

**International Energy Agency
Implementing Agreement
for
Co-operation in the Research and Development
of Wind Turbine Systems**

WIND ENERGY

End-of-Term Report 1998–2003
and
Plans for 2003–2008

4 March 2003

Introduction

The current term of the International Energy Agency (IEA) Implementing Agreement for Cooperation in the Research and Development of Wind Turbine Systems ends 31 October 2003. The Agreement began in 1977, and the most recent extension of the Agreement was approved by the Committee on Energy Research and Technology (CERT) action, IEA/GB(98)34 in October 1999.

This document was prepared following the CERT *Guidelines for End-of-Term Reports for IEA Implementing Agreements* issued 26-27 June 2001 and updates on 28 November 2001 and 7 June 2002. This report includes information to assist the CERT and its Renewable Energy Working Party (REWP) to evaluate the proposed extension of the Wind Energy Agreement for an additional five years. Data in the report follows the *Criteria and Review Process for the Extension of Implementing Agreements*, adopted by the IEA, Energy Technology Collaboration Division, in Paris on 29 July 2002.

The Executive Committee (ExCo) of the IEA Implementing Agreement for Cooperation in the Research and Development of Wind Turbine Systems (Wind Energy Agreement) approved this End-of-Term Report by email ballot on April 3, 2003. The report was delivered to the Chair of the REWP on March 4, 2003 as an End-of-Term (EOT) report with recommendations for continuation of the Agreement for an additional five years.

In parallel with the preparation of this EOT report, the ExCo began updating the *Wind Energy Strategy Plan* that guides the activities of the Wind Energy Agreement. The initial strategy plan was adopted by the ExCo in 1993 and revised and adopted in September 1998. The revised plan will guide activities for the coming 5-year term.

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Summary

Based on the CERT criteria for extension of Implementing Agreements and the planning and evaluation described in this End-Of-Term Report, we conclude that during this term the agreement has been:

- Useful to participants and consistent with IEA goals
- Cost effective, productive, and expanding in membership
- Responsive to changing global R&D needs
- Active in outreach efforts to non-OECD countries

During this term, the IEA Wind Energy Agreement has completed 25 years of collaborative R&D, initiated six new tasks, completed three tasks, and carried work on five tasks into the next term. Membership in the agreement has grown from 19 members to 21 members by the end of the term. The number of publications has nearly doubled over the previous term, and the quality of the annual report was recognized when the Society for Technical Communication awarded its Distinguished Award to the *IEA Wind Energy Annual Report 2001*.

Consequently, the ExCo proposes a five-year extension of the Agreement to 31 October 2008.

Table 1 Quantitative Measures of Performance

Measure	Current Term 1998–2003	Prior Term 1993–1998
Number of members	19	21
Active Tasks at EOT	3	5
Symposia participants	30	170
Topical Expert Meeting (TEM) participants	60	220
Publications	23	44

1.0 Objectives and Strategy

The objectives of the Implementing Agreement for Co-operation in the Research and Development of Wind Turbine Systems (Wind Energy Agreement) [See Reference 1] are to promote

- A. Cooperative research, development, and demonstration of wind turbine systems, and
- B. Information exchange on planning and implementation of wind energy in the participating countries.

The objectives of the Wind Energy Agreement are consistent with the IEA's Mission described in the CERT Strategic Plan [2], to promote the development and deployment of advanced clean energy technologies in the member countries and around the globe. One activity of the IEA Wind Energy Agreement this term that supported this goal was approval of an ad hoc committee report, *Long-Term Research and Development Needs for Wind Energy for the Time Frame 2000 to 2020*, completed in August 2001[3]. The report described the continuing advances necessary to advance wind energy technology and serves as a resource for planning national or IEA collaborative efforts. Further, the CERT aim of increased emphasis on policy issues and outreach was included in the last Wind Energy Agreement Strategic Plan [4], which has guided activities in this term. Added emphasis on policy issues has been well received, but efforts to include more non-OECD member countries have not yet succeeded. Issues of working with industry, in order to help develop the large and important markets in non-member countries, are being considered in the new Strategic Plan. The Wind Energy Agreement strategy has been to increase interactions with other IEA Agreements and expand emphasis on covering the spectrum from R&D through deployment policy.

The Wind Energy Agreement strategy has been to conduct collaborative R&D that is useful to industry and the research community. Results have been well received and widely acclaimed. For example, Task XVII has assembled extensive data on wind characteristics from more than 62 sites in Europe, Egypt, Japan, Mexico, and the United States. More than 165 different industrial and scientific users have accessed the database. A market analysis is determining how the database can be structured as a commercial operation.

Many different groups use results from the IEA Wind Energy Agreement Tasks. For example, the ongoing activities of Task XI Base Technology Information Exchange have provided International standards bodies, such as the International Electrotechnical Commission, with recommended practices that contribute to and thus accelerate their standards development work. The Wind Energy Agreement serves as an authoritative and unbiased source of information for research, non-proprietary business, and policy to accelerate the growth of wind energy technology.

The ExCo manages technology development efforts and has an ongoing process for considering new areas for cooperation. In this five-year period, the Wind Energy Agreement initiated five new Tasks: Database of Wind Characteristics (Annex XVII); Enhanced Field Rotor Aerodynamics (Annex XVIII); Wind Energy in Cold Climates (Annex XIX); HAWT Aerodynamics and Models from Wind Tunnel Tests (Annex XX); and Dynamic Models of Wind Farms for Power System Studies (Annex XXI). Another task on Wind Energy Market Development (Annex XXII) was approved in principle and is on hold pending decisions at IEA about a new Implementing Agreement and commitment of more countries to participate. Three Tasks were completed and are discussed below.

The Wind Energy Agreement strategy is to provide both technology and market information for government, industry, and utilities in both Member and non-Member countries and to be responsive to the changing needs for information products. An example of market related data collection was Task XV, Annual Review of Progress of the Implementation of Wind Energy by Member Countries. Reports from the Task XV Operating Agent were useful to both Member and Non-Member countries. When the Task was completed in 2001, the ExCo decided to pay for the work from the Common Fund and publish the work as a chapter in the IEA Wind Energy Annual Report, which is a public document.

The Wind Turbine Round Robin Test Program (Annex XVI) was also completed in this term. Several publications have resulted from this work, and a final report is in preparation.

The Enhanced Field Rotor Aerodynamics Database Task (Annex XVIII) was also completed this term. The comprehensive final report is available on the ECN Web server. Additional activities in this area will be considered in the coming term. Meanwhile, the database is available for use by designers in industry, universities, institutes, and government research organizations.

The goal of the ExCo is to provide highest quality information at the least cost and with minimum burden on the Members.

2.0 Participation of Countries, Industry and Utilities

2.1 Member Countries

Membership in the Wind Energy Agreement continues to expand. When the Agreement was formed in 1977, 14 countries joined. Membership has grown to include 19 countries and 21 contracting parties at the end of 2002 (See Table 2). New members joining in this term were Ireland and Switzerland (rejoined); Portugal and France have been invited to join and are considering membership.

Member countries participate in at least one of the Tasks operated under the Agreement. In order to join the Agreement, it is mandatory to participate in at least one Task. In some cases, countries were participating in Tasks that have been completed or are now supported through the Common Fund, and they are not interested in joining in current Tasks. In other countries, changing priorities and budget cuts have prevented travel to meetings and other participation.

The ExCo allows continuing membership in the Agreement for an indeterminate period, assuming that there is intent to join in a Task of interest. The ExCo encourages Members to participate in Tasks, in order to obtain the maximum value from participation. Participation in the IEA Tasks is summarized in Table 3 of Section 3.2.

Table 2 Contracting parties to the Implementing Agreement for Co-operation in the Research and Development of Wind Turbine Systems

Australia	Australian Wind Energy Association
Austria	Republic of Austria
Canada	Natural Resources Canada
Denmark	Danish Energy Authority
European Commission	Commission of the European Communities
Finland	Technical Research Centre of Finland (VTT Energy)
Germany	Forschungszentrum Jülich GmbH
Greece	Ministry of Industry/Energy and Technology (CRES)
Ireland	Irish Energy Center
Italy	CESI S.p.A and the Italian National Agency for New Technologies, Energy and the Environment (ENEA)
Japan	Government of Japan
Mexico	Instituto de Investigaciones Electricas (IIE)
Netherlands	Netherlands Agency for Energy and the Environment (NOVEM)
New Zealand	To be determined
Norway	Norwegian Water Resources and Energy Directorate (NVE)
Spain	Instituto de Energias Renovables (IER) of the Centro de Investigación; Energetica Medioambiental y Tecnologica (CIEMAT)
Sweden	Energimyndigheten
Switzerland	Swiss Federal Office of Energy
United Kingdom	Department of Trade and Industry
United States	U.S. Department of Energy

2.2 Industry Involvement

Industry involvement in commercial wind energy development is expanding dramatically in nearly every Member country. During the period from 1999 through 2001, installed capacity of wind turbines grew from 9,545 MW to 24,293 MW. Most of the installations during that period were in IEA Wind Energy Member countries. The portion of global capacity in Member countries increased from 87% in 1999 to 90% in 2001, despite the urgent need for sustainable energy sources in many other countries with good wind resources.

Representatives from industry were involved in the preparation of the IEA Wind Energy Agreement report *Long Term Research and Development Needs for Wind Energy for the Time Frame 2000 to 2020*. This document was prepared after a Topical Expert Meeting (TEM) was held on the subject under Task XI Base Technology Information Exchange. An ad hoc group wrote the report, which was then approved by the ExCo. More than 2,500 copies of the report have been printed and distributed in Member countries. It will also be reprinted in the *Journal of Wind Energy*, published by John Wiley &

Sons, Inc.

Direct industry involvement in most IEA Wind Energy Tasks has been minimal, despite a goal to increase industry involvement. For example, 24 people attended a recent meeting on “Environmental Issues of Offshore Installations” arranged under Task XI, Base Technology Information Exchange. Most of the participants were from government agencies, universities, and research institutes. Although this is a timely topic in an expanding commercial field, only four industry representatives (including commercial companies, utilities, and consultants) attended. Such meetings are by invitation only, and country representatives try to ensure that participants have something to contribute. Experts from Industry are often invited and sometimes they participate in these meetings.

2.3 Non-Member Country Participation

The ExCo has frequently invited Non-Member countries to attend meetings as observers and to participate. The ExCo formally invited India, China, Turkey, Brazil, Portugal, Ireland, Switzerland, and France to attend meetings this term. Representatives from Ireland, France, Portugal, and Switzerland came to meetings, and Ireland and Switzerland joined the agreement. France and Portugal have been invited to join and are considering membership.

Non-Member country participation is a topic addressed in the strategic planning process. Many countries could benefit from membership, but participation has been limited, and there are obstacles to overcome. These obstacles include: funding for membership fees, administrative complexities, and travel cost to attend meetings.

The ExCo also promotes wind energy development in non-OECD countries. For example, in 1999, a full-day seminar on wind energy was presented by ExCo members in Mexico City and was well attended by members of the Mexican government and local power industry leaders. Topics presented covered wind technology, applications, business and financial incentives, grid integration, deployment strategies, and lessons learned. Future programs like this would benefit from better and broader advertising, and possibly leveraging the results by involving several countries. The key is taking the message to an interested audience and allowing enough lead-time for scheduling participation.

2.4 Withdrawals

None.

3.0 Program and Nature of Work

3.1 Nature of the Work

The work program, managed by the ExCo, has been expanding in response to needs of the Member countries and their industry. Most work is carried out through Annexes to the Agreement (also referred to as Tasks). Results from the work take many forms: shared databases, numerous technical papers and reports, Recommended Practice reports, proceedings from meetings, a new interactive Web site, regular annual reports, brochures, and other publications.

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3.2 Active Tasks

Nine approved Tasks have operated under the Agreement during this period. Six of the nine were started during the current five-year term. Tasks and country participation are shown in Table 3 (Countries are marked as a Participant if they are or were involved). Some of the Member countries are not currently participating in an active Task despite the requirement for joining at least one Task for admission to the Agreement. The ExCo has reviewed this issue and concluded that Members should be encouraged to participate in Tasks, but continued membership in the Agreement is acceptable even if there are currently no Tasks of interest to Members.

Country	XI Base Technology Information Exchange	XV Annual Review of Progress (completed)	XVI Round Robin Test (Completed)	XVII Database of Wind Charac- teristics	XVIII Enhanced Field Rotor Aerodynamics Database (Completed)	XIX Wind Energy in Cold Climates	XX HAWT Aero- dynamics and Models from Wind Tunnel Tests	XXI Models for Wind Farm Power Systems	XXII Market Develop- ment for Wind Turbines (on hold)
Australia	x						x		
Austria									
Canada	x		x			x	x		
Denmark	x	x	x	OA	x	x	x	x	x
European Commission	x	x							
Finland	x					OA		x	
Germany	x	x						x	
Greece	x	x	x		x		x		
Ireland	x								
Italy	x	x							
Japan		x		x	x				
Mexico	x								
Netherlands	x	x		x	OA		x	x	
New Zealand		x							
Norway	x	x		x		x	x	OA	
Spain	x							x	
Sweden	OA	x		x		x	x	x	
Switzerland						x			
United Kingdom	x	OA				x		x	
United States	x	x	OA	x	x	x	OA	x	x
Start Date	1988			1999	1991	2001	2002	2002	
End Date	Ongoing	2001	2002	2003	2002	2004	2005	2005	On hold

Table 3. Country participation in Tasks. OA indicates the Operating Agent.

A summary of the ongoing work and results achieved under each active Task follows:

Annex XI Base Technology Information Exchange - Operating Agent: FOI-Swedish Defense Research Agency, Sven-Erik Thor.

In January 2000, the Technical University of Denmark passed the role of operating agent to the Swedish Defense Research Agency. The operating agent representative from Denmark, B. Maribo Pedersen, retired after many years of outstanding leadership of this Task.

This Task is one of the most productive under the Wind Energy Agreement. Since these activities were initiated in 1987, more than 40 volumes of proceedings from Expert Meetings, 16 volumes of proceedings from the symposia on Aerodynamics of Wind Turbines, five from the symposia on Wind Turbine Fatigue, two from the symposia on Wind Characteristics and one from Wind Forecasting Techniques, have been published. In the series of Recommended Practices, 11 documents were published, and five of these have revised editions. The most recent Recommended Practice published, “Wind Speed Measurement and Use of Cup Anemometry” has been popular and copies requested from many industries and utilities.

The objective of the ongoing Task XI is to promote wind turbine technology through information exchange for experts on R&D topics of common interest. Two subtasks are to: 1. Develop Recommended Practices for wind turbine testing and evaluation by assembling an Experts Group for each topic, and 2. Organizing a range of Topical Expert meetings and Joint Actions in research areas where collaboration is useful, but where there is no clearly defined need for establishing a formal Task. These meetings of experts in the design, testing and deployment of wind turbine systems have been part of the Agreement since 1988.

Many of the IEA Recommended Practices have served as the basis for both national and International Norms and Standards. The Operating Agent of Annex XI also acts as the official IEA observer on Technical Committee No. 88, Wind Turbine Generator Systems, of the International Electrotechnical Commission (IEC TC88).

So far, Joint Actions have been initiated in Aerodynamics of Wind Turbines, Wind Turbine Fatigue, Wind Characteristics, Offshore Wind Systems, and Wind Forecasting Techniques. Topical Expert Meetings have been held on many designated topics in these areas. Several new Annexes have resulted from these meetings. Offshore wind plant applications are now becoming a major project development topic, although IEA has been supporting related conferences for many years.

3.3 Tasks Completed During Term

Annex XV, Annual Review of Progress in the Implementation of Wind Energy In the Member Countries of the IEA - Operating Agent: ETSU, on behalf of UK, Ian Fletcher.

The reports of this task described and explained the basis for progress in deployment of wind energy in the Member countries. Tracking included industrial development, installed capacity, financial and other incentives, cost of wind energy, government R&D programs, and other useful data. These reports were so popular that the ExCo decided to finance it from the Common Fund and included it as an overview Chapter in the Annual Report.

This Overview chapter covers market development, installed capacity, national policies and targets, and analysis of the plethora of financial and other incentives for wind development being employed in Member countries. The quantitative and qualitative information on incentive policies and the resulting industry development trends are considered to be the most accurate that is available anywhere.

Because the Wind Energy Agreement Annual Report is a public document, the review of progress is now more widely available.

Annex XVI Wind Turbine Round Robin Test Program - Operating Agent: National Renewable Energy Laboratory in United States, Hal Link.

The objectives of this Task were to validate wind turbine testing procedures, analyze and resolve sources of discrepancies, and improve the testing methods and procedures. A series of field tests were conducted at participating national laboratories and test centers, using a standardized 50 kW wind turbine. Comparison test results are used as a means of validating test procedures and establishing reciprocity between different certification testing laboratories. This effort will also serve as justification for reciprocity and mutual international recognition of turbine certification. Final reports on this Task will be completed during 2003.

Annex XVIII, Enhanced Field Rotor Aerodynamics Database - Operating Agent: Energy Research Centre of the Netherlands ECN, Gerard Schepers.

This Task was begun in this term and completed in 2002. The objective was to enhance the database resulting from the IEA Wind Agreement Annex XIV, Field Rotor Aerodynamics, completed in 1997. In these projects a cooperation was established among six institutes in five countries, that were taking detailed aerodynamic measurements on full-scale wind turbines. The projects resulted in a database of measurements, which is available for outside parties and through the web at http://www.ecn.nl/unit_de/wind/annexxiv/index.html.

3.4 New Tasks This Term

Six new tasks began this term.

Annex XVII Database on Wind Characteristics - Operating Agent: Riso National Laboratory in Denmark, Gunner C. Larsen.

The objective of this Task is to provide wind energy planners and designers, as well as the international wind engineering community, with easy access to quality controlled, measured wind field data collected in a wide range of environments (wind climates, terrain types, wind turbine wakes). The Task is a follow-on to a European Union EU-DG XII (Joule) project.

By October 2002, more than 161,000 hours of wind field time series data from more than 62 sites in Europe, Japan, Egypt, Mexico, and the United States resided in the database. In addition, 555,000 hours of wind resource data from 24 sites were included. These data represent a wide variety of wind climates, terrain types, and wind turbine wake situations.

More than 165 commercial and scientific users have registered to use the database, with the largest group (56 %) coming from wind turbine and component manufacturers. The data is used mainly for investigations of design wind loads and phenomenological studies and for possible use in IEC wind turbine safety codes. This extensive use and broad interest are being investigated to determine whether the database could be operated commercially and support itself from user fees.

Annex XVIII, Enhanced Field Rotor Aerodynamics Database - Operating Agent: Energy Research Centre of the Netherlands ECN, Gerard Schepers.

Begun and completed this term. See above.

Annex XIX - Wind Energy in Cold Climates - Operating Agent: VTT Energy in Finland, Esa Peltola.

The objectives of this Task are to gather and share information on wind turbines operating in cold climates. Participants are working to establish site classification formulae for wind turbine designers, manufacturers and project developers, and wind energy producers. The Task participants also collect on the reliability and availability of standard and adapted wind turbine technology in harsh environments. The overall objective is to develop guidelines for applying wind energy in cold climates.

Annex XX - Horizontal Axis Wind Turbine (HAWT) Aerodynamics and Models from Wind Tunnel Measurements Operating Agent: National Renewable Energy Laboratory, United States, Scott Schreck.

This Task has been approved by the ExCo contingent on IEA legal review of the Annex text. Eight countries plan to join. The objective is to compare theoretical aerodynamic model predictions of wind turbine blade and structural performance and loads with actual measurements taken in carefully controlled wind tunnel tests on actual turbines.

Annex XXI - Dynamic Models of Wind Farms for Power Systems –Operating Agent SINTEF Energy Research (Norway), John Tande.

This Task has been approved by the ExCo contingent on IEA legal review of the Annex text. Ten countries have expressed interest in joining. The work will address effects on power systems of interconnecting and operating large numbers of wind turbines.

Proposed Annex XXII - Market Acceleration – No operating agent or participants have committed at this time.

The ExCo recognizes a need for work in this area and has approved this Task, but it is now on hold. So far only two countries have agreed to join the Annex. Broader representation was needed for the Task to be effective. This proposed Task will conduct programs to assist in development of new markets for wind power, especially in non-OECD countries. It could be useful in forming policies and plans in countries where the demand for electricity is growing and where there is a need to tap indigenous energy sources that are sustainable (like wind power) and do not require expensive imported and environmentally damaging fossil fuels. This Task has been deferred pending the outcome of discussions at the IEA headquarters regarding a possible new agreement on this topic, which might cover multiple renewable energy technologies for applications in developing countries or regions; and because there was no general agreement on how to approach and pay for the work under the Task. Additional discussion on this important Task will take place during the strategy plan development.

3.5 Performance Measures

There has been a continuing trend in the Wind Energy Agreement toward setting specific and quantitative performance measures. These measures have been discussed and accepted informally in some cases in the past, but this is an area that will be examined in preparation of the Strategy Plan for the coming term. For a summary of these measures in this and the previous term, please consult Table 1 in the Introduction section.

Quantitative and qualitative performance measures and results for the Wind Energy Agreement are:

Number of New and Active Tasks—During the current term, six new Tasks were initiated. During the prior five-year term, two new Tasks were initiated. At the end of the previous term three Tasks were active. Today there are five active Tasks.

This indicates an increased interest in IEA and in IEA Wind Energy Agreement products.

Number of Industrial Participants—The number of participants from industry (both directly involved in IEA Wind Energy Tasks or using results of IEA Wind Energy work) is increasing. This is difficult to quantify, but a good indication is the number of people and their affiliation. During the previous 5-year period, there were 30 attendees at Technical Experts meetings and 60 attendees at Symposia. During the current period these numbers increased to 151 and 139 respectively. And there are three more experts meetings and symposia scheduled during the current term.

Number of Awards—The Wind Energy Agreement has produced an Annual report every year since it began twenty five years ago. These reports are substantive and comprehensive, providing an accurate historical record of the research, development, deployment, and maturation issues associated with this new technology.

Recently the Society for Technical Communication has awarded the *IEA Wind Annual Report 2001* its "distinguished" award "as an example of well-written technical communication." Judges' comments included "Very well done... Refreshingly clear...The report is full of interesting and useful content." One judge wrote "This is more than an annual report; it is a significant information resource for anyone interested in the progress of wind energy."

Number of Publications—This is an indication of the productivity of the Agreement. During the five-year term, publications have nearly doubled over the previous term, with publication of 40 technical papers, reports, newsletters and articles, compared to 23 during the prior term.

4.0 Coordination with Other Bodies

The Wind Energy Agreement ExCo has increased its co-ordination and information exchange within the IEA and with other organizations. In addition, outreach to key organizations will be considered in the Strategy Plan, which is currently under development.

4.1 Formal Coordination/Cooperation

Following are areas of increased coordination accomplished by elements of the Wind Energy Agreement:

Support for the IEA Renewable Energy Unit Outreach—In 2001, the ExCo provided funding for the Chair to attend a two-day coordination meeting on renewable energy technologies, organized by IEA Renewable Energy Working Party and held in New Delhi, India with the Ministry of Non-Conventional Energy Sources and local governments. Despite the interest shown in further cooperation and participation by a Ministry representative as observer at an ExCo meeting, no further engagement has yet occurred.

Coordination with American and European Wind Energy Associations—ExCo members presented papers on IEA Wind Energy work at EWEA and AWEA conferences and invited audience participation and involvement in IEA Wind Energy Programs. For example, a meeting was hosted by the IEA Wind Energy Agreement at the European Wind Conference in Denmark. At this meeting, the operating agent representative collected responses from participants as a follow-up to the Topical Experts Meeting on long-term R&D needs for wind energy. These comments contributed to the ad

hoc committee report *Long Term Research and Development Needs for Wind Energy for the Time Frame 2000 to 2020* that was approved by the ExCo for public distribution.

REWP Long-Term R&D Planning—In November 2000, representatives from the Wind Energy Agreement participated in the REWP R&D planning session held in Paris. The report *Long Term Research and Development Needs for Wind Energy for the Time Frame 2000 to 2020* was prepared based partly on the results of their meeting.

Global Wind Energy Conference—In April 2002, the Chair of the Wind Energy Agreement ExCo presented a paper on the long-term R&D needs for wind energy.

Cooperate with the IEA Energy Storage Agreement—Members of the Wind Energy Agreement ExCo assisted that Energy Storage Agreement in defining needed work on electrical energy storage. This action led to a new Annex under that Agreement.

IEA CADDET Agreement Assessment on “Electricity from Offshore Wind Energy”—Wind Energy Agreement ExCo members provided technical support to this effort. This report (published in October 2000) reviewed the status and trends in offshore wind energy over the next five to ten years. Main topics included the development of offshore wind resources, technological challenges, and prospects for improving economics, reducing environmental impact on wildlife, and limiting impact on coastal landscapes. Legal aspects of siting wind turbines in international waters were also explored.

4.2 Informal Coordination activities:

IEA Energy Technology Systems Analysis Programme (ETSAP)—Under Annex VII (1999-2001): Contributing to the Kyoto Protocol with publication of the book *IEA: Experience Curves for Energy Technology Policy*. Class-Otto Wene, previously the ETSAP technical representative for Sweden, and now working at the IEA, is the author.

International Standards Development—Coordination and controlled exchange of technology information is done through Annex XI. Annex participants coordinate with international standards groups providing information exchange on topics of common interest. An example is development of recommended practices that have served as the basis for subsequent international standards.

5.0 Information Dissemination

The Wind Energy Agreement is expanding both internal and external information exchange. Information from IEA headquarters is presented by a representative at the IEA Wind Energy ExCo meetings. Because of increasing membership and the larger volume of information, the **ExCo meetings** were organized so that, in addition to the normal committee business, the first meeting of the calendar year focuses on wind energy R&D activities, while the second meeting of the year addresses deployment and incentives.

Public information products have also been expanded. **Annual Reports** have richer content and are larger (the 1998 report was 179 pages, growing to 233 pages in 2001). A **public Web site** has been available since 1997 at DTU and some public information on the Wind Energy Agreement has been available on the IEA Web site. Because these sites were out of date or had other problems, a new public site has been established. The URL is www.ieawind.org, and the site will be linked to both IEA and National sites. During this term, a **password-protected Web site for ExCo Members** only was created for more efficient information exchange. That site provides access for all Members to archival

information as well as to current postings of meeting information and documents available for review. This activity will continue into the next term. that has been in use by the committee for several years. Four **newsletters** were published and distributed during the term. This activity was discontinued late in the term. Results from IEA Wind Energy Task work, joint actions, recommended practices, analysis of implementation progress and policies are being described in public conferences and forums. The target audiences for each product are quite different, and information is tailored accordingly.

The ExCo Ad Hoc Group report ***Long-Term R&D Needs for Wind Energy for the Time Frame 2000-2020*** was submitted, accepted, and published in the prestigious *Wind Energy*, distributed by John Wiley & Sons, Ltd, during 2003.

A **brochure/folder** describing the Agreement was prepared in 2000 for use by Members. A bi-fold format was used, with a pocket for newsletters, fact sheets, and other documents. Over 5,000 copies were printed and it is currently in use.

The Wind Energy Agreement has been in effect since 1977. To commemorate the 25th anniversary, a special edition of the **Annual Report** is being prepared. It will track the role of IEA in the development of wind energy, and will include interviews with past Chairmen. An **anniversary poster** is also being prepared. The Wind Energy Agreement will participate in **the IEA Energy Technology Fair** for energy ministers with publications, a table-top model of a wind turbine, and posters for distribution.

6.0 Scale of Activities and Management

The scope and scale of activities accomplished under the Agreement has increased substantially during this term, and the cost of operation has increased slightly. The number of formally organized committee and experts meetings has increased. The normal schedule for ExCo meetings has been two meetings per year, normally at a site in one of the member countries. The ExCo meeting was held in conjunction with the wind energy seminar in Mexico in 1999, where about 40 government, industry, and utility leaders attended to encourage wind energy development in Mexico, a Member country.

Additional meetings involve participation in IEA REWP functions, interfacing with other IEA Agreements, and public forums. The number of attendees from the Wind Agreement IEA functions has increased along with increased membership. In addition, attendance is open to non-member participants. Invitations to ExCo meetings have been extended to Ireland and Switzerland (came and joined), France, Portugal, and India (came once and now considering joining), and to China, Brazil, Israel, and Turkey.

6.1 Costs:

The IEA has no central funds to finance projects, so members support the activities of IEA Wind Energy R&D in four ways. Amounts are expressed in U.S. Dollars.

First, the Contracting Parties pay an annual membership fee to cover administrative expenses incurred in connection with the ExCo, including the secretariat, Overview chapter, extension reports and plans, travel to represent the ExCo, and some publications (e.g. Annual Report, Newsletter, Long-term R&D report, Poster, Brochure, etc.). The cost of participation in the Agreement has been kept low. From 1999 through 2003, the cost of membership for small countries has increased from \$2,300 to \$2,690 per year, and from \$9,200 to \$10,700 per year for large countries. During the same period, the annual budget has increased from \$58.6 thousand to \$98.6 thousand in 2002. Costs can be kept low because

new countries are joining and contributing, while the incremental cost of expanded membership and operations is minimal. A larger budget of \$124.4 thousand has been approved for 2003 to pay the extra costs associated with preparing the End-of-Term Report, the Strategy Plan, the 25th anniversary poster, and the special edition of the Annual Report. No increase in country contributions will be required; the planned accumulated cash reserve will be used for that purpose. Assets in the bank accounts and receivables were \$98,352 at the end of 1998 and \$125,225 at the end of 2002. An independent audit of the financial records is conducted annually.

Second, participants in a Task contribute to the expenses incurred by the Operating Agent in the conduct of the Task. The parties agree to a budget for these expenses in advance. Currently there are five active Tasks that cost about \$75,000 annually to operate. One Task, the Round Robin Test, had a one-time fee of \$10,000 to each country that joined.

Third, parties participating in a Cooperative Task may conduct portions of the work designated in the program of work as their in-kind contribution to the effort. Hybrid cooperative Tasks with in-kind contributions of effort, in combination with a cost-shared contribution to support the Operating Agent, are being used more often. For example, in Task XX, (HAWT Aerodynamic Models) participants each contribute about one person-year of labor annually to run their own models using the common database. The Operating Agent's expenses for Task XX of \$75,000 for the three-year program will be shared among the eight participants. The budget for Task XXI (Models for Wind Farm Power System) is \$151,200 for the three and a half year study, or about \$43,200 per year for the Operating Agent, plus in-kind contributions that are still being discussed. Task sharing value is estimated at \$200,000 per person year, but the level of effort varies substantially among and within the Tasks.

The approach of paying the Operating Agents' costs has improved responsiveness and helped ensure that schedules are met on task-shared Annexes. The ExCo recommends an increased use of this hybrid funding principle, because serving as Operating Agent is normally a substantial, complex, and time-consuming task that is crucial for the success of a task-shared Annex.

Fourth, member countries contribute by covering the travel expenses for their members to attend meetings and workshops. The ExCo meets twice annually, and some of the working groups meet several times a year. Travel costs are minimized by doing business by mail and email whenever possible. Meetings are often scheduled to coincide with other events to minimize travel costs.

The contracting parties and the ExCo have indicated that the cost of the Agreement should be kept on the same level as at present. In planning future activities, cost efficiency is of major importance. Sharing the cost and exchange of technical information on the IEA Wind Energy research Tasks is beneficial to all parties.

6.2 Management and Administration

The Implementing Agreement has proven to be a flexible framework for cooperative action. Use of a part-time secretary for handling day-to-day operations in conjunction with the Chair has proven effective. The secretary's duties include preparing the Annual Report, minutes of the ExCo meetings, and most correspondence. Special writing tasks are being done by small consulting contracts. Multiple bids are solicited for these tasks.

New Tasks (Annexes) are usually initiated as a result of Topical Expert Meetings, workshops, or Joint Actions. A draft Annex is prepared, reviewed by the ExCo, and submitted to the IEA for legal review.

Management of Tasks is accomplished by Operating Agents with ExCo oversight. The trend toward Tasks that are structured to involve combined Cost/Task sharing has helped to improve management.

When money is involved, participants demand accountability and increased management control. Tasks involving no exchange of funds proved to be more difficult to schedule and control.

The Joint Actions in Annex XI (Base Technology Information Exchange) represent a useful and flexible method of collaboration where there is no defined need for a Task.

During the next planning period (2003-2008), the number of participants in the Agreement is likely to increase. This may call for reconsideration of the administrative practices of the Agreement.

6.3 Strategic Plan Update

The Wind Energy Agreement has developed and published a Strategic Plan for the past ten years. The most recent update of the Plan was completed in September 1998 [6].

The purpose of the strategy plan is to provide direction for the activities of the Wind R&D Implementing Agreement over the next 5-year term. It has been generated through a consensus process, and represents the views of the ExCo. A dedicated task force comprising members of this committee was established to provide detailed guidance on structure and content.

One of the first steps in updating the plan will be to evaluate results, planned objectives, and actions of the Wind Energy Agreement. Eleven of the 14 strategic objectives in the 1998 Plan were met or partially met. See Table 4.

4 March 2003

Table 4. Strategic Objectives and Planned Actions From the 1998 -2003 Plan		Met	Partly Met	Not Met	Comments As of 1-2003
<i>Improve Co-operation on Research and Development</i>					
	Identify and conduct new Cooperative R, D&D projects (Tasks), Joint Actions, and Expert Meetings in areas as stipulated in the Proceedings from the Expert Meeting in Utrecht.	T			Two new, Three continuing and two planned tasks.
	Continue activities for the definition and updating of Recommended Practices for Wind Turbine Testing and Evaluation in areas yet to be developed for an IEC standard.	T			One completed.
	Include industry and utility sector representatives in all relevant planning activities, Expert Meetings, and Joint Actions.		T		Power systems Task planned.
<i>Exchange of Information and State-of-the-Art Assessments</i>					
	Use existing channels of information (Annual Reports, Expert Meetings, etc.) and develop new information channels via the Internet.	T			Larger, richer reports; new web site started.
	Operating Agent for Task XV plans to introduce further development of implementation information area by the ExCo.	T			Added full Chapter in Annual Report.
	Develop more formal relationships with the World Bank, UN bodies, and international organizations such as the European and American Wind Energy Associations (EWEA/AWEA) and EURE (European Union for RE).			T	Attempts to develop information products failed.
	Further development of information exchange on current R, D&D.	T			Topical focus in ExCo meetings
<i>Extension of Cooperation to Nonparticipating OECD, Developing and Eastern European Countries.</i>					
	Executive committee contacts relevant authorities in Nonparticipating OECD countries.	T			Ten countries contacted; Four Non-OECD
	Invite a number of non-OECD countries join.		T		One invite - zero join
	Consider establishing a new Task to encourage the development and deployment of wind systems in both grid-connected and off-grid connected applications in non-OECD countries.			T	Discussed, but OK work plan unresolved
	Coordinate with other IEA Agreements.		T		Increased contacts
	When invited, Executive Committee representatives will endeavor to attend conferences in countries with a wind energy program and present IEA Wind activities.	T			Did not wait for invitation; two papers presented
	Organize Targeted Workshops, Topical Expert Meetings (TEM) and Joint Actions.	T			One seminar, ten TEMs and seven Joint Actions
	Develop Recommended Practices for wind systems in developing countries (technical solutions and implementation policies).			T	Insufficient interest

The Strategic Planning Task Force is in the process of identifying a clear vision and mission statement. So far, four key issues have been identified relating to Technology R, D, D & D issues, Systems issues, Societal issues, and Market/Support Mechanism issues.

The updating of the Strategic Plan for the Wind Energy Agreement is still in progress and will be finalized in 2003, but several actions are anticipated:

1. Extend the Agreement for an additional five years, 2003-2008.
2. Conduct work on the active Tasks.
3. Encourage more cooperation with other elements of the IEA to share ideas and experiences to help improve work done under the Agreements; and to compile and present cross-technology information on renewable energy, especially to developing countries where the need for information is the greatest.

7.0 Achievements, Benefits and Issues

7.1 Technology Development and Deployment Achievements

- The Society for Technical Communication has awarded the *IEA Wind Annual Report 2001* its "distinguished" prize "as an example of well-written technical communication." Judges' comments included, "Very well done... Refreshingly clear... The report is full of interesting and useful content." One judge wrote, "This is more than an annual report; it is a significant information resource for anyone interested in the progress of wind energy."

- Work under Annex XI on eleven Recommended Practices has laid the groundwork for international standards. Nearly all of the Standards promulgated by the International Electrotechnical Commission (IEC) which are being applied today, have roots in IEA Wind Recommended Practices.
- Annex XI also organized 10 Topical Experts Meetings during the current term of the Agreement. One of these meetings produced the well-received report *Long-Term Research and Development Needs for Wind Energy for the Time Frame 2000 to 2020*, and two other meetings resulted in new Annexes. Since the Annex began, 60 volumes of proceedings from Technical Experts meetings, 15 volumes from symposia on aerodynamics, five from symposia on turbine structural fatigue, two on wind characteristics and one on wind forecasting have been published.
- Annex XI maintains a library of published documents and distributes them upon request of a Member
- The Enhanced Field Rotor Aerodynamics Database developed by the five participating countries contains 324 minutes of high frequency data totalling several terabytes, valued at 10 million Euros. The Annex is now complete, and data has been turned over to participants and is publicly available on the ECN site at <http://www.ecn.nl/main.html>.
- The Overview chapter included in the annual report is an outgrowth of Annex XV, which was completed several years ago. This chapter in the annual report is considered by many to be the most comprehensive and objective assessment of industry trends available. The chapter includes a summary of National Programs and policies, goals and targets, installed capacity growth, market drivers, market development and stimulation instruments and mechanisms, constraints and barriers to market expansion, and technology and cost trends.

7.2 Networking

The IEA Wind Energy Agreement has established a large network of researchers, academics, government officials, and industry users. This network was created primarily through the Tasks. Because participating experts in each Task have their own network, primarily within their own country, the extent of the IEA Wind Agreement network is vast. It would not be an exaggeration to suggest that the IEA Wind network involves most of the people working on, or interested in wind power in the IEA Wind Member countries.

Benefits from international networking include:

- Reduced research cost by eliminating duplication of efforts
- Improved quality of research through peer interaction
- The international scope broadens the view of participants
- IEA tends to be less bureaucratic than most other networks
- Project strategy is largely determined directly by participating country members
- All participants are chosen as recognized experts in their field doing significant research
- IEA work is considered prestigious and sought after

7.3 Policy Relevance

The work done under the Annual Review of Wind Energy Implementation, and data exchanged through the ExCo, are based on proven and validated information that is used by both Member and Non-Member countries in policy planning. An example where this data proved helpful was formulating incentives for encouraging wind energy deployment. Experience in the United States during the early 1980s showed that incentives in the form of investment tax credits resulted in the installation of 1,000 MW in California in less than five years. However, many of the turbines built were early models that did not have sufficient testing time, resulting in premature failures in some cases. Many European countries learned from this experience, at least in part through the IEA, and used incentives that were based on energy production rather than encouraging only the initial investment in the turbines.

Recently there have been many new and innovative mechanisms and incentives for encouraging wind energy development. The IEA Annual Report is one of the most comprehensive and authoritative sources for information on the wide array of policy options in use in the Member countries.

7.4 Environment

In previous terms, the Wind Energy Agreement has supported the study and development of Recommended Practices on environmental issues relating to deployment and operation of wind systems. In this term, Experts Meetings were conducted on life cycle analysis, acoustic noise, possible electromagnetic interference from wind turbines and marine issues for offshore installations.

Wind energy has environmental advantages because it produces energy with no harmful emissions. Remaining environmental aspects were dealt with during a TEM on life cycle analysis.

7.5 More Efficient Use of R&D Resources

Aerodynamic databases and joint wind tunnel testing are good examples where major savings in R&D costs have been achieved. The Aero database was valued at \$10.8 million (€10 million) and cost about \$100,000 (€92,600) to develop. The full scale testing of a wind turbine in the NASA Ames Laboratory cost about \$3 million to conduct. The NASA tunnel facility is unique in size and flow

control, allowing more accurate data collection and reduction of experimental variables. The US wind program planned that test to validate models, but by combining the data collection campaigns from the five participating countries and comparing different model results the value of the test was leveraged many times.

Information exchange on large-scale (1-5 MW) turbine development and field test programs has been very useful, especially in the pre-commercial phase of machine development. The data on government sponsored large turbine design concepts and the results of testing of prototype machines have been shared under the Agreement. Detailed designs and proprietary company information were not shared, however. The resulting data, available to member countries, is now being used to develop commercial turbines.

7.6 Overall Significance of the Agreement:

Tracking the progress being made in the development and deployment of wind technology is one of the achievements of the Agreement. The IEA is viewed as an objective and unbiased source of information, since all countries with significant wind energy programs are participants. There are several reasons that IEA is viewed as an important data source, and that its future roles and activities will continue to influence wind energy development and deployment. Three principal features are:

- **Knowledge** - Through its members, IEA Wind has access to all major public and private sector performers in wind energy technology.

- **Strength** - Through the combined efforts of several nations, IEA Wind can plan, support, and undertake projects beyond the capability of any single country or group.

- **Neutrality** - IEA Wind has no nationalistic orientation: its sole motivation is the improvement and appropriate deployment of wind energy technology worldwide.

7.6 Issues for REWP/CERT Consideration

None currently.

References:

1. IEA Implementing Agreement for Co-Operation in the Research and Development of Wind Turbine Systems, as amended to 21 October 1991.
2. IEA/OECD Report, Energy Technologies for the 21st Century, Paris, 1997.
3. IEA Wind Energy Executive Committee, Long-Term Research and Development Needs for Wind Energy for the Time Frame 2000 to 2020, October 2001.
4. IEA Wind Energy Agreement Non-OECD Countries Task Force Report, April 1997.
5. IEA R&D Wind Executive Committee, "Wind Energy Wind Energy End-of-Term Report 1993-1998 and Plans for 1999-2003," September 1998.
6. IEA R&D Wind Executive Committee, "Strategic Plan October 31, 1998 to November 1, 2003," September 1998.

Attachments:**A. List of Publications.****General Publications**

1. IEA Wind Energy Executive Committee, IEA Wind Energy Annual Report 1998, April 1999.
2. IEA Wind Energy Executive Committee, IEA Wind Energy Annual Report 1999, May 2000.
3. IEA Wind Energy Executive Committee, IEA Wind Energy Annual Report 2000, May 2001.
4. IEA Wind Energy Executive Committee, IEA Wind Energy Annual Report 2001, May 2002.
5. IEA Wind Energy Executive Committee, IEA Wind Energy Annual Report 2002, In preparation.
6. IEA Wind Energy Brochure, November 2000.
7. IEA, Wind Energy Newsletter, Issue 13, November 1999.
8. IEA, Wind Energy Newsletter, Issue 14, November 2000.
9. IEA, Wind Energy Newsletter, Issue 15, November 2001.

Task XI - Base Technology Information Publications

1. Proceedings of IEA Topical Experts Meeting 31, "State of the art on Wind Resource Estimation," Lyngby, Denmark, October 1998, Edited by S-E Thor.
2. Proceedings of IEA 12th Joint Action Symposium on, "Aerodynamics of Wind Turbines," Danish Technical University, Lyngby, Denmark, 1998, Edited by S-E Thor.
3. Proceedings of IEA Topical Experts Meeting 33, "Wind Forecasting Techniques," Boulder, Colorado, US, April 2000, Edited by S-E Thor.
4. Proceedings of IEA Topical Expert Meeting 32, "Wind Energy under Cold Climates," Helsinki, Finland, March 1999, Edited by S-E Thor.
5. Proceedings of IEA 5th Joint Action Symposium on, "Fatigue of Wind Turbine Blades," University of Delft, Delft, The Netherlands, 1999, Edited by S-E Thor.
6. Proceedings of IEA Second Joint Action Symposium on, "Wind Forecasting Techniques," Riso, Denmark, 1999, Edited by S-E Thor.
7. Proceedings of IEA 13th Joint Action Symposium on, "Aerodynamics of Wind Turbines," FFA, Stockholm, Sweden, 1999, Edited by S-E Thor.
8. Proceedings of IEA Topical Expert Meeting 34, "Noise Immission," FFA, Stockholm, Sweden, November 2000, Edited by S-E Thor.
9. Proceedings of IEA 14th Joint Action Symposium on, "Aerodynamics of Wind Turbines," NREL, Boulder, Colorado, USA, 2000, Edited by S-E Thor.
10. Proceedings of IEA Topical Experts Meeting 35, "Long-Term R&D Needs of Wind Energy for the Frame 2000 to 2020," Petten, Netherlands, March 2001, Edited by S-E Thor.
11. Proceedings of IEA Topical Expert Meeting 36, "Large Scale Integration into the grid," Hexham, England, 6-7 November 2001, Edited by S-E Thor.
12. Proceedings of IEA 15th Joint Action Symposium on, "Aerodynamics of Wind Turbines," Athens, Greece, 2001, Edited by S-E Thor.
13. Proceedings of IEA Topical Expert Meeting 37, "Structural Reliability of Wind Turbines," Riso, Denmark 12-13 November 2001, Edited by S-E Thor.
14. Proceedings of IEA Topical Expert Meeting 38, "Material recycling and life cycle analysis (LCA) of wind turbines," Risø Wind Energy Department, Roskilde, Denmark, 7-8 March 2002, Edited by S-E Thor.
15. Proceedings of IEA Topical Expert Meeting 39, "Power Performance of Small Wind Turbines not connected to the Grid," Soria, Spain, 25-26 April 2002, Edited by S-E Thor.
16. Proceedings of IEA Topical Expert Meeting 40, "Environmental issues of offshore wind farms," Husum, Germany, 23-24 September 2002, Edited by S-E Thor.

17. Ad Hoc Group Report to the Executive Committee of the IEA Wind Energy Agreement, Long-Term Research and Development Needs for Wind Energy for the Time Frame 2000 to 2030, October 2, 2001.
18. IEA Recommended Practice 11, Edition 1, "Wind Speed Measurement and use of Cup Anemometers." 1999. Document will be used by IEC MT 13, for updating power performance Measurement.
19. Proceedings of IEA First Joint Action Symposium on, "Wind Forecasting Techniques," Norrköping, Sweden, 2-4 December 2002, Edited by S-E Thor.

Task XV - Review in Progress in Implementation of Wind Energy in Member Countries

1. Final Report Annex XV, November 2001

Task XVI - Round Robin Test Program Publications

1. K. H. Papadopoulos, E. Morfiadakis, N.C. Stefanatos, H. Link, U.S. Paulsen, "Performance Assessment of Cup Anemometers," Paper PB9, Proceedings of European Wind Energy Conference, Location? 1999.
2. Santos, R. et al, "Comparison of Results from the IEA Round Robin Mechanical Loads Testing," Proceedings of the American Wind Energy Association Conference, June 3-7, 2001.

Task XVII - Database on Wind Characteristics Publications

1. Web site access <http://www.winddata.com>
2. Hansen, K.S. and Larsen, G.C. (1999). Cut_in Note. Database on Wind Characteristics, <http://www.winddata.com>. Wind Engineering, Vol. 23, No. 3, pp. 177_181.
3. Hansen, K.S., Larsen, G.C. and Courtney, M. (2001). "Database on Wind Characteristics". EWEC'01, Copenhagen, Denmark, 2_6 July.
4. Larsen, G.C. (1999). "Application of DfWC for Gust Investigations". IEA_Symposium on Wind conditions for Wind Turbine Design, Risø, 12_13. April.
5. Courtney, M.S., Hansen, K.S. and Larsen, G.C. (1999). "Wind Characteristics Database". Energistyrelsens Vindenergikonference, Ringkøbing, 25_26 Marts.
6. Larsen, G.C. and Hansen, K.S. (2001). Database on Wind Characteristics _Structure and Philophopy. Risø_R_1299 (EN).
7. Larsen, G.C. and Hansen, K.S. (2001). Database on Wind Characteristics _Users Manual. Risø_R_1300 (EN).
8. Larsen, G.C. and Hansen, K.S. (2001). Database on Wind Characteristics _Contents of database Bank. Risø_R_1300 (EN).
9. Hansen, K.S. (1999). Presentation of the database at the OWEN workshop on off_shore wind energy at CLRC Rutherford Appleton Laboratory in Oxfordshire U.K., 8 November.
10. Pedersen, T.F (1999). Presentation of the database at 19th IMTS at Ciemat, Madrid, Spain, 18_19 October.
11. Hansen, K.S. and Larsen, G.C (2000). "Extreme Wind Characteristics from a Danish Off_shore Site". OWEMES 2000, Siracusa _ Sicily, Italy, April 13_14. (The paper has received an Award).
12. Hansen, K.S. (2000). Presentation of "Database on Wind Characteristics" on Advanced Topics in Wind Turbine Aerodynamics, PhD course, 16_25 Aug., DTU, Denmark
13. Winkelaar, D. and Dekker, J. (2000). Presentation of "Database on Wind Characteristics" on two workshops in The Netherlands, September.
14. Hansen, K.S. (2000). Demonstration of the new database release (including user groups, resource data and structural data) during the "Vinddag 2000", Risoe 29 November 2000.
15. Hansen, K.S. (2001). On_line presentation of "Database on Wind Characteristics" at the UNAM, Mexico City, April.
16. Hansen, K.S. et.al. (1999). "<http://www.winddata.com/>" 1999 European Wind Energy Conference held March 1_5 in Nice

17. Højstrup, J. et.al. (1999). "Non_Gaussian turbulence", 1999 European Wind Energy Conference held March 1_5 in Nice
18. Bierboms, W. et.al. (1999). "Modelling of Extreme gusts for design calculations", 1999 European Wind Energy Conference held March 1_5 in Nice
19. Larsen, G.C.; Hansen, K.S.; Pedersen, B.J., Constrained simulation of critical wind speed gusts by means of wavelets (poster). In: Proceedings CD_ROM. 2002 global windpower conference and exhibition, Paris (FR), 2_5 Apr 2002. (European Wind Energy Association, Brussels, 2002) 6 p.
20. Hansen, K.S.; Larsen, G.C.; Pedersen, B.J., Analysis of extreme wind shear events (poster). In: Proceedings CD_ROM. 2002 global windpower conference and exhibition, Paris (FR), 2_5 Apr 2002. (European Wind Energy Association, Brussels, 2002) 5 p.
21. Larsen, G.C.; Hansen, K.S., Statistics of offshore wind speed gusts (poster). In: Wind energy for the new millennium. Proceedings. 2001 European wind energy conference and exhibition (EWEC '01), Copenhagen (DK), 2_6 Jul 2001. Helm, P.; Zervos, A. (eds.), (WIP Renewable Energies, München, 2001) p. 753_756
22. Hansen, K.S. (2002). On_line presentation of "Database on Wind Characteristics" at the ENDOW Workshop, Risoe, Denmark, Marts 2002;
23. Hansen, K.S. (2002). Presentation of "Database on Wind Characteristics" at the WINDENG kickoff meeting, Risoe, Denmark, September 2002.

Task XVIII - Enhanced Field Rotor Aerodynamics Database

1. G. Schepers, et al: Final report of IEA ANNEX XVIII – Enhanced Field Rotor Aerodynamics Database, ECN-C-97-016, Netherlands Energy Research Foundation, 2002.
2. J. G. Petersen, et al: Prediction of Dynamic Loads and Induced Vibrations in Stall, RISO-R-1045 (EN), May 1998.
3. H. A. Madsen, et al: Field Rotor Measurements – Data sets Prepared for Analysis of Stall Hysteresis, Risø National Laboratory, RISO-R-1046 (EN), May 1998.
4. P. K. Chaviaropoulos, et al: Viscous and Aeroelastic Effects on Wind Turbine Blades, the Viscel project, proceedings of European Wind Energy Conference, EWEC pp. 347-351, Copenhagen, July 2001.
5. P. Strzelczyk: On Simple Vortex Theory of Horizontal Axis Wind Turbines, Rzeszow University of Technology, Faculty of Mechanical Engineering and Aviation, June 1998.
6. L. Bermudez, A. Velasquez, and A. Matesanz: Numerical Simulation of Unsteady Aerodynamic Effects in Horizontal Axis Wind Turbines, Journal of Solar Energy, Volume 68, 2000.
7. H. A. Madsen: Yaw Simulation Using a 3D Actuator Disc Model, proceedings of the IEA R&D Wind Program, IEA Aerodynamics Symposium, Stockholm, November 1999.
8. J. M. R. Graham and C.J. Brown: ROTOW - Investigation of the Aerodynamic Interaction between Wind Turbine Rotor Blades and the Tower and its Impact on Wind Turbine Design, Final Report, Department of Aeronautics, Imperial College of Science and Medicine, London, UK, September 2000.

Task XIX - Wind Energy in Cold Climates

1. Planned joint conference in Pyhäätunturi, Finnish Lapland, "Wind Energy Production in Cold Climates," BOREAS VI, 9-11 April 2003. The conference is co-organized with VTT.