International Energy Agency

Programme of Research and Development on
Wind Energy Conversion Systems

IEA R&D Wind Energy

ANNUAL REPORT 1987

Published by
National Energy Administration
Sweden,
for the IEA R&D WECS Executive Committee

Statens energiverk
1988:R2

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FOREWORD

This is the tenth Annual Report of the IEA Programme for Research and Development on Wind Energy Conversion Systems (IEA R&D WECS) reviewing the activities during 1987. The report is submitted to the IEA in accordance with the recommendations of the IEA Committee on Research and Development.

D F Ancona
Chairman of the
Executive Committee

B Pershagen
Secretary of the
Executive Committee

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EXECUTIVE SUMMARY

The IEA Programme for Research and Development on Wind Energy Conversion Systems (IEA R&D WECS) started in 1977. Fourteen countries are participating: Austria, Belgium, Canada, Denmark, Germany, Japan, the Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, United Kingdom and United States. Italy is in the process of joining.

The IEA R&D WECS programme comprises nine Tasks, six of which have been successfully completed. Current Tasks include Task VII Study of Offshore Wind Energy Conversion Systems, Task VIII Study of Decentralised Applications for Wind Energy, and Task IX Intensified Study of Wake Effects behind Single Turbines and in Wind Turbine Parks. All current projects are task-sharing, i.e. the participating organisations are committed to in-kind contributions to an agreed programme, managed by an Operating Agent. The Central Electricity Generating Board (U.K.) is acting as Operating Agent for Task VII and Task IX, and the U.K. National Engineering Laboratory for Task VIII.

Substantial progress is reported from the ongoing Tasks. The Study of Offshore WECS (Task VII) is virtually complete and the final report will be published in early 1988. The national studies have established a range of generating costs, at the lower end of which offshore wind energy could be an economic alternative to other forms of electricity generation. The general feeling about the prospects for offshore wind

energy is more optimistic than previously. A programme of further work on offshore wind energy is recommended, including a plan for an offshore prototype.

Eleven countries are participating in Task VIII Decentralised Applications for Wind Energy. The Task has two Subtasks on Site Assessment Techniques to define models and techniques for obtaining wind and load data for decentralised wind systems, and on Wind Diesel Systems for analysing the performance of these systems. The work is also targeted towards the production of two handbooks in the Subtask areas. During 1987, three working group meetings were held. Detailed information has been collected for Subtask A, and work on the handbook is well advanced. Subtask B has concentrated on model validation rather than handbook drafting.

Seven countries are participating in Task IX Intensified Study of Wind Turbine Wake Effects. The objectives, schedules and technical issues were discussed at the first meeting in May 1987. The contributions from the participating countries include wake measurements from windfarms and single turbines as well as theoretical model studies. The following technical issues were identified: wake meander, added turbulence, overlapping shear layers, the near wake, and averaging times.

In the series of documents on Recommended Practices for Wind Turbine Testing and Evaluation, the first edition of Vol 8 Glossary of Terms, and the second edition of Vol 1 Power Performance Testing were published during the year. Other documents are in preparation.

The proceedings from the first seminar in the Joint Action on Wind Turbine Aerodynamics were published during the year. Two working group meetings in the Joint Action for Fatigue Load Spectrum were held.

The Executive Committee had two meetings during 1987. Three proposals for new co-operative action were discussed. Two draft Annexes were adopted: Annex X Systems Interaction and Annex XI Base Technology Information Exchange. Germany, the Netherlands and Sweden agreed to co-operate on a project called UNIWEX, including experimental studies of aerodynamics loads and control strategies as well as validation of computer codes.

The Executive Committee submitted a paper to the IEA CRD, reviewing the activities of the IEA wind energy programme during 1977-1987 and discussing a strategy for the future.

THE IEA R&D WECS PROGRAMME

The Programme of Research and Development on Wind Energy Conversion Systems (IEA R&D WECS) was initiated in 1977. IEA R&D WECS is one of two IEA projects in wind energy. The companion programme is the Co-operation in the Development of Large-Scale Wind Energy Conversion Systems (IEA LS WECS) is reported separately.

The general objective of IEA R&D WECS is to undertake collaborative research and development Tasks as defined in Annexes to the Implementing Agreement. To-date nine Tasks have been initiated, six of which have been completed:

Task I Environmental and Meteorological Aspects of Wind Energy Conversion Systems
Operating Agent: National Swedish Board for Energy Source Development
Completed in 1981

Task II Evaluation of Models for Wind Energy Siting
Operating Agent: U.S. Department of Energy
Completed in 1983

Task III Integration of Wind Power into National Electricity Supply Systems
Operating Agent: Kernforschungsanlage Jülich GmbH, Germany
Completed in 1983

Task IV Investigation of Rotor Stressing and Smoothness of Operation of Large-Scale Wind Energy Conversion Systems
Operating Agent: Kernforschungsanlage Jülich GmbH, Germany
Completed in 1980

Task V Study of Wake Effects behind Single Turbines and in Wind Turbine Parks
Operating Agent: Netherlands Energy Research Foundation
Completed in 1984

Task VI Study of Local Wind Flow at Potential WECS Hill Sites
Operating Agent: National Research Council of Canada
Completed in 1985

Task VII Study of Offshore WECS
Operating Agent: Central Electricity Generating Board (U.K.)
Completed in 1987

Task VIII Study of Decentralized Applications for Use of Wind Energy
Operating Agent: National Engineering Laboratory (U.K.)
To be completed in 1988

Task IX Intensified Study of Wake Effects
Operating Agent: Central Electricity Generating Board
To be completed in 1989

There are fourteen Contracting Parties to the Implementing Agreement. Italy is in the process of joining. The countrywise participation in current Tasks is shown in Table 1.

In the current Tasks the participants contribute manpower and work usually in their home countries to a joint Task programme coordinated by the Operating Agent (OA). The total level of effort is typically about 10 manyears per Task.

In addition to the Tasks, the Executive Committee has established a Standing Committee for the preparation, publication and review of a series of documents on Recommended Practices for Wind Turbine Testing and Evaluation.

Table 1
Participation in current Tasks

Country	Task VII	VIII	IX
Austria			
Belgium			x
Canada		x	
Denmark	x	x	x
Germany			
Italy		x	x
Japan			
The Netherlands	x	x	x
New Zealand		x	
Norway		x	
Spain		x	
Sweden	x	x	x
Switzerland		x	
United Kingdom	OA	OA	OA
United States	x	x	x

The Executive Committee is also operating Joint Actions on Aerodynamical Calculational Methods and on Fatigue Testing and Load Spectrum Definition.

Two new Annexes for task-shared research have been drafted during the year. A joint cost-sharing project has also been established.

The progress of the current Tasks and Joint Actions, and the activities of the Executive Committee and the Standing Committee as well as the planned projects are briefly reviewed in the following sections.

TASK VII - STUDY OF OFFSHORE WECS

During 1983, the study of offshore wind energy conversion systems (OWECS) was commenced to assess the viability of offshore wind power, to define design criteria for an offshore WECS prototype, and to outline a plan for the design, construction and operation of a possible joint prototype.

In pursuit of these objectives, five subtasks were initiated:

A	Data collection and compilation
B	Conceptual design of an OWECS power station
C	Development of design specifications
D	Generic studies
E	Structural dynamics study

A considerable number of major reports and papers have been contributed to the study, some of which are referred to below. The work is now virtually complete and the draft final report has been issued to the participants for comment.

The study has tentatively established a range of generating costs from a value of 3.1 p/kWh (5.2 ¢/kWh) for the Swedish Öland installation to 6.9 p/kWh (11.5 ¢/kWh) for the UK Phase IIB installation.

An OWECS system having generation costs at the lower end of the range could be an economic alternative to other forms of electricity generation, but this would not be the case for costs at the upper end of the range. If a mean value of 5 p/kWh (8.3 ¢/kWh) is taken, then

costs are somewhat above the present range of economic interest. However, it is very important to note that the costs have been derived for wind turbines which are not of the latest design. There is now ample evidence to show that the capital costs of the latest machines are substantially lower than was envisaged when the Annex VII study was started. This suggests that the future costs of an OWECS could be towards the lower end of the range quoted, perhaps even lower.

The general feeling about the prospects for offshore is now more optimistic than it had been previously. Public reaction may force earlier consideration of offshore windpower, particularly in Denmark and the Netherlands, both densely populated countries. Participants therefore feel that a programme of work on offshore wind which should include the following steps, each occupying a maximum of 2 years:

1) Evaluate the latest designs for use offshore
2) Plan for an offshore prototype
3) Construct and install the prototype
4) Test and evaluate the prototype

A decision would be taken at the end of each step on whether to proceed further. By about 1995, therefore, participating countries could be in a position to exploit offshore wind power.

Selected Reports

1 Palutikov, P J, Davies, Kelly, P M. The Variability of the Wind Field over the British Isles - the Implications for Wind Power Production. IEA-A.13. University of East Anglia, Norwich, UK. April 1985 (Obtainable from CEGB, TPRD, HQ, London, UK)

2 Iperen, J van. Conceptual Design of an OWECS Power Station. Comparative Study Phase I: Definition of the Scale and Operational Layout of an Offshore Power Station. IEA7-B.01. Hydronamic BV, Sliedrecht, Netherlands. February 1980

3 Koten, H van. Study of Offshore Wind Energy Conversion Systems (OWECS): Conceptual Design of Supporting Structures. Fugro BV, Leidschendam, Netherlands. 8 August 1984

4 Hardell, R. Wind Power Production of the Swedish Coasts. Estimate of Generation Costs. IEA7-B3.03. AIB, Stockholm. December 1984

5 Offshore Wind Power in Denmark. IEA7-0.05. DEFU Report EEU-83-01E. DEFU, Lyngby, Denmark. March 1983

6 Burton, A L (Ed). Report on Offshore Wind Energy Wind Assessment Phase IIB. Vol 1 Executive Summary. IEA7-0.21. (014V/0W/102). Taylor Woodrow, Southall, UK. February 1985. (Obtainable from ETSU, Harwell, UK)

7 Hardell, R. Technical Specification for OWECS Prototype. IEA7-C.02. 3K Engineering AB, Stockholm. April 1986

8 Hardell, R. Objectives for an Offshore Prototype Wind Turbine. IEA7-C-04. 3K Engineering AB, Stockholm, 25 November 1986

9 Otway, F O J. Offshore Wind Energy: Comparison of British, Swedish and Danish Studies. IEA7-B1.3.21. (GDCD/PE-B/SS/97). CEGB, GDCD, Barnwood, UK. June 1986

Participating Countries/Contracting Parties

Denmark	Ministry of Energy
The Netherlands	Energy Research Foundation ECN
Sweden	National Energy Administration
United Kingdom	Central Electricity Generating Board
United States	Department of Energy

Operating Agent

United Kingdom	Central Electricity Generating Board

Task VIII - DECENTRALISED APPLICATION FOR WIND ENERGY

The formal aims of this Task are as follows

1 The define cost-effective models and techniques suitable for obtaining wind and load data necessary for planning and specifying decentralised wind energy conversion system installations.

2 To apply and further develop models suitable for analysing the performance of wind diesel systems, and to obtain a sound analytical basis for planning and designing such systems.

As stated in the 1986 Annual Report, the participants in the Task have also decided to target their work towards the production of two handbooks which will seek:

1 To set out guidelines on how to appraise a potential site for a decentralised supply system, taking into account wind, load and other factors.

2 To give advice on how to configure an optimised, economically viable, combined wind diesel supply system for a specific site.

During 1987, three Task meetings have been held. These took place on 28 and 29 January in Martigny, Switzerland, on 3 and 4 June in Västervik, Sweden, and on 17 and 18 November on Tenerife, The Canary Islands.

Subtask A Site Assessment Studies

During the year, detailed information on a number of the wind resource assessment models available to the Task has been collected. Classification of all the available models has

been undertaken, and an initial report produced. Specific note has been made of models capable of generating turbulence estimates, as these can be of particular relevance to wind diesel system control. It has not proven possible to carry out widespread validation of the models, due to difficulties in identifying quality assured data sets from suitable sites.

An exercise has been conducted to define the extent of the real consumer load data available to the Task. It would now appear that reliable and suitable data are somewhat sparse.

On the site assessment handbook front, the main chapters to be included have been decided upon, these being:

1 Introduction

2 Wind Assessment Meteorological Considerations
Measurement Methods
Siting Models Available

3 Assessment of Consumer Load

4 Other Factors to be Considered

Work on chapter 2 is well advanced, with the fifth draft currently being circulated. The items to be included in chapter 4 have also been debated, and drafting of this and the other remaining chapters is in the early stages.

Subtask B Wind Diesel Systems

Work during the year has concentrated on model validation, rather than on drafting of the handbook.

The feasibility of data interchange between the various participating organisations has now been established, and data transfer standards have been adopted.

As reported in earlier annual reports, the Subtask is concentrating on models which are designed to appraise overall wind diesel dystem performance, rather than upon models which are capable of describing system dynamics. However, most codes have been developed with specific systems in mind, and therefore are not capable of describing all types of configuration. Because of the large number of models and systems available to the project, it will still by possible to match up most models with at least two practical systems. Thus validation should not be a major logistical problem.

This year, however, the participants have been called upon to carry out a trial validation, using data from a very simple combination consisting of two wind turbines, a diesel gen-set, a dump load and a consumer demand. Data have been supplied from ECN, the Netherlands, and to date three countries have completed their validations. The general conclusion seems to be that although power flows can be difficult to predict, overall fuel consumption can be defined reasonably easily.

The importance of using only quality assured data for model validation has been stressed, and a document describing the effect of experimental errors and uncertainties has been produced.

Work has recently begun on defining the contents of the proposed wind-diesel handbook.

General Comments

At times, progress in the Task has not been as swift as would have been desired. This in the main appears to be due to the fact that wind diesel projects in several countries are at a far more advanced stage than in others. This means that those countries whose domestic work is in its infancy cannot contribute to the Task the levels of participation which had been declared at the time of signing the Implementing Agreement.

Nevertheless, it appears that the overall project is not running too far behind schedule. The site assessment Subtask is now well advanced, particularly in the area of handbook preparation. For the wind diesel Subtask, the results of the imminent, widespread validation exercise will determine the degree of work still to be undertaken before the project can reach a satisfactory conclusion.

Notable documents produced during the year

A large number of working documents have been produced by participants in the Task. In addition to the detailed model and project descriptions, which are updated regularly, the following notable reports have been issued during 1987:

1 Van Hulle, Frans, Site Assessment Models: Interim Report 28 May 1987. ECN, Petten, The Netherlands

2 Walmsley, Jon L, Meteorological Considerations for Siting of Small Wind Energy Conversion Systems. (Various Drafts). Atmospheric Environment Service, Ontario, Canada

3 Horbaty, Robert, Influence of Turbulence on the Energy Output of WECS's. Oekozentrum Langenbruck, Switzerland

4 Manwell, James F and McGowan, J G, Errors and Uncertainty Analysis for Wind/Diesel Experimental Projects. University of Massachusetts, USA

5 Infield, David, IEA Validation Exercise Using ECN Wind Diesel Data - Report on Validation of RAL Statistical Modelling Techniques. Rutherford Appleton Laboratory, Chilton, UK

6 Greisen Helle, Trial Validation of Calculation Programs for AWDS. Risø Laboratory, Roskilde, Denmark

7 Uhlen, Kjetil, IEA Wind Diesel Model Validation Exercise. EFI, Trondheim, Norway

Participating Countries and Organisations

Canada	National Research Councel Atmospheric Environment Service Atlantic Wind Test Station
Denmark	RISO National Laboratory
Italy	ENEA
Netherlands	ECN Laboratory
New Zealand	NZ Meteorological Service
Norway	Research Institute of Electricity Supply (EFI)
Spain	Instituto de Energias Renovables, CIEMAT
Sweden	State Power Board, Vattenfall
Switzerland	Office Federal De L'Energie Oekozentrum Langenbruck Alpha Real AG
United Kingdom	Rutherford Appleton Laboratory
United States	Department of Energy Solar Energy Research Institute University of Massachusetts Atlantic Orient Corporation

Operating Agent

United Kingdom	National Engineering Laboratory

Task IX - INTENSIFIED STUDY OF WIND TURBINE WAKE EFFECTS

At a meeting in London on 11/12 June, attended by all the participating countries, the objectives, timescales and technical issues to be addressed were discussed. Following a review of material already circulated, submissions were made by each of the participating countries on their future programme.

Belgium

The Belgian contribution is centred on measurements from the Zeebrugge windfarm. A two year campaign of measurements is envisaged following inauguration of the windfarm towards the end of June. The windfarm comprises 23x200 kW turbines and measurements will be taken of power output and blade loads. Meteorological information will come from a special mast and sampling will be at 4 Hz with 30 s and 10 minute averages, together with standard deviations.

Denmark

The two wind turbines at Nibe in North Jutland, provide a valuable data source for wake measurements as they are sited in level terrain, 200 m (5 diameters) apart. Measurements are being undertaken on the machines as part of a CEC-funded study, led by the CEGB, but in addition, data from previous measurements will be processed for the purpose of the IEA study.

Measurements will also be made on the cluster of five 750 kW machines at Masnedø.

Netherlands

The Dutch contribution would comprise a literature data base, already circulated, together with the results from the tip vane study, a tower wake study and measurements from the 25 m machine at Petten.

Development of theoretical methods of wake modelling would continue, together with techniques for predicting the output of windfarms. Corroboration with actual measurements would be made wherever possible.

Further projects, which may be contributed include data from the array of 18x300 kW machines at Sexbierum; the measurements here would include dynamic loads. 50 % Government funding for this project had been confirmed.

Sweden

Some wake measurements from the Näsudden machine have already been reported and a continuation wake study is planned for the summer of 1988. The measurements would be made using both SODAR and kites.

United States

Wake measurements from the 90 m 2.5 MW Mod 2 machine will be reported as part of the contribution to the study. 2 60 m and 7 31 m towers have been erected for the purposes of this study and 1 m averages and standard deviations of velocities have been recorded. The experiment would enable the influence of terrain on wakes to be established. Data reduction is in progress and a draft report is expected by mid-1988.

Measurements from the array of Fayette machines in the Altamont Pass are also anticipated. At this site a 17 m beam with 7 anemometers has been deployed to make measurements both upstream and downstream of the machines, at present to 6 diameters, with further measurements to 15 diameters being proposed. Recordings have been made at 10 Hz. The analysis has shown that the wakes spread fairly slowly although the turbulence intensities were of the order 10-20 %.

It is possible that further measurements on the array of 16 Westinghouse machines in Hawaii will be made. Particular attention would be paid to cumulative effects and to the generation of turbulence.

United Kingdom

Recent additional elements in the UK wake studies programme include:

Fatigue Damage Prediction Study

This study is in progress, managed by Garrad Hassan & Partners. The importance of low cycle high amplitude load fluctuations is recognised although this is not necessarily always the main source of damage to wind turbines. The aim of the study is to establish preliminary indications of the connection between fatigue damage and spacing in an array.

Results from a detailed model-scale study of rotor characteristics, carried out at Loughborough Univeristy Technology, will be contributed to

the study. In addition it is hoped to make available results from a recent study of the interactions between two medium size machines on Burgar Hill, Orkney. This study includes measurements of blade loads.

Theoretical Wake Modelling Studies

Attempts are being made to include corrections for wake meander and for estimates of turbulence intensities in wakes. Further improvements will be made during the course of the study and validation work undertaken.

Technical Issues

The review meeting identified or reaffirmed the importance of current technical issues in wake studies as follows:

a) the influence of wake meander had been recognised by a number of measurements; clearly this meander was related to lateral turbulence but further studies of its effect were required;

b) the question of "added turbulence", i.e. the extra turbulence which was present in wakes, partly due to the rotor blades, partly to turbulence generated in the wake shear layers. The importance of the tip vortices, which appear to disintegrate rapidly in turbulent flow was also recognised;

c) overlapping shear layers; the importance of the "superposition" theory in predicting windfarm output was recognised by all parties and TNO would report on their investigations as to the validity of this principle;

d) the near wake - although wind turbines were unlikely to be located within 1-2 diameters the importance of understanding the aerodynamics of this region were recognised; and

e) averaging times: the averaging time used for estimating efficiency losses in arrays will affect the levels obtained.

Additional Contributions

Spain and Italy have expressed interest in participating. Italy has proposed to study the performance of a cluster of 8x50 kW wind turbines at the Alta Nurra Wind Power Plant (N. Sardinia) so as to evaluate interactive effects. In addition to four anemometer towers sited at the corners of the plant, one or two towers will be placed inside to enable a detailed measurement of wind speed. An attempt will also be made to interpret interaction effects among wind turbines with the help of suitable theoretical models.

Contributed and Committed Reports

Origin	Topic	Date
Denmark	Velocity spectra in wakes	1987/8
	Windfarm data	Tentative
Netherlands	Wind tunnel measurements, tip vane model	NL-01
	Wake of horizontal axis model	NL-02
	Evaluation of wake models	NL-03
	Literate data base	NL-04
	Wake data, Petten	1987/8
	Windfarm data	Tentative
Sweden	Field study, wake of 2 MW Turbine Näsudden	SW-01
	further data	1987/8
United Kingdom	Siting Guidelines for arrays	UK-01
	Wake modelling, turbulence	UK-02
	Fluctuating loads, wind turbine wake	UK-03
	Near wake wind tunnel studies	UK-04
	Wake study, Orkney	1987/8
	Fatigue prediction study	1988
United States	Wake study, Mod 2	1988 (2 reports)
	Windfarm studies	1988

Participating Countries and Organisations

Belgium	University of Antwerp
Denmark	Risø National Laboratory
Italy	ENEL
Netherlands	MT/TNO Apeldoorn
Sweden	University of Uppsala
United Kingdom	Central Electricity Research Laboratories
	Garrad Hassan & Partners
	Loughborough University
United States	Department of Energy

Operating Agent

United Kingdom	Central Electricity Generating Board

RECOMMENDED PRACTICES FOR WIND TURBINE TESTING AND EVALUATION

The seventh document in the series of "Recommended Practices" Vol 8, Glossary of Terms, was published during the year. The document serves to introduce consistency into future IEA wind energy publications as well as to be of use to the wind energy community in general.

The first edition of Vol 6 Safety and Reliability and the second edition of Vol 1 Power Performance Testing were ready for print by the end of the year. Second editions of Vol 3 Fatigue Evaluation and Vol 4 Acoustics are in progress.

The Standing Committee for review of the Recommended Practices documents held its 7th meeting on May 6-7 in Glasgow and its 8th meeting December 10-11 in Stockholm.

JOINT ACTIONS

The Proceedings from the first Seminar in the Joint Action on Aerodynamics of Wind Turbines, held October 15, 1986 in London, were published during the year by the Department of Fluid Mechanics of the Technical University of Denmark. Three specific topics are treated: rotor loads during pitch change and unsteady inflow conditions, horizontal-axis wind turbines in yaw, and rotors during stall conditions.

Two working group meetings in the Joint Actions on Fatigue Load Spectrum were held during the year: the 5th meeting on May 21-22 in London and the 6th meeting on December 10-11 in Amsterdam. The purpose of this Joint Action is to arrive at a load standard for wind turbine fatigue testing. This activity, which is co-sponsored by the Commission for European Communities, is known as WISPER (Wind Turbine Load Spectrum Reference).

PROPOSALS FOR NEW CO-OPERATIVE ACTION

Draft Annex X - Systems Interaction

The draft Annex prepared by the U.S. Contracting Party was approved by the Executive Committee with interest in participation expressed by members from Denmark, Germany, Spain and the United Kingdom. The Annex has two Subtasks corresponding to the study of individual or small wind turbine penetration in local networks, and large wind turbine penetration causing global effects on the utility system. The increasing installation of wind farms in most member countries has heightened interest in this Annex.

Draft Annex XI - Base Technology Information Exchange

The draft Annex was adopted by the Executive Committee at its fall meeting. The Annex has three Subtasks which formalize the activities on the development of Recommended Practices for Wind Turbine Testing and Evaluation, the holding of Topical Expert Meetings, and the undertaking of Joint Actions. The Department of Fluid Dynamics of the Technical University of Denmark will act as Operating Agent.

The UNIWEX Project

Germany, the Netherlands and Sweden have agreed on a mixed cost-sharing and task-sharing project, called UNIWEX (Universal Wind Turbine for Experiments). UNIWEX is a computer-controlled, two-bladed experimental wind turbine at the

Ulrich Hütter Wind Test Field at Schnittlingen, Germany. The project will include the experimental study of aerodynamics, operational behaviour, load spectra, and control strategies as well as the validation of computer codes. The University of Stuttgart will act as Operating Agent.

ACTIVITIES OF THE EXECUTIVE COMMITTEE

The 19th meeting of the Executive Committee took place on March 25, 1987 at the Centro de Investigación Energética, Medio Ambiental y Tecnológica (CIEMAT) Madrid, Spain. The 20th meeting was held at Energy, Mines and Resources Canada in Ottawa on September 30, 1987.

At the fall meeting Mr S Engström (Sweden) and Mr H J M Beurskens (the Netherlands) were unanimously elected Chairman and Vice Chairman for 1988. Some changes in membership were announced during the year. The revised list of members and alternate members is attached.

During the year, Belgium signed the Implementing Agreement for participation in Annex IX. Italy is in the process of joining, also for participation in Annex IX.

At the fall meeting, the Executive Committee finalized a paper reviewing the activities of the IEA wind energy programme during its ten years of existence, and discussing a strategy for the future. It was concluded that the IEA R&D WECS programme has made important contributions to wind energy research, that the technology and market for wind energy has developed considerably during the ten-year period, and that there was a strong need for continued international co-operation in the IEA wind energy research programme. The emphasis in future co-operation would be on task-sharing rather than cost-sharing projects and on information exchange activities.

The Executive Committee published a paper, entitled "The International Energy Agency Wind Energy Programe - A Ten Year Review", at the Windpower '87 Conference October 5-8, 1987 in San Francisco, California.

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