achieve the best performance.

The Health Authority has a well established Energy Department, which has been operating for the last three years very successfully, and now requires a new Manager to carry on the excellent work on which this department has been founded. The two primary functions of this post are:

- i. to draw up Energy Conservation strategies and implement Energy Conservation schemes from inception through to their construction and implementation.
- ii. to undertake a role of monitoring performance against set targets and giving operational advice to local management on how best to achieve optimum use from all sources of energy.

With the advent of changes in privatisation to both the Gas and the Electricity industry, the job will have a demanding role in negotiating with these industries the best tariffs available for the Health Authority.

The successful candidate will be a professional engineer with a proven track record who should have experience in computer based analytical systems.

In addition to an attractive salary, benefits include: an index linked pension system, generous holiday entitlement and the possibility of a lease car. Assistance with a relocation expenses is available where appropriate.

Informal enquiries welcomed by Mr G. Beech, District Estates Manager, on 01-672 9911 extension 42544.

Application form and job description available from the District Personnel Department, Grosvenor Wing, St George's Hospital, Blackshaw Road, London SW17 0QT. Tel: 01-784 2608 (24-hr ansaphone) quoting Ref M/95. Closing date – 31st May 1990.

### New members

#### Fellow

**Michael Collingwood Roberts**, PA Consulting Group, London (transfer)

#### Member

**Dwarka Nath Acharya**, Building Design Partnership, London

**Richard Hugh Ballard**, Energy Research Institute, South Africa (transfer)

**Peter Howard Chester**, Anthony Wilder & Associates, Milton Keynes

**Nicholas Robert Collins**, Nuclear Electric Plc, Hartlepool

**John Alan Dorling**, **Richard Saul Godfrey**, South Wales Electricity, Cardiff

**Kevin Herriott**, London Borough of Croydon

**Kenneth Knox McKinstry**, Howden Sirocco Ltd, Belfast

**Michael Andrew Peter Murray**, IDC Ltd, Warwickshire

**Sami Hussain Nasser**, University of Cambridge

**David Andrew Smith**, British Coal, Durham

**Anne Elizabeth Wheldon**, Energy Group, University of Reading

**Associate Member**

**William Alfred MacLean**, British Gas North Western, Lancs

**Brian Clifford Roberts**, Gwent County Council

#### Associate

**Roderick William Cargill**, Coaltrans Conferences, Surrey  
**William Hammond**, London Electricity

#### Graduate

**Gary Cooper Burns**, Foster Wheeler Wood Group Engineering Ltd, Aberdeen (transfer)

**Ben Farrington**, British Gas, Peterborough

**Graeme Robertson**, Satchwell Control Systems, East Kilbride

#### Group Affiliate

**South Eastern Electricity Board**, Hove, East Sussex

#### Student

**Marcella Ceraolo**, University of Newcastle upon Tyne

**David Robert Frankin**, University of Leeds

**Joshua Nicholas Ouma**, Heriot-Watt University, Edinburgh

**Vassilios Mavridis**, Cranfield Institute of Technology

**Xavier Devadas Samymuthu**, Heriot-Watt University, Edinburgh

**John Scott**, University of Aston

**Siu Yan Sham**, University of Newcastle upon Tyne

**Gordon Alan Smith**, University of Leeds

**David Graham Woodgate**, University of Birmingham

**Chun Wai Yuen**, University of Newcastle upon Tyne



## The Institute and international affairs

ONE OF the standing committees of the Institute is the International Committee, which is chaired by the President Elect, and on which the President, the Vice President and eight other members also serve.

The committee is responsible for co-ordinating activities with those organisations in other countries with whom the Institute is associated; for dealing with the special requirements of overseas members; for introducing initiatives to help those concerned with energy in the developing countries; and for stimulating informed international discussion on energy matters.

Committee members also try to maintain contacts with those overseas students who, after qualifying in an energy-related subject, return to their home countries.

Energy is of prime concern to all the world, and, as we are now becoming aware, the environ-

mental effects of energy utilisation are global. The developed world is undoubtedly profligate in its use of energy, and yet the standards of comfort and convenience achieved by the ready availability of energy are those to which the developing world naturally aspires.

The Institute and all its members therefore have a responsibility to ensure that energy is efficiently and wisely used, and that maximum use is made of all resources, be they fossil, nuclear or renewable.

Though the resources of the Institute are limited, it seeks to fulfill its responsibilities, frequently depending upon those individual members of the Institute to give of their 'spare' time to assist.

As part of its efforts the Institute is to mount an international workshop on Biomass as a source of energy, from 2-6 October 1990. Through the efforts of Guy Masdin, Brian Locke and Peter Dunn, this will be sponsored by The Institute of Energy, and will attract funding from the United Nations Development Organisation and Shell International to help meet the cost of inviting overseas representatives to participate in the workshop.

It is believed that by pooling the knowledge already available, relatively small sums of money, invested in practical projects, can produce significant improvements in the living standards of those in the developing world. The workshop is designed to identify suitable projects.

**Doug Willis**  
*President Elect and Chairman,  
International Committee*

## Change of status

TERRY R COLLINS (Member), who was recently appointed general manager of TC Socotec Ltd, has been awarded the title of European Engineer (Eur Ing) by the Fédération Européenne d'Associations Nationales d'Ingénieurs (FEANI).

Mr Collins has been a member of The Institute of Energy since 1971. Prior to his recent appointment he was quality assurance manager for QGPC on the Qatar North Field Development Project.

## British Steel Prize presentation



**Davina Lim, who has recently been awarded the £500 first prize in a competition run by The Institute of Energy to find the most promising energy and environmental engineering student in the UK.**

DAVINA LIM, a building services engineer with Oscar Faber of St Albans, has won first prize in a competition, run by The Institute of Energy and sponsored by British Steel, to find the most promising energy and environmental engineering student in the UK.

On 6 March she was presented with a cheque for £500 at the Royal Institution by Mike Brown, British Steel's technical development manager, during a meeting of the London & Home Counties branch.

For Davina, aged 29, the award comes after study in the UK and her native Singapore. She won the prize with a 100-page dissertation on the use and energy savings obtained from fan-assisted variable air volume air-conditioning systems using ice storage for low temperature air.

The dissertation was part of her final year studies for the first class honours degree in building services engineering which she gained at Ulster University last year.

"I am surprised and delighted," said Davina who decided to enter the competition, open to all higher education establishments in the UK, only a few days before entries closed.

She came to the UK in 1985 to extend her education and training and add to the Diploma in Building Maintenance and Management she had obtained in Singapore. She joined Oscar Faber as a replacement trainee in 1987.

Davina is studying for an MSc in building economics and management at present and intends to become a Chartered Engineer.

## Sainsbury student prize awarded

THE 1989 J Sainsbury Student Prize at the University of Surrey has been awarded to Mr Geoffrey Sheppard (Member).

The prize was presented by Mr Fred Nash (Fellow), director of McLellan and Partners of West Byfleet, for the best performance in the MSc Energy Engineering course at Surrey University in 1989.

Mr Sheppard is currently em-

ploied by McLellan and Partners as an energy engineer, after working in conjunction with the company on his course project.

Mr Sheppard gained his award for the excellence of his examination results and for the high standard of a study of a project to convert steam turbine electricity generation in a paper mill to cogeneration utilising gas turbine technology.

## IoE co-sponsors IMEX conference

IMEX 90, the maintenance management and engineering conference will be held on 5-7 June at Olympia in London.

Co-sponsored by The Institute of Energy and The Institute of Marine Engineers, the conference has been organised by The Institution Plant Engineers.

A recent DTI survey has suggested that industry could save around £1.5 billion each year just by implementing proper maintenance strategies. However, maintenance is not only important because it is so expensive. Maintenance is also important because plants have become more complex, more automated, operating at higher speeds or in more extreme conditions.

The conference will provide an ideal opportunity for engineering managers from process and manufacturing industries to meet and discuss key aspects of their professional responsibilities. Delegates may attend on a day, morning or afternoon basis, and further information and a conference programme/registration form are available from: Rosemary Wood, CMC, Bankside, Hollybush Lane, Frensham, Farnham, Surrey GU10 3BN.



# Financing the energy sector in developing countries

NO MATTER what path of development is chosen by a country, ultimately development depends upon the effective substitution of other means of energy for human labour. Whether this energy is used to move water, make cement, heat or cool a house, move a truck, or cook food, it is an input into making the human condition more bearable.

Being a developed country, almost by definition, means being a consumer of little energy other than that generated by human labour. Even a relatively high income and industrialising developing country such as Brazil has only about one-tenth the per capita energy consumption of the United States or many European countries. There are few African countries, for example, that have the electric power consumption of a minor provincial town in Europe or North America.

If the developing countries are to grow they will have to expand their use of energy in the whole range of economic and social activities.

by Anthony A Churchill BA, PhD,\* and Robert J Saunders BS, PhD\*\*

According to the World Bank, the annual investment in electricity supply alone in the developing countries during the next decade will be about US\$100 billion per year. In the following article, based upon a paper presented at last September's World Energy Congress, Drs Churchill and Saunders examine the potential sources of this funding, including a number of innovative financial options, and point out some of the internal institutional changes that are desirable in order to relieve the financial constraints that inhibit the expansion of all forms of energy.

But the substitution of energy for labour requires capital — a commodity in very scarce supply in all of these countries. And as a scarce commodity, capital is expensive and efficiency demands its careful use.

As shown in Table 1, for electric power

\**Director, Industry and Energy Department, The World Bank*

\*\**Head of Energy Strategy, Management and Assessment Division, The World Bank, Washington DC*

supply alone the annual investment bill for all developing countries could be about US\$100 billion per year<sup>1</sup> depending on one's assumptions on the rates of economic growth, and about improvements in energy production efficiency, pricing and end use efficiency. Three large countries, China, India and Brazil account for nearly half this total. Figure 1 shows the breakdown of future developing country electric power sector investment by plant type and region of the world. In addition

<sup>1</sup> This does not include the large additional investment needed to consume energy, ie, motors, appliances, air conditioning, light bulbs, etc, and to improve the efficiency of consumption.

## The authors



Dr Anthony A Churchill, a Canadian citizen, is currently Director of the Industry and Energy Department of the World Bank. Prior to joining the World Bank in 1965, he followed an academic career, obtaining a BA degree from the University of British Columbia and a PhD from the University of Washington (Seattle) before going on to teach at the University of Western Ontario.

Since joining the World Bank's Public Finance Division in 1965, Dr Churchill has held a number of senior positions in the Bank; Chief of the Transportation and Public Utilities Division, Chief of the Transportation Research Division, then Economic Adviser in the Transportation Department, Urban Operations Adviser in the Urban Development Department and, immediately before his present assignment, Director of the Water Supply and Urban Development Department.

He has also written a large number of papers and other publications for the World Bank.

Dr Robert Saunders, an American citizen, began his career by obtaining a BS degree from Wittenburg University and a PhD in economics from the University of Kentucky. Prior to joining the World Bank he held various university teaching posts and served as the Director, Regional Research Institute, West Virginia University and Chairman, Department of Economics, Kent State University.

His earlier positions in the World Bank included that of Senior Economist, Chief of the Telecommunica-



tions Project Division, Economic Adviser and Chief of the Energy Policy and Advisory Division, before moving on to his present position.

During his career, Dr Saunders has also written and published numerous books, articles and research monographs. His books include *Village Water Supply; Economics and Policy in the Developing World* (Johns Hopkins University Press, 1976), and *Telecommunications and Economic Development* (Johns Hopkins University Press, 1983).



to the capital requirements of the electric power sector, other forms of energy production and consumption are equally capital intensive. The requirements for investments in oil, gas and coal are at least of similar orders of magnitude.

At a minimum some US\$25 billion of the annual power investment requirement will be in the form of imported equipment. At the present moment the combination of bilateral and multilateral funds allocated for electric power investment is less than US\$10 billion per year. The prospects for any significant increase in the amounts of aid funds available is slight. The pressure, in fact, is to reduce even these amounts both in response to declines in total funds available and to the priorities given other areas of concern. The same holds true for international commercial banks. They have sharply reduced their lending to developing countries since 1982.

In addition to constraints on international concessionary and commercial bank finance, domestic public resources are also seriously constrained. Most governments of developing countries are finding it difficult to raise sufficient funds to meet the pressing social and economic needs of their growing populations, let alone the billions required by the energy sector.

This leaves only two alternatives, the domestic and international capital markets. Domestic capital markets are usually underdeveloped. But much of this underdevelopment is self-inflicted. The problem is not low savings rates but lack of financial intermediation between savers and investors. In many developed countries, the financing of public (although sometimes privately owned) infrastructure by attracting private savings was a major element in the development of their capital markets. In funding this infrastructure through the tax system, most developing countries have limited this important part of capital market development.

### Energy enterprise performance

Before capital markets can be utilised to raise funds for the energy sector, the sector, particularly the electric power part of it, will have to dramatically improve the performance of its institutions. Institutional arrangements in the energy sector in developing countries are characterised by: (a) widespread *ad hoc* government involvement in most aspects of the management of energy supply enterprises and the sector as a whole; (b) rivalry and inadequate coordination among sector institutions and with other agencies; and (c) weak accountability of sector managers to both supervising ministries and their consumers. As a result, with a few exceptions, the energy sector suffers from a combination of poor pricing, investment and regulatory policies, and inefficient operating and maintenance practices. This has led to a situation in which the sector is not in a position to raise resources either in domestic or international capital markets because most of its institutions are unable to earn a return sufficient to attract private debt or equity investment.

For example, in electric power it is not

**Table 1: Planned power investments by developing countries between 1990 and 1999 (units in US\$ billion at current prices)**

Power System Component	US\$ Billion	%
Generation	642	61
Transmission	105	10
Distribution	211	20
General	95	9
Total	1,053	100
<b>of which</b>		
Local currency	642	61
Foreign exchange	411	39

uncommon to find total technical and non-technical system loss rates of over 30 per cent; to find excess capacity in generation side by side with shortages in transmission and distribution systems; to find expensive capital operating at a fraction of its rated capacity; to find excessive employment, etc. In the oil and gas sector the inefficiencies of state monopolies are often covered up by the large rents earned by the state in this sector. This generally unsatisfactory performance will have to change if this sector is to meet its growing financial requirements.

Fundamental changes in the institutional structure often will be required to effect changes in performance. Almost everything else has been tried. The World Bank, for example, in over four decades of lending, has supported a broad range of measures to improve and modify existing institutional structures. At best the results have been mixed. Improvements in management structures or investment planning, for example, have been compromised over time by the unwillingness to change the business environment and incentive structures for most public institutions.

In fact, the performance of power utilities in developing countries has actually deteriorated over the past few decades. Accompanying this deterioration has been a shift towards large, monolithic government owned and operated utilities. The formation of these government power utilities was based on arguments relating to the need for: economies of scale in investment and operations, improvements in coordination and efficiency, reducing reserve margins and increasing reliability, larger and longer term investments, political pressures for nationalisation and elimination of foreign ownership, and so on. Although some of these reasons may be valid,<sup>2</sup> there is a growing awareness in third world countries and in the development community that fundamental change is needed to improve efficiency in the power sector.

### Why a new awareness

First, as developing countries have expanded their economies, they have become more urbanised and more industrialised and have sharply increased their energy intensities. The absolute size of the capital requirements for the electric power sector alone are many times larger than those of primarily rural economies just beginning the growth process. Today there are single power projects which in real

terms require more capital than the total funds available from the World Bank in any one year in the 1950s and 1960s.

Second, the growth process has placed enormous demands upon the limited financial resources of the public sector. The energy sector is only one of many claimants. Today it is not unusual to find from one quarter to one third of public resources available for investment going solely to electric power. And it is still inadequate.

Third, the experience of the last few decades has brought into focus the disadvantages as well as the advantages of relying on public ownership and public credit. In spite of valiant attempts it has not always been possible to isolate the power, oil, gas and coal sectors from the inherent inefficiencies of government.<sup>3</sup> These inefficiencies can be costly in such capital intensive sectors. The failure to adequately maintain costly plant and equipment, for example, can result in not only shorter equipment life but also loss in the output of other firms where energy is a critical input.

### The role of government

It is clear that many problems relating to management accountability and inefficiencies in energy production, distribution, and consumption in developing countries can be attributed to inappropriate roles played by the public and private sectors. All too often the public sector has tried to undertake more than it can handle given its limited human and financial resources. An important principle must be recognised — that the complexity of energy problems and the scarcity of resources and managerial talent in developing countries requires that each set of issues be dealt with at that level of decision making and management best suited to analysing the difficulty and implementing the solution. Thus, political decision makers, senior government officials and ministry level staff should focus on critical macroeconomic issues and energy sector strategy and policy, in order to set out global expectations of energy enterprise performance.

The senior management of a power or gas company, for example, appropriately buffered by an independent board of directors and operating in a known regulatory framework, could then conduct its daily operations free from government interference, to meet the agreed service targets within the regulatory guidelines. As far as possible, the utility management should be assured of continuity at the top, subject to satisfactory performance, even in the face of political change. While the enterprise has provided wider autonomy, it would become more accountable in terms of performance measured against an agreed set of

<sup>2</sup> In many instances potential for economies of scale and better coordinated operations have been negated by managerial/institutional inefficiencies, and their potential has been lowered by technological and regulatory change, i.e. combined cycle turbines and co-generated power sold to the grid.

<sup>3</sup> These inefficiencies stem partly from the fact that many developing country governments tend to take on more than their underdeveloped institutions can handle and from the fact that governments have multiple objectives which are not well suited for translation into managing commercial and technical ventures.

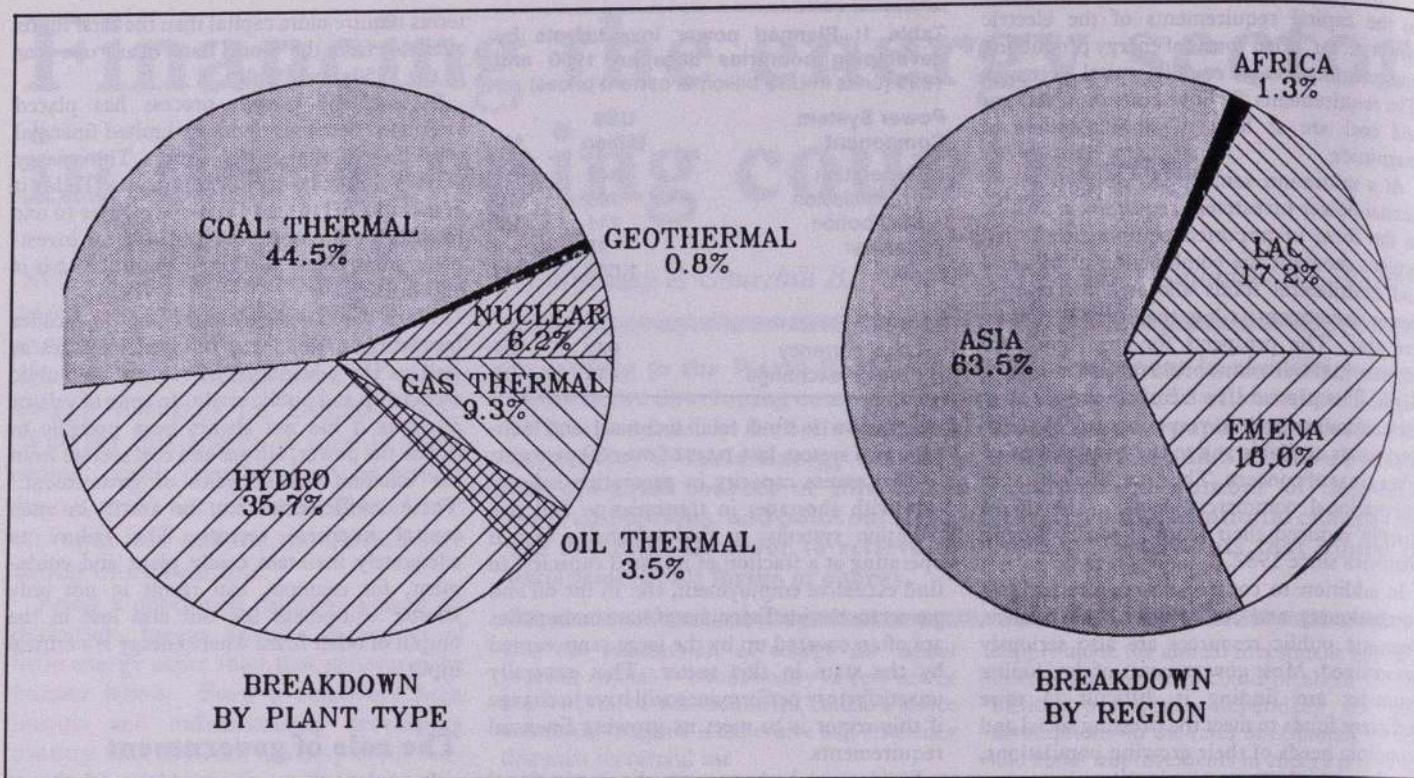


Fig 1: Breakdown by plant type and region of capacity expected to be added in the less developed countries during the 1990s (384GW total).

specific objectives and monitored indicators. The senior management of the energy enterprise would be well advised to meet regularly with government and consumer representatives, to discuss performance problems and successes.

Also, many developing countries need to re-examine the role of government in the energy sector with a view toward defining a more productive partnership between it and private operating companies. Complete privatisation is too simple an answer. It would be naive to assume that the state would be willing to give up control of such an important sector where it has legitimate responsibilities for protecting general public interests. Compromises have to be found that both recognise the general public interests and at the same time provide incentives for efficient management of the sector. A new social compact between the state and consumers and producers is required, one which relies more on the state as a regulator and less as an owner of the means of production.

### Involving the private sector

Institutional and legislative developments in both the developed and developing countries are indicative of the changes that are emerging as attempts are made to secure financing and improve the accountability and performance of enterprises in this sector. Many of these institutional changes move in the direction of government acceptance of a greater degree of market forces and private sector participation.

For example, a number of innovative options have been suggested which might involve the private sector in efforts to assist in improving sector performance and maintaining energy investment programmes while minimising the

accrual of new government debt. These options include some of the following:

- more international oil company farm-ins or other joint venture arrangements with national oil or gas companies;
- financial leasing arrangements involving offshore companies, commercial banks, and suppliers;
- operational leasing arrangements in which the lessor also operates and maintains the installations;
- enclave financing arrangements for power generation in which the owner-operator sells power to a public grid or wheels it to specific consumers;
- sale of existing operating facilities by utilities to private operators under contracts to sell back or distribute power;
- the sale of electricity futures to consumers that desire longer term price contracts;
- conversion of some portion of country energy debt into leasing arrangements;
- conversion of some portion of country energy debt into equity with a possible put option to reconvert the equity into debt after a given period;
- other debt-equity swaps and related operating arrangements;
- direct, private equity financing;
- third party financing of energy conservation, whereby energy service companies carry out efficiency improving investments and are repaid from the realised savings;
- contracting out selected services of a utility to private firms, ie, for rehabilitation, maintenance, accounting, collection, etc; and
- the use of management contracts for operation and maintenance work.

Some countries are now encouraging industrial producers of energy to produce electric power and sell the surplus into the public grid

as part of co-generation schemes. A few countries are considering breaking up large national distribution monopolies into regional or municipal groups. In some instances, governments are encouraging private investors to come forward and manage and invest in small, local, non-grid supplies. In many cases these measures are aimed at both domestic and foreign investors with the expectation of improving efficiency and inflows of capital.

### Domestic capital markets

The capital markets of most developing countries are often more underdeveloped than necessary. There is generally a great shortage of readily tradable securities. Deposits in foreign banks are often the preference of local investors. Yet if one studies the history of North American and European capital markets, the issuing of securities by large public companies, most of which were in what today would be called the public utility business, was the foundation of the development of the capital market. Developing countries generally have precluded this possibility by making the financing of these public works an exclusive prerogative of the government Finance Ministry.

Could not the increased interest in private foreign investment be expanded to include local private investors? There are a number of advantages to all concerned. For the government the encouragement of a local capital market has to be an important developmental goal. For local investors, large and small, putting money in a large partially foreign financed domestic enterprise may offer an attractive alternative to foreign bank deposits. For the government the existence of local interests in utility finances may ease some political problems and at the same time provide



some assurances to the foreign investor who would know that his interests coincide with local interests.

In practice there are many ways in which domestic capital markets can be encouraged. The degree to which special incentives have to be offered to local investors will depend on the current state of the local capital market. Local investors may be willing to accept shares valued in local currency as long as dividends receive the same type of treatment given to foreign owners — perhaps convertible to foreign exchange. The foreign shareholders could be permitted (or required) to sell (or buy) part of their shares each year in the local market. Foreign banks now holding non-performing government loans could be encouraged to swap these debts for equity or other forms of financial participation.

The objective is to establish a local market in which shares or debt instruments held by both local and foreign nationals can be traded. The existence of such a market will improve the liquidity and acceptability of private participation in electric power, gas and similar types of investment as well as providing a channel for encouraging local savings.

### Examples worth watching

The World Bank is actively encouraging countries to seek alternatives to the traditional public monopolies in the energy sector. However the pace of change is going to be highly dependent on local circumstances. Change will not come easily and there will be considerable opposition from both vested interests and those that see these moves as being primarily of an "ideological" nature. The speed at which these innovations are adapted will depend also on the perceived success, particularly in attracting additional capital, of those currently pioneering the process.

Progress has been slow because of lack of experience of many governments with the private sector, and existing cumbersome government administrative procedures. Private sector participants need to be encouraged by evidence of governments' willingness to support private developments. Since international capital markets are becoming integrated, investors in developing country energy projects will expect treatment similar to what they can get elsewhere. They will look for incentives such as tax breaks, access to land, exemptions from import duties and labour requirements, and simplified customs procedures. Government guarantees are needed that the power or gas produced will be purchased, prices will be set to provide adequate returns to investors, foreign investors can repatriate profits and service debt in hard currency, and fuel will be available at reasonable prices. Draft agreements will help to clarify such uncertainties such as access to foreign exchange for debt service and dividend payments and set out explicitly who bears what risks. In Turkey, for example, model agreements and an invitation have led to proposals by private sector consortia to build and operate large coal fired thermal plants in which Government proposes to take a 30 per cent equity.

In Pakistan, under the World Bank's recent Public Sector Energy Development Project, coal thermal, hydro, and oil thermal power projects estimated to cost \$1.9 billion have been approved or are under consideration or preparation. Loans to private investors of up to 30 per cent of project cost are being provided from a fund initially of \$520 million. The fund was created with money from bilateral and multilateral sources. It is being managed by the National Development Finance Corporation. The arrangements being established include a security package for private investors providing incentives and guarantees, co-financing agreements and proper appraisal of projects. These arrangements appear to be among the most progressive and encouraging currently being offered in developing countries.

Chile's efforts to encourage private sector participation are also worth attention. These efforts, which led to nearly 100 per cent private ownership in the electricity sector by 1988, started in the late 1970s when generation/transmission and distribution activities were separated. In the case of ENDESA, Chile's largest power company, distribution activities were consolidated into economically and geographically coherent units which are open to distribute non-ENDESA generated power (eg by municipalities, large industrial users and/or self-producers of electricity, and the public in general). CHILECTRA, another large power company mainly responsible for distribution in Central Chile was reorganised into one generating and two distribution companies. Smaller generation/transmission units of ENDESA which could be independently operated were then auctioned off (eg small- to medium-sized hydro units below 50 MW). Subsequently, ENDESA and CHILECTRA were transformed into privately organised corporations whose shares were broadly distributed to company employees, public sector employees, pension funds, etc, and which are now traded on the local stock exchange.

The privatisation of the electricity sector in Chile was greatly facilitated by important changes in the tariff system. Originally based on accounting criteria and aimed at providing a guaranteed return to the sector enterprises, irrespective of their efficiency, tariffs now are based on long-run marginal cost for generation/transmission and short-run marginal costs for distribution companies. The standard cost of an efficient "model company" serves as a yardstick. The application of technical criteria, which are revised only every four years, ensure automatic adjustments at the bulk tariff and distribution tariff levels, with a minimum of Government intervention. A system of node prices and wheeling charges for use of the ENDESA-run transmission network and an efficient load dispatch system allow rapid transactions of electricity between generation and distribution companies, large industrial users, and self-producers. Ownership and tariff reforms in Chile's electricity system thus have succeeded in (a) promoting competition among generating companies, (b) stimulating major consumers to seek least-cost sources of electricity, (c) optimising the use of the transmission systems, and (d) establishing

effective independent monitoring of electricity prices by electricity consumers.

In addition to the countries already mentioned, a build, own, and operate type project has been implemented in China and others are being actively considered in Indonesia, the Philippines, and Bangladesh. In Poland, the government is considering a new system of regulation of the energy sector during the transition from central planning to greater use of market forces. It is also considering separating power distribution from generation and is looking at models in other countries for developing future energy facilities. In the Dominican Republic, the government is considering a policy whereby most new power generation would be located outside of the public utility. Finally, a recent study showed Costa Rica's 900 MW public power system could be economically augmented with 100 MW of additional power purchased from private power sources including small hydro, bagasse fueled sugar mill plants, and surplus output from existing industrial thermal plants.

### Regulation

One of the major constraints on new approaches such as these is the lack of adequate regulatory systems in most developing countries. These countries, by relying primarily on ownership as the means of control, have not developed much experience with more indirect means of regulation. They also lack the institutional structure to undertake this regulation. This means, that for most investors, the "rules of the game" are unclear and, in fact, outside investors are usually excluded from the game. Undoubtedly, as investors gain confidence and governments gain experience, the number of private participation schemes will increase. But until this happens there is a tendency for all parties to be excessive in their demands for guarantees and controls of performance and income.

Generally, countries wishing to reform the institutional relationships and financing of the power sector fall into two categories. First, those who wish to retain predominant public ownership of the sector but which want to reduce government interference in operational matters, make regulations more transparent and predictable, and tolerate some private participation at the fringes, eg, industrial co-generation, or contracting out of services such as revenue collection. Second, those willing to encourage much greater private participation such as build, own and operate schemes, build, own and transfer projects, large-scale divestiture of existing assets, franchising and leasing arrangements, and large-scale independent power production. Although both of these approaches encompass a wide spectrum of ownership and control, each has a common need for a regulatory framework that promotes economic efficiency, enterprise accountability, mobilises domestic and foreign resources, and internalises social and environmental costs with minimum impact on efficiency.

One of the unique features of private power generation sales is the existence of usually only



one or at most a few purchasers of the output. This puts a great deal of stress on the negotiations over what quantities are to be sold, at what times, and at what price. Investors try to minimise the risk with some form of multi-part or take or pay contract with various provisions to insure the pass through of cost uncertainties such as fuel prices, general inflation or exchange rate changes. In some cases the investors are simply suppliers of a product where risks are minimised and profit margins guaranteed by the government. Incentives for improved efficiency and entrepreneurial activities are present but may not be large.

Such arrangements can be improved. Countries might well benefit from some loosening up of the market structure. Is it really necessary that foreign investors be only suppliers of base load? Many developing countries are far from the situation where the national grid extends to all parts of the country. Could not investors (both local and foreign) be invited to supply and distribute power or gas in isolated markets, perhaps in competition with the national monopoly? What about permitting private owners of plants to expand their markets at their own risk — perhaps to large industrial consumers? Or alternatively to invest with large industrial users in co-generation of heat and electricity with some of the power being sold to the grid or to other consumers.

There are undoubtedly numerous variations of regulatory and market structures that can be used to enhance the opportunities for entrepreneurial activities in the energy sector. Among the regulatory options that might be analysed to better understand their advantages, drawbacks and potential applicability in individual situations are:

- regulations by contract, eg, for gas or large unique base load power plants;
- a USA-style independent regulatory agency;
- regulation by previously established legislation or decree;
- regulation through intent-openness and fairness are demonstrated in deliberations;
- regulation through pricing and taxation, eg, through setting avoided cost or bidding;
- regulation by setting precedents; and
- hybrid or mixed systems.

There is little doubt that many existing enterprises in the energy sector will oppose change. Technical, safety and other reasons will be given, some valid, some not. Experience in the developed countries suggests that many of the problems can be solved and that large gains in efficiency are possible. Again it requires that governments set out from a much broader perspective than is presently the case, a simple and transparent regulatory framework for the entire energy sector. All parties involved should be assured that their legiti-

mate interests can be adequately taken into account and safeguarded within a framework that provides mutual benefits to all.

## Need for discussions

The diversity of the parties involved (governments, domestic investors, foreign consortia, bilateral and multilateral aid agencies, commercial banks, power or gas utilities, etc) and the complexity of the issues suggests it would be useful to begin to pull together some of this experience, to get the parties together to discuss their expectations and needs, in forums that are less pressured than those generated by immediate investment decisions. A consensus on acceptable sets of "rules of the game" would increase the willingness of all parties to reach the accommodations required by the differing circumstances of each developing country.

## Acknowledgement

This paper was originally prepared to stimulate discussion in the World Energy Conference Committee on Energy Problems in Developing Countries. The World Bank/UNDP/Bilateral Aid Energy Sector Management Assistance Programme partly supported the preparation of the paper. The authors acknowledge helpful input from John Bessant-Jones, Charles Feinstein, Joe Gilling, Alastair McKechnie, Ted Moore and Uwe Richter. □

# THE COSTS OF FLUE GAS DESULPHURISATION

a one day conference organised by The Institute of Energy

19 September 1990

at The Scientific Societies Lecture Theatre, London W1

The removal of sulphur oxides from the flue gases of power stations and large industrial plants has been a frequent topic of conferences and seminars. The discussions have, however, mostly centred on the means of removal and assessment of the possible environmental effects of such removal. The costs of removal and associated aspects have hardly figured in these conferences.

The practice of sulphur dioxide removal from both pulverised fuel and stoker fired plants are well established on the Continent representing the worldwide practice.

The Institute of Energy's conference will include speakers from the European operators, designers and suppliers of the various systems: wet, semi-dry and dry for pf firing, and dry systems for stoker-fired plants who will present their experience of costs of installing and operating their units.

The conference will also include speakers from: British Coal, IEA Coal Research, Babcock Energy, National Power and Power Gen.

With the imminent implementation of the EC Directive requiring flue gas desulphurisation from large combustion plants of UK power stations, industries and refineries, this conference will provide an ideal opportunity for delegates to obtain first hand information on the costs of flue gas desulphurisation from those who have already designed and supplied these systems and are operating them.

For further details please complete the reply slip below.

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# What's the use of twenty watts?

by Anne E Wheldon, PhD MInstE MInstP and Mark Hankins\*

TWENTY watts of electric power may seem irrelevant to a national supplier, for whom a one megawatt power station is very small. Yet the storms and the consequent disruption of power supplies in Britain at the beginning of this year reminded many people that a little electric power would be a great deal better than none at all. Twenty watts (0.5 kWh per day) could have provided a family with a surprising number of basic services — a few hours of light, radio, television or the pump for the central heating. The usefulness of the 'first' twenty watts of supply contrasts sharply with the trivial benefits derived from the 'last' twenty watts — feature lighting and the third television perhaps, and, as Bob Hill so aptly put it "the electric carving fork to go with the electric carving knife."<sup>1</sup>

This article looks at a selection of interesting applications for very small power supplies, particularly those based on renewable energy sources, and at some of the issues related to their use. (Readers may wish to refer to review publications

**Twenty watts of electricity may be a mere drop in the ocean to a national power supplier, but to families in developing countries, it can mean the provision of basic services, which energy consumers in the developed world tend to take for granted. Anne Wheldon and Mark Hankins look at the possibilities of small-scale power generation, and the benefits new technology in this area can bring to the developing world, as well as examining its applications in the West.**

[eg 2,3,4] for more comprehensive surveys of applications.)

Many people, particularly in developing countries, live in areas remote from an electric power grid. For them, 20 watts represent basic amenities, not luxuries. The use of stand-alone power supplies is one option for providing power to individuals and communities in remote areas. Such supplies are usually based on diesel or petrol generators, but renewable

energy conversion systems, powered from wind, water or biomass (wood and agricultural waste) have also been used for many years. Photovoltaic (solar electric) power supplies have been developed and used more recently.

## Applications in remote areas

Immunisation against the life-threatening diseases is one of the most basic aspects of primary health care, and the expansion of immunisation programmes could save many lives in developing countries. Most vaccines require refrigeration from the point of manufacture to the point of use in order to remain effective, and a 'cold chain' of refrigerated distribution and storage facilities must therefore be set up. One essential stage in the cold chain is the vaccine refrigerator in a rural health centre, which may be remote from mains power. An array of photovoltaic cells with storage batteries can provide a reliable power supply, in areas with high solar radiation. The power requirements for such a refrigerator are small, but its service to a community can be immense. Twenty watts can run a refrigerator which stores enough vaccine for the complete immunisation of over 1,000 infants and their mothers.<sup>4,5</sup>

Light from low voltage dc fluorescent lamps can have a major impact on rural life in developing countries. During the day, most people are occupied with household tasks, farming and caring for livestock. It is only in the evening that family members have the opportunity to study, sew, read and engage in other productive activities. Electric lamps supply better quality light for these tasks than traditional open fires, candles or hurricane lamps. In tropical countries with high insolation, a 30 Wp (thirty watt peak) photovoltaic panel can supply around eight watts of continuous power. Panels as small as 10 Wp supply enough power to operate a fluorescent lamp for several hours each evening.

## The authors

Anne Wheldon is a lecturer in the Energy Group, Department of Engineering, University of Reading. She obtained a PhD in Environmental Physics from the University of Nottingham in 1982.

From 1982-1987 she worked as a lecturer in Applied Physics, and latterly as Head of the Physics Department, at the University of Swaziland. During 1988 she held a visiting position at Universities in Thailand, Australia and Fiji.

She joined the Reading Energy Group in 1989, where she teaches on postgraduate courses in renewable energy. Her main interests are solar energy, efficiency and the environmental impact of energy use.

Mark Hankins is studying for an MSc in Alternative Energy for Developing Countries at Reading University. He previously spent five years working with small scale energy technologies in Kenya. His MSc research examines practical problems of small photovoltaic lighting systems in rural areas.



\*Energy Group, Department of Engineering, University of Reading



A survey of small solar electric systems installed in a rural Kenyan community shows the varied uses for small amounts of electric power.<sup>6</sup> Using a 10 Wp photovoltaic panel, a second-hand car battery and a fluorescent lamp, one tailor now lights the communal hut on his compound, enabling his children to do their homework while he completes a few extra hours of sewing. But the use of a few watts of solar power is not limited to lighting. Entertainment is a high priority for many families, and several of the systems visited use the power for radios, cassette players or televisions. One enterprising teacher uses solar power to charge the batteries for his part-time business, a disco and light show! Facilities for education and entertainment make rural life more varied: they might thus make a small contribution to reducing the drift from rural areas to the cities.

A study of rural clinics in Zaire indicates the benefits of small amounts of power in improving medical care. Photovoltaic panels, used to run fluorescent lights, have a direct impact on the quality of treatment, since medical procedures can be performed more safely and over a longer period of the day, with good quality light. They also have an indirect impact, since medical workers are less reluctant to work in rural areas if they are provided with lighting, radio and television.<sup>7</sup>

Small wind turbines are also used to supply power in remote areas. Tens of thousands of wind turbines were used in homes worldwide from the 1930s, to generate electric power for lighting and radios. Several remote homes in Britain and elsewhere currently use wind turbines for the same purpose, some with as little as 100 W of rated capacity, equivalent to 20 to 30 units of continuous power.<sup>2</sup>

The establishment of a telecommunications network requires small amounts of power in remote areas, and the power supply must be reliable and require little maintenance. Photovoltaic panels and wind turbines are frequently used for this purpose. They are also used off-shore to supply power to navigation aids. An unusual 'off-shore' application is in the fish-farming industry.<sup>8</sup> Salmon farmers in Scandinavia and Scotland use battery-powered automatic fish-feeders.



33 Wp photovoltaic panel used for a domestic electricity supply in rural Kenya.



50 W wind turbine used to supply power for an automatic fish feeder.

### Other applications

Small stand-alone power supplies also have uses in areas which are not normally regarded as geographically remote, since they may provide a more convenient or cost-effective supply, even where mains power is available.

An obvious example of such a supply is the dry cell used in torches, radios, etc. We readily pay over £50 per kWh for the convenience of portable power. Very small photovoltaic cells are also used extensively for pocket calculators and other consumer electronic goods.

One application of small stand-alone supplies where mains power is very close, is in the rail industry.<sup>9</sup> British Rail Research need to measure the movement of 25 kV overhead contact wires as locomotives pass underneath. The position transducers which are used to make these measurements could be powered from the 25 kV supply via a step-down transformer. However, it is cheaper and technically simpler to use a battery, trickle-charged from a 50 W wind generator, as the power source. Conveniently, the sites where movement of the contact wires may cause the most problems are usually in exposed areas, which provide good resources of wind energy.

### Efficiency

Efficiency is a key issue in small power stations: if you are limited to a few watts, then it makes no sense to waste them. To state the obvious, one hour of light from a 60 W incandescent bulb is much less useful than five hours of equivalent illumination from an 11 W high-efficiency fluorescent tube.

The vaccine refrigerators which are used with photovoltaic systems (discussed above) are designed to require little power, by using thick insulation and efficient compressors. Efficient domestic appliances, such as lights and refrigerators, are also becoming available

for use with stand-alone supplies. They need to be developed further, and distributed more widely in remote areas. At present their initial cost is often high, even though they may be cheaper than conventional appliances when costed on a life-cycle basis.

The need for efficient energy use is not restricted to remote areas and stand-alone supplies. The conversion of energy is a major contributor to environmental damage. Areas of global concern directly related to energy use include global warming (to which the burning of fossil fuels and biomass is a major contributor); pollution of the troposphere and acid rain (fossil fuels and biomass); ionising radiation (nuclear power); and shortages of fuelwood (biomass).<sup>10</sup> In the long term, this damage cannot be arrested simply by changes in the mix of current fuels, since they are all contributors. We support the argument that energy conservation, including more efficient end-use, is an essential component of long-term energy planning to protect the environment.<sup>10, 11</sup>

### Conclusions

Small amounts of electrical power, used efficiently, can provide important services, if available at the right place and time. Stand-alone power supplies can contribute significantly to the quality of life, particularly in remote areas of developing countries, even though the kWh which they generate may be quite insignificant in a national energy budget.

### Acknowledgements

We are grateful to Bob Hill of the Newcastle Photovoltaics Centre, the Small Wind Turbine Group of the British Wind Energy Association, BP Solar, British Rail Research, IT Power and Marlec Engineering for discussions and permission to use information.

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# Energy consumption in developing countries

ANY FORWARD view of energy demand requires explicit assumptions on socio-economic and international oil market developments. This paper rests on global studies developed in 1987/88 and reviewed more fully in references 1 and 2.

Two cases were developed; a 'High case' with a strong emphasis on successful economic performance and a 'Low case' in which politics prevails and, in particular, the developing countries suffer from low economic growth. The main features are presented below:

## 'High case':

- Assumes that the restructuring of organisations and economies in the early 1980s provide the basis for the effective use of resources.
- Has forces at work that assist in these developments, especially a new generation which is pragmatic and flexible in outlook and has increasing influence.
- Has governments that endorse and implement 'No-Nonsense' policies underpinned by clear models of economic success.
- Markets become more global.
- World economic system has considerable resilience. Most of the present problems. e.g. debt crisis, ultimately get defused, if not resolved.
- OPEC successfully manage oil prices.

## 'Low case':

- Assumes that the pendulum could swing back in the 1990s from market-oriented policies to greater emphasis on social and political priorities.
- 'No-Nonsense' policies fail, which leads to a rationalisation of failure and rejection of successful economic models. Economic under-performance results — world economic growth is only 2 per cent per annum compared to 3.5 per cent per annum in the 'high case'.
- Population growth and rapid urbanisation proves unmanageable in the DCs.
- OPEC are unable to manage markets due to low demand and relatively high non-OPEC oil supplies.

The future of energy demand in developing countries is discussed primarily in the context of the 'high case'.

We begin with the preconditions for high economic growth and thus energy demand.

by Ged Davis\*

The following article, based upon a paper first presented at last year's Congress of the World Energy Council, reviews the prospects for energy consumption in the developing countries, based on two scenarios — a 'high case' and a 'low case'. The starting point for the review is the premise that the 1985 primary energy demand in all developing countries, excluding traditional fuels, amounted to 33 million barrels per day oil equivalent (Mb/doe), of which China accounted for 10 Mb/doe, while oil demand was some 14 Mb/doe, of which China accounted for 2 Mb/doe.

Firstly DCs will need a hospitable international economic environment. The issues are well known:

- a resolution of the current imbalances and restoration of confidence in financial markets,
- a need to avoid a major recession and strengthen the openness of the global trading system, and
- for the developed countries to take some leadership on the debt crisis.

Suffice to say putting the necessary policies in place will not come easily.

But this will not be sufficient alone; many countries will need to reform their economic policies. The need for change and prospects vary greatly across countries.

This can be seen clearest by reviewing economic performance since 1973. Two points stand out:

- The *resilience* of the South and East Asian countries who not only weathered the oil price shocks and the severe 1980 to 1982 recession in the OECD, but emerged with higher rates of

growth and reduced inflation: growth rates in India rose to 5.5 per cent pa and in E. Asia to over 8 per cent, while inflation was held to 7 to 8 per cent in the 1980's.

- The *weakness* in Latin America and Africa, with many countries facing crises of debt and declining per capita incomes in the 1980's. A symptom of the crisis, especially in Latin America has been the resurgence of inflation — averaging over 100 per cent pa in the eighties.

A few countries such as Botswana and Malawi avoided the worst but other, and particularly the large economies, faced losses in per capita income greater than US and European countries experienced in the Great Depression.

Eight years since the start of OECD recession, Latin America and Africa remain deeper in recession, deeper in debt and with major short-term problems to solve.

The Latin American and African weaknesses result from failings in economic policy and management of the public sector. Recent

## The author

Ged Davis is Head of Energy in the Group Planning co-ordination division of Shell International Petroleum Ltd in London. He joined the Group's New Enterprises division in 1972 and spent much of the 1970s in the Coal Co-ordination division working on planning, business and technology development.

In 1977 he moved to the Shell Company of Australia, initially to work on coal technology development and then as manager, coal supply and marketing. He returned to London and the Group Planning division in 1980.

Prior to his present job he spent four years in the European Regional organisation in The Hague.



\*Head of Energy, Group Planning, Shell International Petroleum Co Ltd.



reviews of economic development in DCs by the World Bank and IMF indicate the required direction of economic reforms:

- less constraints on markets, more competition and a larger role for the private sector,
- reduction of budget deficits, including the heavy support for state-owned enterprises,
- allocation of public investments on the basis of cost-effectiveness and prospective earning powers, rather than ideology and prestige, and reduction of the heavy subsidies for public services.
- more outward orientation to encourage local companies to compete in international markets. Countries which have taken such an approach have performed successfully in the last decade.

The full cost of past policies is very apparent in the electricity sector, for example, which with few exceptions is dominated by a single, publicly-owned vertically-integrated utility. In many countries this is the largest state-owned enterprise. The United States Agency for International Development (USAID) estimates<sup>3</sup> that electricity companies consume 20 per cent of government development budgets and this borrowing can amount to some 40 per cent of a country's foreign debt. Many plants operate only 35-50 per cent of the time compared to 70-85 per cent in developed countries.

## Electric power projects

A World Bank review of electric power projects<sup>4</sup> points to the deteriorating financial performance of utilities since 1965: operating ratios (ratio of operating costs, before debt service, depreciation and other financing charges, to operating revenues) have been rising, rate of return dropping, and days receivable increasing. These all reflect difficulties over metering, billing and collection and the self-financing (internal funds as a proportion of enterprises and requirements). Debt service ratios have also been falling. As a result, many utilities now look to government for investment financing at preferential rates, the waiving of debt and even subsidy of operating costs. Electricity charges are subsidised in many countries. Recent estimates for six African countries indicate that by raising user charges to long-run marginal costs total central government revenue would increase by five to 10 per cent.

For countries in Latin America and Africa to implement those reforms will require a high level of commitment and political skills. Whereas in East Asia we can foresee growth rates at seven per cent, for Latin America there

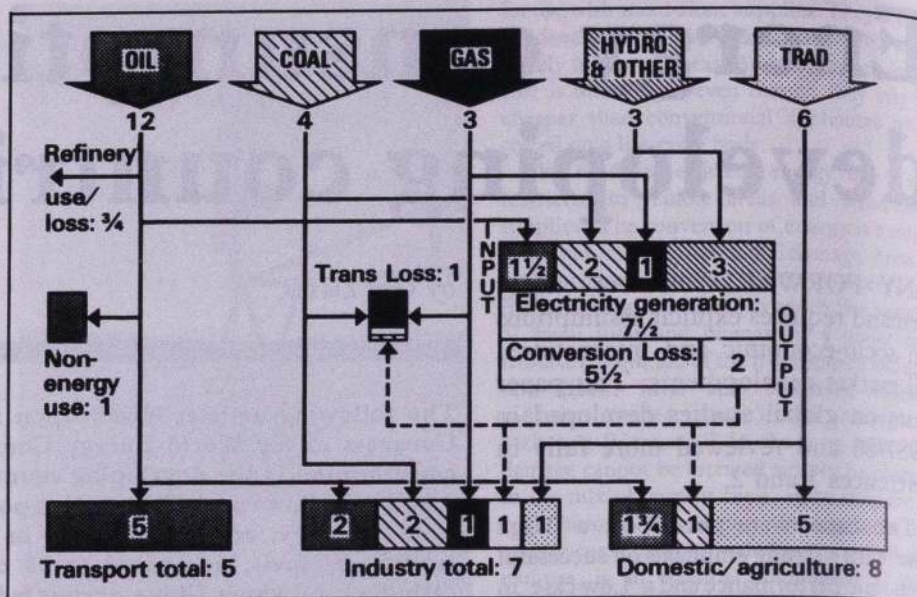


Fig 1: Simplified energy flows LDC's (in WOCA) 1985 (million b/dae).

are three to five years of structural adjustments ahead before growth rates might be restored to the levels experienced in the 1960's and 1970's. For African countries, the adjustment will be from five to 15 years.

We have assumed the fastest route to reform, ie, that problems will be addressed in 1989/90. The short-term costs will be high. For example, Mexico's 'Economic Solidarity Pact' will probably lead to an estimated one to two per cent decline in GDP in 1989.

On the 'downside', a rejection of structural reforms could lead to virtually no per capita growth and social turmoil. There will be a need to progress on many fronts to achieve economic potential in the 1990's.

## Energy demand

The current use of energy in DC's is summarised in Figure 1. Commercial primary energy consumption totals 22 Mb/dae. The main end-users of commercial energy are: transport, 5 Mb/dae; industry, 6 Mb/dae; domestic/agriculture, about 3 Mb/dae. (Most traditional fuel is used in the domestic/agricultural sector and here the data is rather sketchy). The main factors influencing demand in end-use markets are now reviewed.

**Households** — In our studies of energy use in DCs we distinguish between subsistence and industrialising economies. For the former group (comprising some 2.3 billion people in rural areas) energy is used for the necessities of cooking, water heating, space heating

(depending on climate) and lighting (when it can be afforded).

The main fuels are traditional — fuelwood, agricultural and animal residues. They are used inefficiently (with but 10-15 per cent combustion efficiency) and are subject to availability through deforestation and desertification; this is particularly a problem in Sub-Saharan Africa and parts of India. Income levels and fuel prices are an important determinant of fuel selection by households.

The Kenyan experience is typical of many countries. Families with low incomes consume fuelwood, charcoal and kerosine; those with higher income use charcoal (for cooking), LPG and electricity. Although the heating value of the fuel delivered to the richer households is only a third higher than the poorer, the higher conversion efficiencies lead to richer households gaining three and a half times more energy in end-use than the poor. In many countries kerosine, LPG and electricity are subsidised. If economic reforms lead to cost-reflecting pricing there will in the early years be some dampening of demand growth. If we assume that one-half of the increase in traditional fuel needs in rural areas were to be replaced by commercial fuels this would still only amount to about 0.5 Mb/dae — assuming an ability to pay by householders. Although these markets are of local importance their impact on global markets is small.

A significant driving force for increasing household energy consumption is urbanisation. As incomes increase consumers desire to acquire appliances and thus 'climb the ladder of energy'.

The Malaysian and Filipino experiences are typical of many countries, with many families (even at low incomes) having refrigerators and at higher income water heaters and air conditioners — see Table 2. Appliances tend to be inefficient. Even allowing for substantial improvements in conversion efficiencies and reduced subsidies, delivered commercial energy to households would rise more or less in line with income growth, from below 2 Mb/dae in 1985 to 4 1/2 Mb/dae in 2005.

Table 1: Electric power generation in developing countries — trend of key financial indicators based upon World Bank review of 120 projects

Financial Ratio*	1966/73	1974/79	1980/85
Operating ratio	0.68	0.73	0.80
Rate of return (%)	9.2	7.9	6.0
Days receivable	77	97	112
Self-financing ratio (%)	24.6	18.6	17.2
Debt service ratio	2.0	1.8	1.6

\* Financial ratios correspond to actual values at appraisal, completion, or supervision, depending on project status



**Industry** — Industrialising countries use energy to meet both domestic demand for industrial goods (with a focus on infrastructure requirements) but also for manufactured exports and commodities. Experience has taught that energy consumption for basic materials grows at 1½ times income growth up to US\$ 5000/capita when saturation occurs. However, technological innovations in the last decade will reduce unit energy requirements for these industries. For example, in the paper industry purchased energy consumed per unit of paper produced is nearly double in the DCs compared to developed countries. The exception is Brazil, where there are large mills with foreign participation, which shows it is possible for DCs to drastically reduce energy inputs.

International commodity markets for metals and agricultural products are very competitive. With the emphasis on achieving low cost positions there is a drive to use energy efficiently.

For newly industrialising countries (NIC's) with aspirations to be global players we can expect a significant shift in export portfolios to higher technology areas.

Consider the case of South Korea which by 2000 envisages 42 per cent of value-added in manufacturing to come from machinery, electronics and automobiles. Korea is a major importer of Japanese technology, and, like future successful NICs, will need to employ the same or better technology than its OECD competitors.

We estimate that by 2005 the manufacturing share that total GDP of all DC's will rise by five to eight per cent. This translates into an almost doubling of energy demand to 11 Mb/doe, when efficiency improvements are taken into account.

**Transport** — As countries urbanise there develops a basic need for mobility. Public transport dominates in low income countries or those where strong policies exist to impede private car ownership, but there is a strong desire for 'wheels' which has manifested itself, particularly in Far Eastern countries, in a growth in the motorcycle fleet.

In Indonesia, three-quarters of all vehicles are motorcycles. However, motorcycles are not large fuel users. We estimate that the DCs motorcycle fleet of 25 million vehicles consumes only 50,000 b/doe of fuel compared to

**Table 2: Electric appliance ownership and income in urban areas**

Income Group	Refrigerator	Air Conditioner	Water Heater
(per cent of households in group)			
Kuala Lumpur/Kajang (M\$/month)			
150-299	13	0	0
300-599	50	0	6
600-999	65	1	6
1000-1999	79	10	14
2000-4999	87	23	31
5000 +	96	79	50
Philippines			
Low	15	0	—
Middle	66	2	—
High	93	20	—

Sources: Socio-Economic Research Unit (1981); Philippines Ministry of Energy (1982a)

**Table 3: Developing countries energy demand: 1985-2005**

Million b/doe	1985	2005	
		HIGH	LOW
Primary energy	22	44	32
Oil consumption	12	18	15
Direct markets (energy)	14	26	19
Transport	5	9	7
Industry	6	11	7
Residential, Services, Agriculture	3	6	5
Electricity generation	7	16	11

the 2 Mb/doe of fuel consumed by DC's 45 million cars. Even if the Indonesian experience were replicated over all the developing world (so that we had 100 million motorcycles by 2005) the increase in fuel demand would be more than 0.2 Mb/doe.

In the high economic growth case we could expect the car fleet to triple, but fuel consumption would not rise as fast. Cars in DC's are less efficient than comparable cars in OECD. For example, in Venezuela the average fleet efficiency was only 10-12 mpg in 1983 and the on-the-road efficiency of new Brazilian cars on the market may have been at least 20 to 30 per cent below comparable cars in Europe and Japan.

By 2005, we might imagine some 20 per cent of the world's car market to be in DCs. This would be a major growth area for international car manufacturers. As DCs grow in a world of global markets, strategic alliances will become important means for increasing rates of technology diffusion and transfer.

Many car manufacturers have assembly plants in DC's. Their current strategies include taking more substantial positions, eg, Toyota's recent agreement with the Indonesian government to build an engine plant. As such developments proceed we can expect large increases in the efficiency of cars entering the market.

For the whole transport sector we would see a rise of demand from five to nine Mb/doe — almost all of it oil — by 2005.

## Summary

As DCs adjust to more open internal markets, become more susceptible to the disciplines of the private sector and more integrated in global markets, marginal energy intensities could drop sharply.

A recent example of what economic reforms can mean for energy use is that of China, where from 1953 to 1979 energy consumption grew at 1.6 times income but since 1979 has grown at a rate only half that of the economy. Current

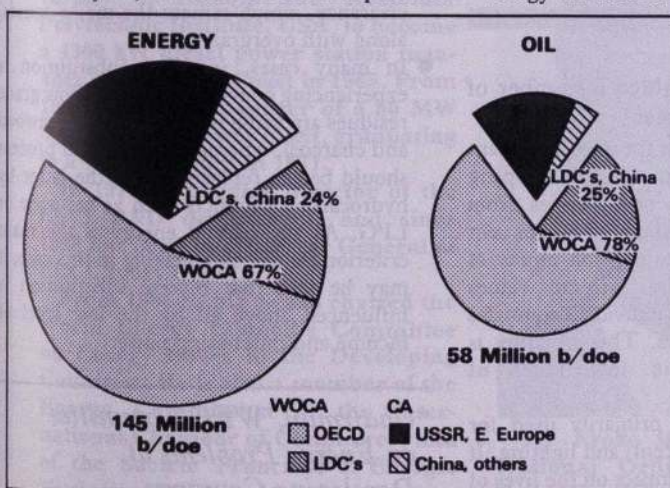


Fig 2: World energy and oil demand 1985.

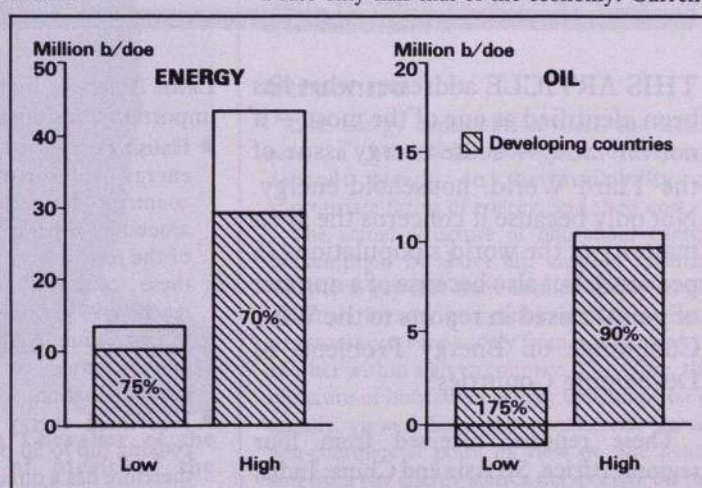


Fig 3: WOCA energy and oil demand incremental growth 1985-2005.



plans are to maintain this record with a wide range of conservation policies. In a number of countries shortages of capital, due to their debt crisis, is forcing electricity companies to consider low-capital conservation and demand management options rather than just continuing to build power stations.

Total energy, oil and end-use consumption in 2005 for all DC's are summarised in Table 3.

## Conclusions

**World Energy and Oil Demand** — Some 60 to 75 per cent of incremental energy demand in the world outside centrally planned economies and virtually all incremental oil demand is projected to occur in the DCs, eg, in the *high* case energy consumption rises from 22 to 44 Mb/DOE by 2005 and oil 12 to 18 Mb/DOE.

OECD energy markets are seen as maturing, a consequence of changing economic structures, new technologies and saturation of some uses; whereas DC growth in energy markets, which has historically tracked GDP growth, is seen to continue rising under the pressures of population growth and desire for industrialisation and motorisation. What we observe are 'two worlds' moving apparently in different directions.

**Call on OPEC** — Should oil prices stay in the US\$ 20-25/bbl range (in 1988 US\$) and only modest technological improvements

**Table 4: DC capital requirements for incremental and replacement supply of energy: 1985-2005 (US\$ billion — 1986 money)**

Oil	400
Gas	100
Coal, Others	160
Electricity Generation	800
Total	1460
Average pa	73

occur in the 1990's non-OPEC oil supply could remain steady.

Even in the *high* economic growth case, the combination of a six Mb/d increase in developing country oil demand and relatively high non-OPEC oil availability will pose a challenge for OPEC management in the 1990s.

**Private sector** — The doubling of energy demand and the 50 per cent increase in oil demand for all DC's by 2005 (in the *high* case and in a climate of 'economic' reform) does offer opportunities for private investors over the full range of energy sector activities.

We estimate annual investment requirements in the energy sector of some US\$ 75 billion/annum, of which 55 per cent would be for electricity generation projects (Table 4). This reduction from prior estimate reflects the assumption of major shifts in policy in this sector, and assumes that reform of the electricity sector is possible along the lines championed by USAID and the World Bank. The

key is active involvement of the private sector, eg, through Build-Own-Operate (BOO) schemes, as in Turkey, protected by new insurance schemes such as Multilateral Investment Guarantee Agency (MIGA). If this can be achieved there would be a large growth in indigenous gas and coal projects to meet electricity industry needs.

The latest views on interfuel economics for electricity generation favour smaller, more flexible power stations using natural gas. Current economics favours this development, and such plans have the added benefit of being less polluting.

Clearly there will be a wide range of opportunities for private investors in the non-oil energy sector, from the small such as fuelwood plantations and energy management, through power generation to upstream projects.

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# Energy demand and trends in interfuel substitution

by Diby M Kroko BS, MS\*

**One of the most acute energy issues of the Third World is household energy. In the following article, based on Diby Marcel Kroko's paper presented at the WEC in Montreal last September, Mr Kroko reviews household energy sources, supply, demand and consumption, as well as interfuel substitution and household energy strategy formation. He concludes by calling for appropriate policies and positive action, avoiding generalisation which he sees as not only impossible but also dangerous.**

THIS ARTICLE addresses what has been identified as one of the most — if not *the* most — acute energy issue of the Third World: household energy. Not only because it concerns the great majority of the world's population (75 per cent), but also because of a number of points raised in reports to the WEC Committee on Energy Problems of Developing Countries.

These reports, received from four regions: Africa, SE Asia and China; India, Pakistan, Iran, Jordan and Nepal; and

Latin America, highlighted a number of important considerations:

- Housing energy is by far the most important energy sub-sector in all developing countries. Its relative share varies from around 20 per cent to about 70-80 per cent of the total energy consumption in any of these countries, some extreme values reaching 95 per cent in individual countries in, for example, Africa. This situation is mainly due to the low level of industrialisation.
- Household energy is primarily used for cooking (up to 50 per cent) and lighting. It therefore has a direct impact on the lives of people as well as on their living conditions.

- Household energy is used inefficiently. Traditional cooking stoves are largely responsible for this.
- Household energy is primarily derived from wood. Fuelwood being a depletable resource, it follows that availability of household energy in the future is not necessarily guaranteed. Firewood is not, of course, the main cause of deforestation and desertification, as it is generally a by-product of logging and agricultural land clearance, which remain the major causes, along with overgrazing.
- In many cases, interfuel substitution is experiencing a reverse process, as low grade residues are being used in place of firewood and charcoal, whereas the expected process should be the replacement of the latter by hydrocarbon products such as kerosene or LPG. As the cost of energy is the main criterion for decision making in this case, it may be said that reverse substitution is influenced above all by the low level of income and purchasing power.

\*Chairman, WEC Committee on Energy Problems of Developing Countries



## Household energy supply

The household sector uses a large spectrum of energy sources: both commercial and non-commercial forms of energy in rural as well as urban areas. What most of these have in common is that they are depletable, the most obvious example being firewood. Sources such as candles, coal coke, alcohol and solar represent an insignificant part of the total supply.

Energy is generally available in one form or another. However, accessing that energy can be costly and time consuming, and the relative importance of any given energy source is dependent upon the location being considered. Thus firewood can account for between 0 and 60 per cent or more of the total energy supply in certain countries, whereas in others, hydrocarbons represent up to 98 per cent of the total energy supplied to the household sector.

Developing countries also lack sufficient financial and human resources to develop and manage energy, this applies in particular to household energy, where estimates can vary by factors as high as five times or more.

Rapid large-scale urbanisation has a direct impact on biomass supply. In Africa, for example, the population growth is higher than 2.5 per cent, and up to a third of the population live in urban areas. This tends to lead to faster rates of depletion of woodfuel stocks, and a greater use of charcoal as opposed to firewood.

The use of fuelwood has ecological consequences. In addition to deforestation, which has already been mentioned, emission of smoke leads to respiratory diseases, making these consequences a vital issue for the environment, people and animals alike.

Another important issue in relation to energy supply is that most countries which rely on hydrocarbons do not produce oil. This has obvious implications for the respective countries' balance of payments.

In addition to lack of technical expertise, the greatest limitations to the use of biogas are the strong psychological barriers, which impose significant restraints upon its supply.

**Table 1: Spectrum of energy sources supplying the household sector in developing countries**

Energy sources		Africa	Asia	India	Latin America
Non-commercial	Firewood	•	•	•	•
	Charcoal	•	•	•	•
	Crop residues	•	•	•	•
	Animal waste (dung)	•	•	•	•
	Biogas		•	•	
Commercial	LPG	•	•	•	•
	Kerosene	•	•	•	•
	Electricity	•	•	•	•
	Alcohol				•
	Candles				•
	Coal coke			•	•
	Solar	•	•	•	

**Table 2: Consumption of commercial energy in the household sector in India (in millions tons of oil equivalent)**

Year	Coal Mtoe	Oil Mtoe	LPG Mtoe	Electricity Mtoe	Total Mtoe
1960-61	0.9	2.0	—	0.4	3.3
1965-66	1.3	2.4	—	0.6	4.3
1970-71	1.3	3.3	—	0.9	5.5
1975-76	1.2	3.4	—	1.4	6.0
1982-83	0.8	5.2	0.5	2.9	9.4
1984-85	1.0	6.6	0.9	3.7	12.2
1999-2000*	9.8	15.0	12.0	23.0	59.8

\* projected consumption

## Demand and consumption

The regional and country reports received by the WEC shows that energy demand is high in the household sector, but is comparatively low compared to that of industrialised countries.

The reason for the high demand can be accounted for in several ways. Between 65 and 85 per cent of people in rural areas are keen to improve their living conditions. In order to prevent rural dwellers from moving to cities, governments provide them with 'urban' commodities, such as televisions, refrigerators and other modern electrical appliances.

However, energy consumption continues to be low in both urban and rural areas due to inadequate incomes. Lack of data makes it impossible to quote either regional or global

figures for past, present or projected consumption figures. However, a study of commercially-produced energy used by Indian families shows that consumption rose steadily from 8.88 per cent in 1960-1, to 9.24 per cent in 1984-5, ie, from 3.3 million toe to 59.8 million toe per year.

During the same period, however, the household sector's share of total energy consumption has fallen, due to increased industrialisation. So too has the proportion of non-commercial energy in India's total energy consumption.

India, of course, is not typically representative of all developing countries, but it does illustrate the case of so-called countries in transition, where adequate data exist due to the availability of equally adequate human resources and institutional organisation. None the less, the share of the household sector in total energy consumption remains high, over 40 per cent, the equivalent figures in other countries being either lower (Jordan 16.6 per cent), or higher (African countries 70-85 per cent), depending on the country's specific economic situation.

## Structure

Like energy consumption itself, the structure of household energy consumption depends greatly on the availability of appropriate forms of energy, and their cost.

The actual structure of household energy consumption is, above all, location specific. That is to say that there cannot be any single structure for any geographic region, as such structures can vary widely from one location to another within a given country. Therefore, the structure of household energy consumption is usually viewed from the commercial versus non-commercial point of view on one hand, and from the energy source perspective on the other.

## The author

Diby Kroko graduated from the University of Illinois and Rensselaer Polytechnic Institute, USA, to become a 1300 kW diesel power station manager on the Ivory Coast in 1965. From 1965-68 he was manager of a 50 MW hydroelectric power plant, graduating to a 175 MW plant in 1971.

In 1979 he became director of the EECI R&D department, and since 1988 has been the Director General of EECI, Ivory Coast.

From 1986-89 Mr Kroko chaired the World Energy Council's Committee on Energy Issues in the Developing Countries. He is also a member of the Energy Commission of the International Chamber of Commerce, and of the Societe Francaise D'Énergie Nucleaire (SFEN).



Mr Kroko is a Chevalier of the National Order of Merit of the Republic of the Ivory Coast.



To look at such a structure from the former viewpoint, it should first be remembered that the most common non-commercial energy is biomass, or products derived from it, eg, firewood, charcoal, crop residues, agro-industrial wastes and dung. Where these fuels are available, the regional reports show that firewood and charcoal are the most widely used fuels, both in rural and urban areas. Their collective share of non-commercial energy consumption is generally high and can reach 100 per cent in some cases.

Commercial energy is generally used (up to 98 per cent) where non-commercial energy is not available, although its cost may be high, even prohibitive. Such is the case for hydrocarbon products, for example, kerosene or electricity.

### Consumption issues

In trying to identify issues on this matter, it should be borne in mind that the demand for energy is a derived demand to satisfy social needs. Issues in household energy consumption are therefore closely linked to national economic and managerial contexts, as well as to this sector itself.

The following are the most common issues raised in the reports to the WEC:

- Massive energy consumption is difficult to achieve due to inadequate income and purchasing power.
- Future availability of domestic fuels is threatened by present inefficient use of these fuels. For example, figures from different sources show that the average African family used five times more energy for cooking than a typical industrialised country family would use.
- The patterns of household energy consumption are not always well understood, particularly where adequate man-power is lacking.

- Institutional organisation is generally either lacking or inappropriate, or inefficient for sound policy formulation and for planning and project implementation or adequate data collection.
- Too much waste still exists both in energy supply and use. For instance, all the available biomass is wasted for lack of appropriate technologies to convert it into useful energy.

### Interfuel substitution

Interfuel substitution is generally understood as a forward shift from bio-fuels to commercial fuels. It is a natural process that takes place according to the availability of commercial fuels, and is dependent on adequate levels of income and purchasing power.

Fuel prices are less of a determining factor: people want better living standards, and are prepared to pay if they can afford to.

This process is a reality, although lack of adequate data means it cannot be measured. Nevertheless, it has been observed that the most common fuels are LPG for cooking, kerosene and electricity for lighting.

The WEC reports also show that there can be a reverse fuel substitution, whereby people move down the fuel ladder, changing from firewood and charcoal to crop residues and dung.

No matter what the direction of the fuel substitution process, managerial capability must be developed so that the movement can be better monitored.

### Strategy formulation

It is generally agreed that any household energy strategy formulations should cover at least the five following points:

- Adequate and reliable data bases to improve knowledge of fuel supply, patterns of energy and customers' preferences.

**Table 3: Share of household sector in energy consumption in India**

Year	Share in commercial energy consumption	Share in total energy consumption
1960-61	8.88%	69.36%
1970-71	8.93%	62.17%
1984-85	9.24%	49.39%

**Table 4: Share of non-commercial energy in total energy consumption in India**

1960-61	1970-71	1984-85
66.37%	58.46%	44.24%

- Good knowledge of biomass supply, bearing in mind that in most developing countries, a high percentage of energy requirements are met by biomass.
- Sound demand management programmes.
- Consistent interfuel substitution and energy saving policies.
- Appropriate institutional organisations allowing for efficiency across all sectors of the economy.

The case of household energy is a vital issue in developing countries, in both rural and urban areas. Trying to find satisfactory solutions is a far from easy task, as the problems are often specific to certain locations. For this reason generalisation is not only impossible, but dangerous and should therefore be avoided.

Any attempt to address the problems should avoid isolation from the social and economic environment of the location under consideration. Indeed, it is because of these social, economic and environmental dimensions and implications that appropriate policies are needed, along with positive action to address the energy requirements of the Third World as a priority issue. □

## ELECTRICITY FROM GAS

a one day conference organised by The Institute of Energy

31 October 1990

at The Royal Garden Hotel, London W8

Business opportunities abound for energy users to profit from combined heat and power. The 1983 Energy Act ensures that the electricity industry will co-operate with customers' electricity generation schemes. Privatisation of fuel supply industries has brought a competitive edge to fuel pricing. The environmental issue is creating the condition for combined heat and power to flourish.

The Electricity From Gas Conference is where decision makers in industry and commerce can hear and debate the opportunities with key people from the energy industries. Case studies ranging from hotels to factories to power stations will illustrate the real benefits and difficulties. An exhibition and evening reception will give ample time for informed and informal discussion.

Here is the opportunity within one day, to become fully informed on what combined heat and power could mean to your company.

For further details please telephone Judith Higgins, Conference Manager on 01-580 0008. The Institute of Energy, 18 Devonshire Street, London W1N 2AU.



## Annual review

### 'BP Statistical Review of World Energy 1988'

Published by Government and Public Affairs Department, British Petroleum Company, London, 1989  
36 pp. Free of charge (one copy only)

This review, issued annually by British Petroleum, provides a comprehensive analysis of the performance of the world's oil industry. Primary energy consumption is given on a global scale covering statistics on gas, coal, hydro-electricity and nuclear energy.

World primary energy consumption increased by nearly 3.7 per cent to 8.1 billion tonnes of oil equivalent (toe). The most rapid growth in energy demand occurred in the industrialised countries of South East Asia, where consumption rose by 11.4 per cent to 241.8 million toe. Detailed information on South East Asia is given because of its increasing significance in the world's energy markets. For the first time since the recession years of the late 1970s and early 1980s, primary energy consumption in OECD countries grew in line with GDP.

The largest consumer of energy in the world is the USA, nearly 2,000 million toe being demanded in 1988. The energy consumption per capita is more than eight toe, double that of Japan. In contrast, Western Europe's consumption was markedly less, only 1 per cent growth in 1988, some 1,311 million toe. The countries of Europe with the greatest growth rate were Greece, Spain and Turkey.

In real terms, oil prices in 1988 were lower on average than in 1986. Robust economic growth is given as a key factor behind oil demand, representing 49.8 million barrels a day in the non-communist world (one barrel is equivalent to 35 gallons (Imperial) or 7.33 barrels equates to one tonne). The global figure is 63.2 billion barrels a day. Consumption in South East Asia has risen over 42 per cent in the last ten years, highlighting the importance of the region in the oil market.

In the United States, oil has shown a productivity decline to 9.7 million barrels a day, despite an increase in consumption. This has meant an increase in imports of oil to 42 per cent. OPEC continues to dominate the oil supply scene. Harmony amongst the members of OPEC does not always prevail and, throughout the year, quota violations occurred particularly in the latter half of 1988.

Oil reserves continued to grow and the present situation indicates that these will last for the next 41 years at the present rate of oil production. For gas, the reserves available fell slightly to a corresponding figure of 58 years.

In the coal industry, Socialist countries dominated the scene, accounting for more than half of the world's production. World production of coal in 1988 was over 2,400 million toe. Western countries' production increased last year by a mere 0.6 per cent to 263 million toe.

For a comparison, the use of nuclear energy grew by some 8 per cent. This represents nearly 440 million toe and is now 5.4 per cent of the total energy demand. Despite the fact

that no new nuclear power plants have been constructed for almost a decade, the USA is by far the largest user of this form of energy. France ranks second to the USA. In the United States, nuclear electricity production grew by 16 per cent, representing an energy usage of 145 million toe. This is over six times as much as the total amount of primary energy used in Britain.

For the United Kingdom, the total energy consumption was 208 million toe, a rise of 0.7 per cent over 1987. Most of the increase came from a greater demand for oil, 6.5 per cent growth to 80 million tonnes. Gas and coal consumption fell in Britain in 1988.

F John L Bindon

## Some coal science

### 'Coal Classification'

by Anne M Carpenter  
IEA Coal Research, 1988  
104 pp. £60.00 (£180.00 to non-member countries of IEA Coal Research)

Due to its complex and heterogeneous nature, the full characterisation of coal is a time-consuming and expensive process. Therefore, a great deal of effort over the years has gone into developing systems for classification. This report shows that the nature of a classification system depends upon the particular application, whether it be scientific or commercial, for which the system is to be employed.

In this excellent report the author has examined the current classification systems in use in the IEA Coal Research member countries. In Section 2, tests concerned with chemical composition are described and, in Section 3, those concerned with mechanical and physical properties. The petrographic tests are covered in Section 4. Since some of these tests are empirical, newer analytical techniques that have been used to characterise coal are discussed in Section 5. These tests may provide parameters that are more reproducible than some of the conventional empirical tests.

Three processes were chosen by the author to illustrate the relationships between the characteristics of a coal and its behaviour — combustion for its commercial importance, liquefaction as an example of the newer technologies, plus coking for historical reasons. Some additional properties employed by industry for the evaluation of coals (for example, in coal specifications) that could possibly be used as classification parameters are also considered.

The author concludes that once the critical coal properties have been found, they must be presented in a legible and easily memorable way. Traditionally, they have been arranged as a hierarchy. However, more recent classifications are being presented as 'faceted classifications' (codifications). With the wide diversity of coals, it may be easier (and of more use) to classify them in a faceted manner rather than in a hierarchical system. However, it is concluded that since different properties of coal are important in the different end-use processes and with the wide heterogeneity of

coal, it seems unlikely that the desired objective of a simple classification that is relevant to all coal uses and for all coals, and that will be accepted worldwide, will be realised in the near future.

I am sure that this report will become essential reading for many students and professional staff involved in coal science.

Dr Andrew W Cox

## The latest on pollution

### 'The Engineer's Clean Air Handbook'

by Peter D Osborn  
Butterworth Scientific, 1989  
201 pp. £40.00

This book is written for engineers in a comparatively simple style, so that it should be understandable by anyone who is interested in atmospheric pollution and the problems of removing pollutants. It is only 201 pages long but deals very methodically with the causes of the various types of air pollution and the complicated nature of many of the pollutants, such as CFCs and radioactivity. Methods of removing the pollutants are considered in detail together with instruments for monitoring and controlling contaminants. Finally, the quality of breathing air ie, ventilation and the effects of atmospheric contamination on health are considered.

Naturally in a book of this size the subjects cannot be considered in detail, but the final section contains excellent reference material on the physical and chemical characteristics of many dusts and compounds associated with pollution. There are also useful references for further detailed study.

This is essentially a practical book for engineers in many industries. It is also a useful reference book for those who have specialised in one branch of atmospheric pollution and who may wish to have basic information on other forms of atmospheric pollution and physical methods of monitoring and controlling many industrial contaminants. It does not attempt to study more complicated large-scale subjects such as desulphurisation.

A very useful book to keep one up to date with the latest thinking on new developments associated with atmospheric pollution.

Byrom Lees

## Recently published

'The Work of HM Nuclear Installations Inspectorate'  
HMSO, 1990, 25 pp. £3.50

'Energy and Nuclear Sciences International Who's Who'  
Longman Group UK, 1990, 424 pp. £180.00

'1990 European Oil & Gas Management Directory'  
Publishing & Production Services/Editions Technip/Petroleum Management, 1990, 700 pp. £55.00



## Fifth fuel — the debate continues

Sir,

I was most interested and encouraged to read the 'Fifth Fuel' article in the February 1990 issue of *Energy World*. I was interested because of the subject matter, and encouraged that, as the professional body for energy specialists, we should be seen to publicise such views for the benefit of politicians who are unsure to whom they should turn for advice.

To follow Dr Brookes' theme, the evidence to support the view that an increase in the efficiency of use or supply of an elastic commodity invariably increases its consumption, is overwhelming. Those who would like to believe the opposite, in spite of the accumulated evidence of human nature to the contrary, are simply looking through rose-tinted glasses, expecting the world to conform to their ideal.

To consider, for example, a suitable parallel: the fifth fuel protagonists would have predicted a decline in the number of aircraft flights with the advent of the high-capacity wide-bodied jet. The opposite situation has of course come about. Reducing the real cost of travel has encouraged people to travel more, not travel less.

In a free society a reduction in energy consumption will be achieved only by pricing

marginal consumers out of the market, or by employing an army of energy police to prevent lights and radiators being turned on without permission, and thermostats being turned up.

For the sake of all our futures, I hope other members support Dr Brookes in consigning this specious 'fifth fuel' philosophy to the waste-paper basket before any harm is done or any energy police are appointed.

**P H Spare** (*Fellow*)  
Davenham, Cheshire

## Wind farms — current state of play

Sir,

Following the item 'Wind farm for the Tees?' (*Energy World*, February 1990) which reported the situation as of last November, I should like to place on record the current state of play.

Newly aquired data from the met office show wind speeds averaging 6.85 m/s at 10 m height for this site. That implies a significant increase in annual power generation. The Government's Non Fossil Fuelled Obligation (NFFO) will now enable distribution companies to pay up to 6 p/kWh and finally a new manufacturer has offered larger machines which, at the recorded mean wind speed would given an annual production of 6.5 GWh.

In combination these factors put up the expected annual revenue from £200,000 to £378,000. The total investment is still well under the £2 million previously mentioned. The capital cost of a fully working system including grid connection seems to be firming up at about £1.8 million.

Of course the ultimate returns for such an investment will depend on the continuation of the NFFO, the future strength of the wind, future bank interest rates, and other factors such as energy policy following a possible change of government. If recent predictions from the Institute of Fiscal Studies are to be believed then profits from wind farms may increase due to the general rise of electricity prices in real terms.

The previously hoped for help from the EC seems now unlikely to materialise but, even so, these new figures for profitability ought to be attractive to venture capital. No firm commitments have yet been made and I am open to offers.

**Owen Dumpleton** (*Fellow*)  
Consultant Engineer, Tyne and Wear

The Editor welcomes letters for publication from readers. However, correspondents are requested to keep their letters as short as possible, up to a maximum of 500 words. This will enable the views of as many readers as possible to be published.

## ENGINEERING COUNCIL



### Eur Ing leaflet campaign

A NEW leaflet to encourage British Chartered Engineers to apply for the recently-introduced title of European Engineer has been issued by the British National Committee for International Engineering Affairs.

The leaflet, which details the benefits and the route to European Engineer status, is part of a campaign by the Federation Europeenne d'Associations Nationales d'Ingenieurs (FEANI) aimed at Europe's 1,000,000 professional engineers who could qualify for the title.

In Britain, most of the 200,000 Chartered Engineers on the register of The Engineering Council could become European Engineers which carries with it the designatory letters Eur Ing. Three thousand have already done so. To gain the European title candidates have to prove that they have successfully completed an approved degree, training and experience not less than seven years in total.

FEANI represents 20 European countries each of which has a national committee. Professor Jack Levy FEng, Secretary General of the British National Committee, said: "The new European title should now become a 'passport' enabling greater mobility and recognition for engineers working in Europe. Internationally it is a guarantee of professional engineering status helping engineers to practise their profession worldwide".

Copies of the leaflet *European Engineer, a*

*professional title for Europe* are available free from BNC for FEANI, c/o The Engineering Council, Savoy Hill House, Savoy Hill, London WC2R 0BU.

### 'Engineering for People'

EACH of the 740,000 young people in Britain who are making a decision about their GCSEs or Ordinary and Standard grades will be given a personal copy of a new colourful ten-page brochure which tells them of the excitement and challenge of modern engineering.

The Engineering Council's brochure *Engineering for People* goes to all Britain's secondary schools at the end of this month.

The Council, which has led many initiatives to raise the awareness of engineering, wants young people to discuss the engineering careers brochure with their parents, teachers and careers officers to help them map out their future.

*Engineering for People* illustrates the importance of teamwork and creativity in improving the quality of life for all. It explains how young people with a wide range of abilities and ambitions can choose the best route to qualify to give them a worthwhile and well-paid career in a tremendously wide variety of jobs.

The brochure was tested on a national basis with young people, teachers, advisors, parents and governors. It is endorsed by the Engineer-

ing Careers Co-ordinating Organisation, an independent body which co-ordinates engineering careers information.

*Engineering for People* is available free from The Engineering Council, 10 Maltravers Street, London WC2R 3ER.

### WISE guidance

INITIATIVES supporting the Women Into Science and Engineering (WISE) campaign have doubled over the last 12 months. This is reflected in the 1990 edition of a booklet *Awards, Courses, Visits* aimed at encouraging young women to take up a career in engineering.

The booklet, published by The Engineering Council and sponsored by BICC plc, the cables and construction group, is a handy reference of new opportunities for discovering engineering careers. The initiatives listed include ten award and scholarship schemes, 64 courses and 16 visit arrangements.

The WISE campaign seeks to change attitudes among young people, parents, teachers and the general public about the value of engineering and its suitability as a career open equally to girls as to boys.

The six-year-old campaign has resulted in more women studying engineering and technology in higher education. Now 12 per cent of engineering students are women compared to seven per cent when the campaign started in 1984.



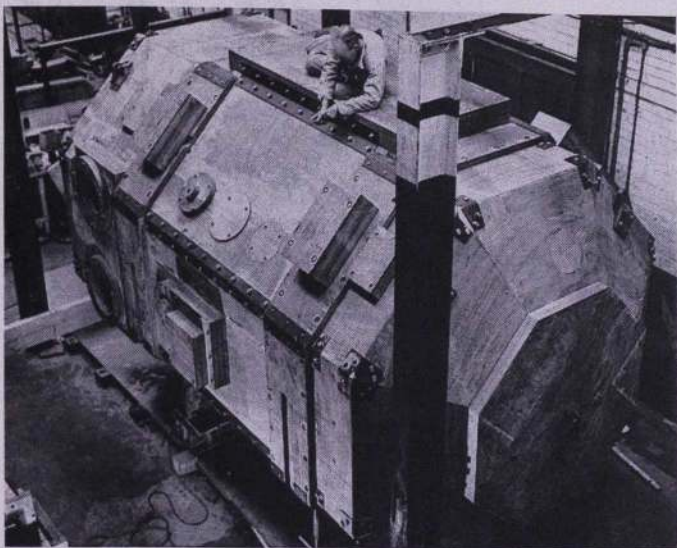
**Nuclear shielding for the Tokai power station**

PERMALI Gloucester Ltd is supplying a variety of nuclear shielding components for use in the Tokai power station in Japan.

The shielding components are made from Permal's Jabroc "N" material, a boronated, densified wood laminate. The material is relatively lightweight and easy to handle, yet is extremely strong, impact-resistant and easy to machine. It is used for biological shielding in applications where the gamma radiation produced on neutron capture could otherwise reach unacceptable dose rates.

Jabroc "N" is manufactured from selected beech veneers which are impregnated under vacuum with a boron-containing solution and laminated together using a phenolic glue film under heat and pressure. This process combines the strength and resilience of natural timber with the dimensional stability and moisture resistance of thermo-setting resins.

Tokai power station on the Pacific coast 70 miles north east of Tokyo houses a single Magnox



The shielding structure is made from densified wood.

reactor with four steam raising units feeding, two 85 MW turbo-generators.

First commissioned in 1965, it was designed for the Japan Atomic Power Company by GEC/Simon Carves Atomic Energy Group with the British General Electric Company of Japan acting as main contractor

for the reactor and generating plant.

The design incorporates a number of special earthquake protection features, including structural reinforcements.

For further details contact Permal Gloucester Ltd, 125 Bristol Road, Gloucester GL1 5TT.

**ERS for Telford plant**

INGERSOLL-RAND's Energy Recovery System (ERS) is being used by Sonoco Polysack in a new air compressor installation at the company's plant in Telford, Shropshire.

With the ERS, up to 80 per cent of the energy used to compress air in the company's SSR rotary screw air compressors can be recycled. Although intended as an optional feature of SSR compressors, Ingersoll-Rand can produce customised systems for smaller units such as the ML-75 machines at Sonoco. The ERS can be installed in already commissioned compressors and the package generally includes oil/water heat exchanger, installation kit including inlet and outlet water temperature gauges and all the necessary valves, pipings and fittings.

For further details contact Ingersoll-Rand Information Centre, Freeport, Conrad House, Birmingham Road, Stratford-upon-Avon, Warwickshire CV37 0BR.

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**Title: Circulating fluidised bed technology.**

**Location:** London.  
**Duration:** 1 day.  
**Starting:** 15 May 1990.  
**Content:** A review of development of the circulating fluidised bed to date. Hydrodynamics. Gas and solids mixing. Heat transfer. Reactor modelling, applications and scale-up.  
**Contact:** Conference section, IChemE on 0788 78214.

**Title: On-line monitoring of particle size.**

**Location:** London.  
**Duration:** 1 day.  
**Starting:** 16 May 1990.  
**Content:** Particle populations. Distributions of particle size. Measures of central tendency. On-line particle size analysis: stream scanning and field scanning methods. Differential flow fractionation methods. The use of existing process separators for particle size monitoring.  
**Contact:** Conference section, IChemE on 0788 78214.

**Title: Understanding newer techniques**

**Location:** Aston University, Birmingham.  
**Duration:** 2 days.  
**Starting:** 22 May 1990.  
**Content:** Alternative furnace atmospheres. Fluidised beds.

Vacuum heat treatment. Plasma processing. Computerised control systems. Nitrocarburising treatments. Advances in induction hardening. Laser and electron-beam hardening. Ultra-hard coatings (CVD/PVD/TD). Energy-saving options.  
**Contact:** Wolfson Heat Treatment Centre, Aston University on 021-359 3611 x 5212.

**Contact:**

**Title: Principles of reactor design.**

**Location:** London.  
**Duration:** 1 day.  
**Starting:** 17 May 1990.  
**Content:** Types of reactor. Basic chemical kinetics. Design equations. Reactor selection. Non-ideal flow behaviour. Simulation examples illustrating the operational features of batch, semi-batch, tubular, stirred tank and cascade reactors. Heterogenous reactors.  
**Contact:** Conference section, IChemE on 0788 78214.

**Contact:**

**Title: Buying a control computer.**

**Location:** Teeside Polytechnic, Middlesbrough.  
**Duration:** 2 days.  
**Starting:** 31 May 1990.  
**Content:** Feasibility study/budgeting. Objectives and scope of the system. Production of

enquiry specifications. Software requirements. Tendering and system selection. Procurement and acceptance testing. Installation and commissioning.  
**Contact:** IChemE on 0788 78214.

**Contact:**

**Title: Chemical engineering for engineers.**

**Location:** Bingley.  
**Duration:** 2 days.  
**Starting:** 27 June 1990.  
**Content:** What is chemical engineering? Material balances. Energy balances. Reactor design. Basic mass transfer. Gas absorption.  
**Contact:** Conference section, IChemE on 0788 78214.

**Contact:**

**Title: Introduction to oil industry operations.**

**Location:** The Institute of Petroleum, London.  
**Duration:** 3 days.  
**Starting:** 27 June 1990.  
**Content:** Changing perspectives in the international oil industry. Exploration for oil and gas. Basic concepts of drilling. Petroleum production. Marine transportation. Supply. Refining. Petrochemicals. Research activities. Introduction to marketing and distribution. The retail market.  
**Contact:** Conference Officer, Institute of Petroleum on 01-636 1004.

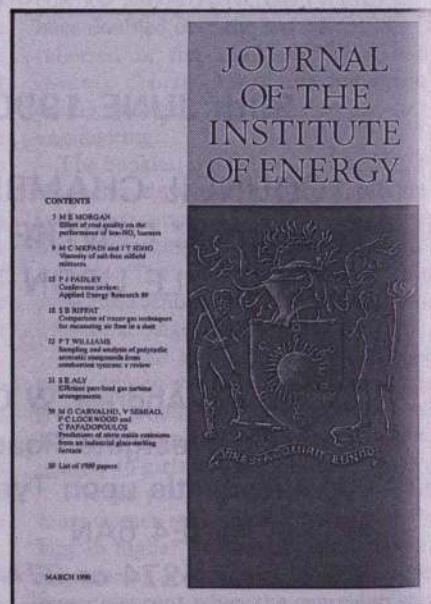
**Contact:**

# Are you missing out on the Journal?

The *Journal of the Institute of Energy* is the technical journal of record for the Institute. Published quarterly, it carries refereed technical papers on a wide range of subjects and it is available to members of the Institute who register their wish to receive it. To put yourself on the mailing list, simply write to the Membership Secretary at The Institute of Energy, 18 Devonshire Street, London W1N 2AU, stating your preference to receive the Journal (please include your membership number in all correspondence).

To those outside of membership, it is available on subscription jointly with *Energy World* — price £130 (UK and overseas).

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



*April 1990*

**Toxic Waste Management Conference**, 23-24 April, London.  
Details from Shailesh K Adalja.  
Tel: 01-409 7130.

*May 1990*

**22nd Offshore Technology Conference**  
7-10 May, Texas, USA.  
Details from SPE Meetings Dept, PO Box 833836, Richardson, Texas 75083-3836. Tel: 214/669-3377, fax: 214/669-0135.

**British Flame Research Committee**

AGM & Technical meeting, 10 May, Institute of Energy, London.  
Details from Colin Rigg on 01 580 7124.

**Commissioning and Operation of Advanced Gas Cooled Reactors**

Seminar, 15 May, London.  
Details from Vanessa Whitehead at IMechE. Tel: 01-222 7899, ext 222, fax: 01-222 4557.

**Environmental Auditing**

One-day seminar, 17 May, London.  
Details from Liz Hide, IBC Technical Services Ltd, Bath House, 56 Holborn Viaduct, London EC1A 2EX. Tel: 01-236 4080, tx: 888870, fax: 01-489 0849.

**International Flame Research Foundation**

Conference on fuel combustion characterisation applied to pulverised coal, fluidised bed combustion and liquid fuels. 20-22 May, Paris.  
Details from Colin Rigg on 01 580 7124.

**Fluid machinery: for the oil, petrochemical and related industries**

4th European congress, 21-23 May, The Hague, Netherlands.  
Details from the Conference Department, Institution of Mechanical Engineers, 1 Birdcage Walk, London SW1H 9JJ. Tel: 01-222 7899, tx: 917944 IME LDN, fax: 01-222 9881.

**Eurogas 90**

Conference, 28-30 May, Trondheim, Norway.  
Details from Eurogas 90, Norwegian Petroleum Society, PO

Box 6050, 7003 Trondheim, Norway. Tel: +47 7 54 03 26/54 03 25, fax: +47 7 94 38 61.

*June 1990*

**Cities for the 21st Century**  
International exhibition and conference, 2-10 June, Glasgow, Scotland.  
Details from World Trade Promotions, 19-21 High Street, Sutton, Surrey SM1 1NF. Tel: 01-642 7688 (exhibition), or CEP Consultants Ltd, 26-28 Albany Street, Edinburgh EH1 3QH. Tel: 031 557 2478 (conference).

**IMEX 90**

Conference and exhibition, 5-7 June, London.  
Details from Rosemary Wood, CMC, Bankside, Hollybush Lane, Frensham, Farnham, Surrey GU10. Tel: 025-125 4808.

**Pneumatech 4**

International conference, 26-28 June, Glasgow, Scotland.  
Details from Pneumatech 4, Powder Advisory Centre, PO Box 78, London NW11 0PG. Tel: 01-455 0011, tx: 8954242, fax: 01-458 2278.

*July 1990***Harwell Coal Combustion Programme**

Seminar, 18 July, Oxfordshire, England.  
Details from Dr J Sykes, Engineering Sciences Division, B10.4 Harwell Laboratory, Oxfordshire OX11 0RA. Tel: 0235 821111, ext 2845/3951; tx: 83135 ATOM HA G, fax: 0235 432529.

*September 1990***Pittsburgh Coal Conference**

10-14 September, Pennsylvania, USA.  
Details from Pittsburgh Coal Conference, University of Pittsburgh, One Northgate Square, PO Box 270, Greensburgh, PA 15601, USA. Tel: 412/836-6813, tx: 650/343-8943, fax: 412/836-8617.

**1990 European Community Wind Energy Conference and Exhibition**

10-14 September, Madrid, Spain.  
Details from H S Stephens & Associates, Conference Organ-

isers, Agriculture House, 55 Goldington Road, Bedford MK40 3LS.

**Inpower 90**

Conference and exhibition, 25-26 September, London.  
Details from Christine Yates, FMJ International Publications Ltd, Queensway House, 2 Queensway, Redhill, Surrey RH1 1QS. Tel: 0737 76811, tx: 948669 TOPJNL G, fax: 0737 761685.

*October 1990***Appropriate Development For Survival: The**

**contribution of technology**  
Conference, 9-11 October, London.  
Details from Miss S Frye, Conference Office, Institution of Civil Engineers, 1-7 Great George Street, London SW1P 3AA.

**Quality Assurance of Personnel for the Nuclear Industry**

Conference, 17-18 October, London.  
Details from the Conference Dept, IMechE, 1 Birdcage Walk, London SW1H 9JJ. Tel: 01-222 7899, tx: 917944 IME LDN, fax: 01-222 9881.

*November 1990***A New Look at Offshore Safety**

Conference, 22 November, London.  
Details from Caroline Little, The Institute of Petroleum, 61 New Cavendish Street, London W1M 8AR. Tel: 01-636 1004, tx: 264380, fax: 01-255 1472.

*April 1991***2nd European Conference on Industrial Furnaces and Boilers**

Conference, 2-5 April, Algarve, Portugal.  
Details from INFUB, c/o Prof Albino Reis, Praça Dr Pedro Teotónio Pereira, 125-Esc 33, 4300 Porto, Portugal. Tel: 351-2-564849, tx: 26261 ENTEC P, fax: 351-2-563968.

**Environmental Pollution**

International conference, 15-19 April, Lisbon, Portugal.  
Details from ICEP Conference Office, ICTR Secretariat, 11-12 Pall Mall, London SW1Y 5LU.

Tel: 01-930 6825, tx: 925312 REICO G, fax: 01-976 1587.

*May 1991***2nd International Conference on FGD and Chemical Gypsum**

Conference, 13-15 May, Toronto, Canada.  
Details from Lydia Luckevich, ORTECH International, Tel: (416) 822-4111 ext 322.

*June 1991***Power Supply Europe**

International exhibition, 18-21 June 1991, Birmingham, England.  
Details from Swan House Special Events Ltd, Holly Road, Hampton Hill, Middlesex TW12 1PZ. Tel: 01-783 0055.

*July 1991***3rd International Conference on Probabilistic Methods Applied to Electric Power Systems**

3-5 July, London.  
Call for papers. Details from the IEE, Savoy Place, London WC2R 0BL. Tel: 01-240 1871, Tx: 261176 IEELDN, Fax: 01-240 7735.

*July 1992***ElectroTech '92**

Exhibition, 20-24 July, Birmingham, England.  
Details from ElectroTech Exhibitions Ltd, Wix Hill House, West Horsley, Surrey KT24 6DZ. Tel: 0483 222888, Fax: 0483 224321.

*September 1991***Metals Engineering 91**

Exhibitions, 2-6 September, Birmingham, England.  
Details from FMJ International Publications Ltd, Queensway House, Redhill, Surrey RH1 1QS. Tel: 0737 768611, tx: 948669 TOP JNL G, fax: 0737 761685.

*November 1991***Power Supply USA**

Exhibition, 4-7 November, Washington DC, USA.  
Details from Chris Timmins, Swan House Special Events, Holly Road, Hampton Hill, Middlesex TW12 1PZ. Tel: 01-783 0055.

# INSTITUTE OF ENERGY CONFERENCES



The following programme is currently being organised by The Institute of Energy, and its associated overseas societies, and other UK societies 'in association'.

For further details please contact Judith Higgins on 01-580 0008.

## In 1990

- 9-11 April      **Ceramics in Energy Applications — New Opportunities**  
Venue: Sheffield City Polytechnic  
Chairman: Mr M L Hoggarth (British Gas)
- 19 April      **Orimulsion: The Wonder Fuel?**  
In Association with Financial Times Management Reports  
Venue: The Conference Forum, London E1  
Chairman: Mr D M Willis (Institute of Energy)
- 17-20 May      **Institute of Energy Annual Conference & Social Weekend**  
**How Green is Our Energy?**  
Venue: Hotel St Nicholas, Scarborough  
Chairman: Mr G Burbage-Atter (Institute of Energy)
- 30 May      **Innovations for the Next Decade: Building Energy Management Update**  
Venue: South Bank Polytechnic  
Chairman: Mr M C Roberts (PA Consulting Group)
- 19 September      **The Costs of Flue Gas Desulphurisation**  
Venue: Scientific Societies Lecture Theatre, London W1  
Chairman: Dr A Sanyal (Babcock Energy)
- 31 October      **Electricity from Gas**  
Venue: The Royal Garden Hotel, London W8  
Chairman: Mr J Masters (British Gas)

## Conferences with which the Institute is in association

### In 1990

- 26 April      **Industrial Oil Fuels for the 90s**  
Contact: Combustion Engineering Association on (0685) 879119
- 5-7 June      **IMEX 90 Maintenance Management and Engineering Conference**  
Contact: Rosemary Wood, Institution of Plant Engineers on (025125) 4702/5117
- July      **Comadem 90 International**  
(Congress on Condition Monitoring and Diagnostic Engineering Management)  
Contact: Dr Raj Rao, Birmingham Polytechnic on 021-331 5441
- 17-18 July      **3rd International Conference on Small Engines and their Fuels for use in Rural Areas**  
Contact: Mrs P Harris, Reading University on (0734) 875 123
- September      **Piper Alpha - Lessons for Life-Cycle Safety Management**  
Contact: Conference Office, Institution of Chemical Engineers on 0788-78214
- 15-18 October      **3rd International Conference on Circulating Fluidised Beds**  
Contact: Professor Hira Ahuja on (902) 439-8300 ext 2014 (Canada)