

ENERGY OPTIONS

The role of alternatives
in the world energy scene



Conference Publication
Number 233

E 56-2
1984

8563856

E 56
1984-2
TK01-53
E 56.7
1984

Fourth International Conference on

ENERGY OPTIONS

**The role of alternatives in the
world energy scene**

3-6 April 1984



Organised by the

Science, Education & Technology and Power Divisions of the
Institution of Electrical Engineers

in association with the

British Wind Energy Association

Institute of Electrical and Electronics Engineers Inc
(Oceanic Engineering Society)

Institute of Electrical and Electronics Engineers Inc
(Power Engineering Society)

Institute of Electrical and Electronics Engineers Inc
(United Kingdom and Republic of Ireland Section)

Institute of Energy

Institute of Mathematics and its Applications

Institute of Physics

Institution of Chemical Engineers

Institution of Civil Engineers

Institution of Mechanical Engineers

International Solar Energy Society (UK Section)

Royal Aeronautical Society

Watt Committee on Energy Ltd



E8563856

with the support of the

Convention of National Societies of Electrical Engineers of Western Europe (EUREL)

Venue

The Institution of Electrical Engineers, Savoy Place, London WC2, UK

Organising Committee

Dr R H Taylor (*Chairman*)
 A C Baker
 G G Bevan
 Professor B J Brinkworth # #
 R Carruthers
 Professor I Fells
 Dr J D Garnish
 Professor D O Hall
 Dr P Hutchinson + +
 Dr D Lidgate
 Dr D Lindley #

Professor N H Lipman*
 Professor P E O'Sullivan
 M J Platts
 Dr M P Reece
 R Roff***
 J M Solbett + + +
 F C Treble
 Dr K G Wilkinson # # #
 Dr J R Vadus§**
 N Worley + x

§ corresponding member

* representing the British Wind Energy Association

** representing the Institute of Electrical and Electronics Engineers Inc
 (Oceanic Engineering Society)

*** representing the Institute of Electrical and Electronics Engineers Inc
 (United Kingdom and Republic of Ireland Section)

+ representing the Institute of Energy

+ + representing the Institute of Physics

+ + + representing the Institution of Chemical Engineers

representing the Institution of Civil Engineers

representing the International Solar Energy Society (UK Section)

representing the Royal Aeronautical Society

x representing the Watt Committee on Energy Ltd

Published by the Institution of Electrical Engineers, London and New York, ISBN 0 85296290 8 ISSN 0537-9989.

This publication is copyright under the Berne Convention and the International Copyright Convention.

All rights reserved. Apart from any copying under the U.K. Copyright Act 1956, part 1, section 7, whereby a single copy of an article may be supplied, under certain conditions, for the purposes of research or private study, by a library of a class prescribed by the U.K. Board of Trade Regulations (Statutory Instruments, 1957 No. 868), no part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means, without the prior permission of the copyright owners. Permission is, however, not required to copy abstracts of papers or articles on condition that a full reference to the source is shown.

Multiple copying of the contents of the publication without permission is always illegal.

MULTIPLEX techniques Ltd

© 1984 The Institution of Electrical Engineers.

List of Authors

	<i>Page No.</i>		<i>Page No.</i>
Allen, J C J	383	Gale, I N	232
Anderson, J	81	Galletti, A	296
Anthony, E J	400	Garner, I F	13
Armstrong, J R C	105	Garrad, A D	105
Arneaud-Clarke, J	171	Gibbs, B M	77, 270
		Goodall, E G A	340
Barlow, J M	207	Green, A A	43
Barnes, N	304	Grove-Palmer, C O J	188
Bartholomew, D M L	50		
Batchelor, A S	223	Hall, D O	69
Bellamy, N W	198	Hally, M L	138
Berrie, T W	363	Harrison, R	237, 241
Berry, P	175	Hassan, U	105
Birkett, N	175	Hau, E	122
Bornebroek, D J	126	Hayward, K	47
Brown, A	85	Hill, R	21
Brown, A	112	Hillyer, C R E	344
Budden, R J R	274	Holding, N L	134
		Holmes, J	413
Cadman, M H	400	Hope, C W	356
Caldon, R	292	Hovgaard Jensen, E	89
Clare, R	179	Hoy, H R	262
Clayton, R H	420	Hynes, K M	21
Clennell, W A	304		
Coleman, A R	325	Ito, S	359
Collier, J G	3		
Collins, P Q	29	Jones, B W	54
Cooper, B J	143		
Count, B M	175, 211	Kawasaki, S	359
Coutts, T J	21	King, B	329
Cross, B M	43	Knobbout, J A	315
		Kuipers, J A	126
Davidson, B J	413		
Davis, M	5	Law, H	143
de Rothschild, E L	166	Lawrence, D J	280
Dixon, J C	396	Leary, J	406
Duffie, J A	34	Lennard, D E	192
		Leung, K S	151
Elliot, G	202	Lightbody, D M S	256
El-Shirbeeny, E H T	333	Lilley, P D	285
Evans, D V	211	Lindley, D	99
		Lloyd-Dodd, W A	316
Ford, J G	220		
Fowler, G J	387		
Franzidis, J P	81		
Freeman, A T	25		

List of Authors

	<i>Page No.</i>		<i>Page No.</i>
Macadam, J A	288	Schmitter, K H	350
Marshall, R	216	Schultz, J K	89
Mays, I D	116	Shackleton, R J	406
McKendrick, D	262	Shaw, T L	179
McLoughlin, J H	58	Simpson, P B	105
Meijer, B J	17	Sisouw de Zilwa, L G	130
Merrett, A J	391	Skipper, R G S	368
Merrick, D	413	Smith, M D	249
Miyahara, A	359	Starr, M R	10
Moffatt, A M	207	Stecco, S S	296
Moon, J E	43	Stronach, A F	151
Mortimer, N D	237	Strub, A S	6
Munasinghe, M	374	Sulley, J L	134, 207
Murray, R D	383	Swift-Hook, D T	396
Musgrove, P J	93		
		Talbot, J R W	155
Nakajima, K	359	Taylor, J E	308
Nicol, D A C	175	Taylor, P J	47
Nimmo, W	77	Taylor, R H	155
Norgett, M J	378	Telfer, R G J	4
Norton, B	39	Tolbert, R E	9
		Tolley, D L	274
Oreszczyn, T	54	Tomkins, R	29
Overend, R P	62	Toms, A H	220
		Turtle, J	252
Page, D E W	321		
Parise, J A R	336	Vermij, L	17
Parker, F J	183		
Pearsall, N M	21	Walker, J F	378
Peatfield, A M	198	Warnock, J G	391
Pfirsch, D	350	Wilson, E M	163
Pillai, K K	266	Wrigley, S	300
Porteous, A	81	Wüster, H-O	349
Probert, S D	39		
		Yamamoto, K	359
Raisman, J M	1	Yerkes, J W	9
Rao, K K	69	Young, T	112
Richards, K M	73		
Rollin, K E	232		

Contents

The Institution of Electrical Engineers is not, as a body, responsible for the opinions expressed by individual authors or speakers.

Page No.

KEYNOTE ADDRESSES

- 1 'The future for fossil fuels: a global perspective'
J M Raisman CBE
Chairman and Chief Executive, Shell UK Ltd, UK
- 3 'Nuclear energy'
J G Collier
Director-General, Generation Development and Construction Division,
Central Electricity Generating Board, UK
- 4 'Energy conservation'
Dr R G J Telfer
Chairman and Managing Director, Mather & Platt Ltd,
also Chairman, Advisory Council on Energy Conservation, UK

EVENING LECTURE

- 5 'The European Community energy demonstration project scheme'
Dr M Davis
Director, Energy Saving, Alternative Sources of Energy, Electricity and Heat,
Commission of the European Communities, Belgium

Contents

Page No.

SOLAR I: ELECTRICITY GENERATION

Invited Papers:

- 6 'Solar electricity: current trends'
Dr A S Strub
Commission of the European Communities, Belgium
- 9 'Megawatts from the sun'
J W Yerkes and R E Tolbert
ARCO Solar, USA

Contributed Papers:

- 10 'Solar photovoltaic generators—the implications for utilities'
Dr M R Starr
Sir William Halcrow & Partners, UK
- 13 'Photovoltaic applications activities in the Netherlands'
I F Garner
Howard Design BV, Netherlands
- 17 'Economics of small multi-source power systems'
Dr L Vermij and Dr B J Meijer
Holec Nederland BV, Netherlands
- 21 'The prospects for cost reductions in photovoltaic modules'
Dr R Hill, Mrs K M Hynes, Dr T J Coutts and N M Pearsall
Newcastle upon Tyne Polytechnic, UK
- 25 'A solar powered car'
A T Freeman
Design Consultant, UK
- 29 'Flexible operation of a system of SPSs for load following'
P Q Collins and R Tomkins
Imperial College of Science and Technology, UK

Contents

Page No.

SOLAR II: THERMAL CONVERSION

Invited Paper:

- 34 'Solar thermal applications—an overview'
Professor J A Duffie
University of Wisconsin-Madison, USA

Contributed Papers:

- 39 'Characteristics of thermosyphonic solar-energy water-heaters'
Dr B Norton and Professor S D Probert
Cranfield Institute of Technology, UK
- 43 'Thermal performance testing of air heating solar collectors'
A A Green, B M Cross and J E Moon
University College, Cardiff, UK
- 47 'Assessing the durability of solar thermal collectors'
K Hayward
GEC Power Engineering Ltd, UK
P J Taylor
University College, Cardiff, UK
- 50 'Passive solar building design: principles, progress and prospects'
Dr D M L Bartholomew
Energy Technology Support Unit, AERE Harwell, UKAEA, UK
- 54 'The optimum level of insulation for a solar heated house'
T Oreszczyn and Dr B W Jones
Open University, UK
- 58 'Solar energy studies applied to large scale industries'
J H McLoughlin
James Henry EC Consultants Ltd, Italy

Contents

Page No.

SOLAR III: BIOFUELS

Invited Paper:

- 62 'Biomass energy: current status and promise'

Dr R P Overend

National Research Council, Canada

Contributed Papers:

- 69 'Photochemical and photobiological research in the European Community solar programme'

Professor D O Hall and Dr K K Rao

King's College, University of London, UK

- 73 'Anaerobic digestion—a credible source of energy'

K M Richards

Energy Technology Support Unit, AERE Harwell, UK

- 77 'Waste gasification and pyrolysis for low-grade fuel gas'

W Nimmo and Dr B M Gibbs

University of Leeds, UK

- 81 'Glucose from waste cellulose as a fermentation substrate for ethyl alcohol production'

Dr A Porteous and Mrs J Anderson

Open University, UK

Dr J P Franzidis

University of Capetown, Republic of South Africa

- 85 'Energy from the combustion of wastes'

Dr A Brown

Energy Technology Support Unit, AERE Harwell, UK

- 89 'Pilot project for alternative future energy supplies to Danish villages'

E Hovgaard Jensen and J K Schultz

Steensen & Varming International, Denmark

Contents

Page No.

WIND ENERGY

Invited Papers:

- 93 'Developments in wind energy—a world review'
Dr P J Musgrove
University of Reading, UK
- 99 'Wind energy—status of the technology'
Dr D Lindley
Wind Energy Group, also Taylor Woodrow Construction Ltd, UK

Contributed Papers:

Machines

- 105 'The Orkney project'
Dr J R C Armstrong, Dr A D Garrad, Dr U Hassan and P B Simpson
Wind Energy Group, UK
- 112 'A medium sized wind turbine for isolated sites'
A Brown and T Young
James Howden & Co Ltd, UK
- 116 'The development programme for the Musgrove wind turbine'
Dr I D Mays
Sir Robert McAlpine & Sons Ltd, UK
- 122 'Status of Continental Europe large wind energy converters'
E Hau
MAN Neue Technologie, Federal Republic of Germany
- 126 'The Netherlands windfarm project'
D J Bornebroek and J A Kuipers
NV KEMA, Netherlands

Contents

Page No.

WIND ENERGY — continued

Contributed Papers:

Applications

- 130 'Practical use of windenergy by a Dutch utility, the Provincial Energy Company of Zeeland'
L G Sisouw de Zilwa
NV Provinciale Zeeuwse Energie-Maatschappij, Netherlands
- 134 'Optimum economic penetration of aerogenerators into small island systems'
J L Sulley and N L Holding
North of Scotland Hydro-Electric Board, UK
- 138 'A utility wind energy programme—findings and conclusions'
M L Hally
Electricity Supply Board, Republic of Ireland
- 396 'A review of offshore wind power'
Dr J C Dixon
Open University, UK
Professor D T Swift-Hook
Central Electricity Research Laboratories, CEGB, UK

Technology

- 143 'A review of control system options for WECS'
B J Cooper
GEC Power Engineering Ltd, UK
H Law
GEC Energy Systems Ltd, UK
- 151 'Integration of wind turbine generators into small diesel-based power systems'
Dr K S Leung
ERA Technology Ltd, UK
Dr A F Stronach
University of Aberdeen, UK

Economics

- 155 'Economic assessment of wind turbines in an electricity supply system'
J R W Talbot and Dr R H Taylor
Central Electricity Generating Board, UK

Contents

Page No.

TIDAL AND HYDRO

Invited Papers:

- 163 'Tidal power'
Professor E M Wilson
University of Salford, UK
- 166 'Overview of hydro-electric power'
E L de Rothschild
Straflo Ltd, also AUR Hydropower Ltd, UK

Contributed Papers:

- 171 'The development of small community hydropower in the Morobe Province of Papua New Guinea'
J Arneaud-Clarke
Papua New Guinea University of Technology, Papua New Guinea
- 175 'Optimal control theory applied to tidal power'
Dr P Berry, Dr B M Count and Dr D A C Nicol
Marchwood Engineering Laboratories, CEGB, UK
N Birkett
University of Reading, UK
- 179 'A review of recent developments concerning the Severn Barrage'
R Clare and Dr T L Shaw
Sir Robert McAlpine & Sons Ltd, UK
- 183 'The design of generators for use in mini-hydro applications'
F J Parker
GEC Large Machines Ltd, UK

Contents

Page No.

WAVE AND OTEC

Invited Papers:

- 188 'The status of wave energy technology'
C O J Grove-Palmer
Former Wave Energy Programme Manager, UK
- 192 'Ocean thermal energy conversion—progress and prospects'
D E Lennard
Ocean Thermal Energy Conversion Systems Ltd, UK

Contributed Papers:

- 198 'Further development of the SEA-Clam wave energy converter'
Dr N W Bellamy and A M Peatfield
Coventry (Lanchester) Polytechnic, UK
- 202 'NEL Breakwater—Britain's proposed first wave power station'
G Elliot
National Engineering Laboratory, UK
- 207 'Technical aspects of integrating wind and wave generation sources into small island systems'
J L Sulley, A M Moffatt and J M Barlow
North of Scotland Hydro-Electric Board, UK
- 211 'The harbour concept in wave energy'
Dr B M Count
Marchwood Engineering Laboratories, CEGB, UK
Dr D V Evans
University of Bristol, UK
- 216 'Ocean thermal energy conversion for developing countries'
Dr R Marshall
University of Keele, UK
- 220 'Ocean thermal energy conversion for island applications'
A H Toms and J G Ford
PREST, University of Manchester, UK

Contents

Page No.

GEOHERMAL

Invited Paper:

- 223 'An overview of hot dry rock technology'

Dr A S Batchelor

Camborne School of Mines, UK

Contributed Papers:

- 232 'The geothermal resources of the United Kingdom'

I N Gale and K E Rollin

Institute of Geological Sciences, UK

- 237 'UK drilling cost estimation'

Dr R Harrison and Dr N D Mortimer

Sunderland Polytechnic, UK

- 241 'Economics of low enthalpy geothermal district heating developments, Northern France and the UK'

Dr R Harrison

Sunderland Polytechnic, UK

- 249 'The Western Esplanade geothermal project in Southampton, England'

M D Smith

Southampton City Council, UK

- 252 'Making the most of geothermal power'

J Turtle

Marchwood Engineering Laboratories, CEGB, UK

Contents

Page No.

'ADVANCED' FOSSIL FUEL SYSTEMS

Invited Paper:

- 413 **'A comparison of combined power generation cycles using coal: an overview'**
Dr B J Davidson
Central Electricity Research Laboratories, CEGB, UK
Dr J Holmes and Dr D Merrick
Coal Research Establishment, National Coal Board, UK

Contributed Papers:

- 256 **'Advanced gas turbines in the industrial scene'**
D M S Lightbody
John Brown Engineering Ltd, UK
- 262 **'Power generation via combined cycle power plant burning coal in pressurised fluidised bed combustion systems (FBC)'**
H R Hoy OBE
Coal Utilisation Research Laboratory, National Coal Board, UK
D McKendrick
National Coal Board (IEA Grimethorpe) Ltd, UK
- 266 **'Off-design performance of combined cycle power plant utilising pressurised fluidised bed coal combustors'**
Dr K K Pillai
Coal Utilisation Research Laboratory, National Coal Board, UK
- 270 **'Coal fired rotating fluidised bed combustion for power generation'**
Dr B M Gibbs
University of Leeds, UK

Contents

Page No.

COMBINED HEAT AND POWER

Invited Papers:

- 400 'The economics of CHP and district heating in the UK'

E J Anthony
W S Atkins & Partners, UK
M H Cadman
Atkins Planning, UK

- 274 'The role of the electricity supply industry in CHP'

R J R Budden and D L Tolley
Electricity Council, UK

- 280 'Developing a CHP scheme in a local authority area'

D J Lawrence
Sheffield City Council, UK

Contributed Papers:

- 285 'Prospects for private CHP in the UK'

P D Lilley
GEC Power Engineering Ltd, UK

- 288 'The residential market for district heating from combined heat and power'

J A Macadam
Orchard Partners, UK

- 292 'Optimizing the power capacity of cogeneration plants for independent electrical and heat demands'

Dr R Caldon
University of Padova, Italy

- 296 'Comparison criteria of total energy gas turbine power plants'

Professor S S Stecco
University of Firenze, Italy
Dr A Galletti
Turbotecnica SpA, Italy

- 300 'Nuclear reactors for district heating'

S Wrigley
Honeywell Control Systems Ltd, UK

- 304 'Domestic refuse—an alternative fuel'

N Barnes
Consulting Engineer, UK
W A Clennell
Motherwell Bridge Tacol Ltd, UK

Contents

Page No.

HEAT PUMPS AND BIVALENT SYSTEMS

Invited Papers:

- 308 'The electric heat pump—an overview'
J E Taylor
Electricity Council, UK
- 315 'Absorption heat pump, state of the art and future development'
J A Knobbout
Steering Group on Energy Research, TNO, Netherlands

Contributed Papers:

- 406 'The design of heat recovery systems for indoor swimming pools using heat pumps'
J Leary and R J Shackleton
Electricity Council, UK
- 316 'Heat pumps in perspective'
W A Lloyd-Dodd
British Gas Corporation, UK
- 321 'Making the most of it—link-up'
D E W Page
Solid Fuel Advisory Service, UK
- 325 'Ground water source heat pumps for space heating in the UK'
A R Coleman
W S Atkins & Partners, UK
- 329 'Experiences in the use of ground water-to-water heat pumps for building heating'
B King
Essex County Council, UK
- 333 'Energy conservation prospects through electric load management'
Professor E H T El-Shirbeeney
University of Technology, Iraq
- 336 'The use of latent heat thermal storage heat pumps for space heating'
Dr J A R Parise
Pontificia Universidade Católica do Rio de Janeiro, Brazil
- 340 'Energy and cost savings with air/air heat pumps'
E G A Goodall
Trace Heat Pumps Ltd, UK
- 344 'Developments in the application of thermal wheels'
C R E Hillyer
Thermal Technology Ltd, UK