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Wind Energy Department annual progress report 2001

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Wind Energy Department Annual Progress Report 2001

**Birthe Skrumsager, Søren E. Larsen and
Peter Hauge Madsen (Eds)**

**Risø National Laboratory, Roskilde
October 2002**

Abstract

The report describes the work of the Wind Energy Department at Risø National Laboratory in 2001. The research of the department aims to develop new opportunities in the exploitation of wind energy and to map and alleviate atmospheric aspects of environmental problems. The expertise of the department is utilised in commercial activities such as wind turbine testing and certification, training programmes, courses and consultancy services to industry, authorities and Danish and international organisations on wind energy and atmospheric environmental impact.

A summary of the department's activities in 2001 is shown, including lists of publications, lectures, committees and staff members.

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1 Introduction

The Wind Energy Department is involved with R&D within boundary layer meteorology, fluid dynamics, structural mechanics, power and control engineering as well as loads and safety for wind turbines with the aim to meet the needs for knowledge, methods and consultancy assistance in relation to wind energy. This includes technology development, manufacturing, testing, operation and maintenance, certification and export of wind turbines as well as the solution of problems in relation to the application of wind energy. Hence the overall objective is to create new possibilities for technological development and the exploitation of wind energy through research, innovation, education, testing and consultancy. The department's activities also include research and environmental issues in the atmosphere and commercial activities within consultancy, software, accredited testing of wind turbines and blades as well as approval and certification in co-operation with Det Norske Veritas.

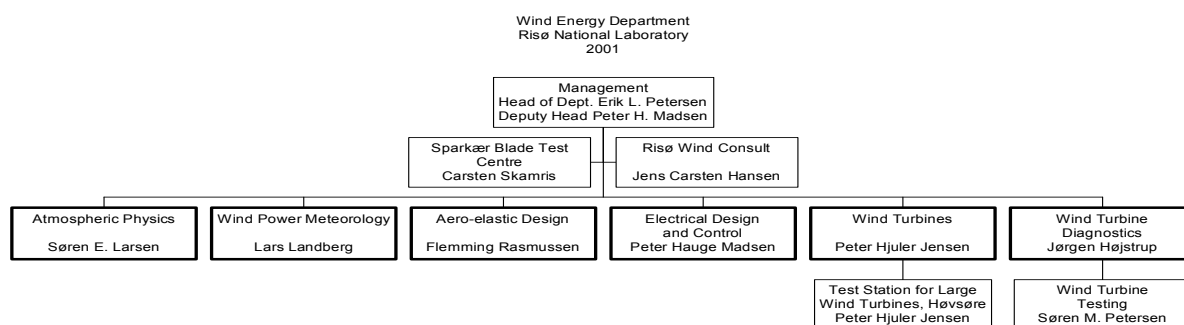
The department is organised in programmes according to its main research and technical activities.

Research programmes:

- Aeroelastic Design
- Atmospheric Physics
- Electric Design and Control
- Wind Power Meteorology
- Wind Turbines
- Wind Turbine Diagnostics

Commercial programmes:

- The Test Station for Large Wind Turbines, Høvsøre
- Risø WindConsult
- Wind Turbine Testing
- Sparkær Blade Test Centre



The “Aeroelastic Design” programme involves the key issue development and use of aeroelastic codes, computational fluid dynamics (CFD) codes and design tools for wind turbine blades and airfoils as well as wind tunnel measurements of airfoil section flows. The codes are used for establishment of design load

basis for wind turbines, further development of the three-bladed wind turbine concept and development of new wind turbine concepts.

In the "Atmospheric Physics Programme" basic research into boundary-layer meteorology and atmospheric turbulence is carried out. In addition we study environmental problems related to transport of air-borne pollutants and turbulent exchange of matter in the interaction between the atmosphere and terrestrial or sea surfaces.

The programme "Electrical Design and Control" aims to lower the cost of wind energy by optimising the wind turbine as well as the grid interface and operation of the power system. The research involves topics such as control concepts for wind turbines; electrical components; grid connection and large-scale wind energy penetration; hybrid power supply systems and energy storage Combined with renewable energy sources.

The "Wind Power Meteorology" programme is aimed at assessments of wind resources for power production and wind loads on wind turbines and other constructions. The programme comprises development of models and software, field measurements and in-house as well as commissioned assessment studies.

The "Wind Turbine" programme conducts strategic and applied research in load and safety, experimental verification, technical/economical analysis of wind energy's utilisation in grids and in hybrid energy systems. Our research within this program supports our consultancy activities for Danish and international authorities, organisations, banks and investors regarding wind energy projects. It also supports our participation in international standardisation.

The "Wind Turbine Diagnostics" programme conducts research to develop methods for experimental determination of wind turbine characteristics, including test methods aimed for use by the wind turbine industry. Furthermore the programme serves as a departmental expert in organising and conducting field meteorological measurements, providing instruments, data systems, data management and organisation.

The objective of the commercial programme "The Test Station for Large Wind Turbines, Høvsøre" is to establish a test facility for large wind turbines near the west coast of Jutland in an area with the best possible conditions with respect to high wind speeds and reproducible wind conditions (flat terrain) in order to verify both the performance and the wind-turbine design basis for all wind conditions in relation to large wind turbines.

The commercial programme "Risø WindConsult" aims to utilise the knowledge and state of the art tools available at Risø to provide consulting and technical advice concerning international projects on the development and application of wind power technology.

The commercial programme "Wind TurbineTesting" offers its expertise in measuring techniques for wind turbine testing at Risø and from field measurements.

The commercial programme "Sparkær Blade Test Centre" is accredited for static and dynamic fatigue test of wind turbine blades and it is offering this to Danish blade producers at the test centre in Sparkær. By the end of 2001 the

Sparkær Centre is able to test blades with a length of up to 60m, both statically and dynamically.

In 2001 the department engaged 114 man-years, 7 of which involved PhD students and post-doctoral researchers. The departmental structure by the end of 2001 is illustrated in the block diagram below.

This annual report presents the department and the results in 2001, including the programmes and services, research highlights and other achievements. The report also presents lists of publications, lectures, committees and staff members.

Additional information on the department and its activities can be found on World Wide Web (WWW) on the address <http://www.risoe.dk/amv/>. The department's web pages are constantly updated.

2 Status 2001 for the Department

In November 2000, Risø's Board of Governors adopted a new strategy for a renewed Risø without nuclear facilities following the definite closure of the DR3 research reactor in September 2000. According to the strategy, Risø's mission is to promote an innovative and environmentally sustainable technological development within the areas of energy, industrial technology and bio-production through research, innovation and advisory services. The clients come from industry, research centres and Danish authorities. One of the key priorities is to strengthen the research in wind energy, using national and international alliances to ensure that we remain the world leading authority in this area.

The Wind Energy Department is responsible for the main effort in Risø's programme area of wind energy. In wind energy, our aim is to develop cost-effective and reliable wind turbines and to reduce the uncertainty related to the use of wind power.

The main objectives are:

- A globally applicable tool for modelling and predicting wind resources, based on the integration of micro- and meso-scale meteorological models with global databases
- A next-generation numerical wind tunnel that integrates computational fluid dynamics (CFD), dynamic models for the design of wind turbines, and systems for visualising and interpreting test results
- A design basis for multi-megawatt offshore wind turbines based on a complete statistical description of wind, waves and ice
- Test facilities and methods for megawatt-scale wind turbines and turbine components.

Hence, year 2001 was the first year, where the department operated according to the new strategy. In addition, an international evaluation of Risø and the department was carried out in 2001 as the follow-up of the second four-year performance contract with the Ministry of Information Technology and Research, signed in 1997.

Table 2.1. Important milestones for each of the individual scientific programmes in the department for 2001, also presented is the follow-up evaluation of the milestones as carried out in connection with the international evaluation of Risø and the department.

Department milestones for 2001		
Programme objectives	Important milestones for 2001	Follow-up
Atmospheric Physics To contribute with new knowledge of boundary layer meteorology, climatology and atmospheric turbulence with respect to exploitation of wind energy and a description of the transport of airborne substances	International presentation of the Risø concept for Soil-Vegetation-Atmospheric-Transfer (SVAT) modelling	Risø's SVAT concept is presented at national and international conferences and published in international journals. The concept explains why previous SVAT modelling often failed
Wind Power Meteorology To contribute with new knowledge on wind climatology, atmospheric flow and turbulence as a basis for development and application of methods and models to predict wind resources as well as wind loads on wind turbines and structures in all kinds of natural terrain.	The Wind Atlas Analysis and Application Program (WASP) Engineering is completed and launched	The program was launched at the European Wind Energy Conference in Copenhagen. More than 30 users, first course held (12 participants)
Aeroelastic Design To develop new knowledge and models within aerodynamics, structural dynamics, aeroelasticity and design loads for application in design and optimisation, description of design basis and analysis of existing and new wind turbine concepts.	An aeroelastic model with detailed nacelle dynamics	Dynamic model developed for suspension of main shaft with gear function. The model is used to describe the gearbox part (planetary stage) of the wind-turbine dynamic system
Electric Design and Control To contribute with new knowledge and computational models for analysis and development of wind turbines with respect to electric and control characteristics as well as grid integration to increase their value with respect to energy production and capacity value	Establishment of framework to develop a simulation platform for electric design and control of wind turbines in collaboration with the Danish wind turbine enterprises	Establishment of framework in collaboration with the Danish wind-turbine enterprises to develop a simulation platform for electric design and control as well as grid/system integration of wind turbines. The models will be implemented at the program platforms DigSILENT, HAWC, Matlab/Simulink and Saber
Wind Turbines To develop new knowledge and methods to verify load and safety for wind turbines; develop new opportunities within structural design, technical and economical application and opportunities with regard to electric grids and hybrid energy systems	Development of a revised design basis for offshore wind turbines	In collaboration with wind-turbine manufacturers and the utilities a research based design basis for offshore wind turbines has been drawn up. The design basis has been incorporated in Recommendation for Off-shore Wind Turbines (December 2001) and used as principal instrument in international standard-insertion for design of offshore wind turbines
Wind Turbine Diagnostics Through a long-term and strategic research effort to develop methods for experimental determination of wind-turbine characteristics as well as meteorological measurements including testing methods for industrial application and communication of results to the wind-turbine industry	Verification of the site-calibration method for power performance measurements in complex terrain	The results illustrate that the atmospheric stability (heating/cooling of the surface of the earth) has a great influence on the site calibration and power-curve measurements. There is international agreement that the existing standards now need to be modified accordingly

The department's achievements in 2001 have been quite satisfactory, the growth has continued, and all the research programmes have achieved significant scientific and technical results, as illustrated by the table above, which shows the objectives, a primary milestone and the follow-up for the programmes in 2001.

2.1 Social and industrial relevance in Denmark and abroad

Global wind generating capacity increased by some 6800 MW in 2001, an annual growth of just over half the corresponding figure for 2000. The year of 2001 was the third consecutive year in which new wind power capacity exceeded new nuclear power capacity, showing the maturity of wind power technology. Total installed wind power worldwide by the end of 2001 was close to 25,000 MW. Europe leads the world in both the technology and the application of wind power. Germany, Spain and Denmark are the main players, accounting for 56% of the world's capacity increase in 2001 and a total cumulative installed capacity of 14,750 MW, or 59% of the global total.

USA and India are also significant users of wind power; in 2001 the USA added 1700 MW of new installed capacity to become the world's second largest market for wind power. The tax credit known as PTC, which is an important incentive for US investment in wind power, was extended for two years. A number of other countries including Japan and France are now starting to invest in wind power.

In 2001 world market shares for the manufacture of wind turbines were: Denmark about 45%, Germany about 24%, Spain about 12% and USA about 13%. The world's largest wind turbine manufacturer is the Danish company Vestas, which markets a pitch-regulated machine with a standard gearbox drive train. In 2001 Enercon, a Germany company, became the second largest supplier, pushing the Danish company NEG-Micon into third place. Enercon produces a gearless machine with a direct-driven multi-pole generator. In 2001 the Danish wind turbine industry, including sub-suppliers, employed an estimated 20,000 people.

Since the beginning of the 1980's Denmark's continuous support of wind energy had produced an installed wind energy capacity of approximately 2500 MW by the end of 2001. In a year with average wind conditions, wind energy covers almost 17% of Denmark's electricity demand. Land-based wind turbines are still cheapest, but wind conditions at sea are considerably better. Offshore wind farms are therefore expected to become competitive in step with the development of suitable technology, expanding within a few years to 6–8% of the world wind power market from less than 1% today.

Denmark has had a wind energy research environment at Risø for more than 20 years and today Risø is the largest wind energy R&D centre in the world. In recent years, efforts have been boosted through expansion in terms of resources, while R&D activities have been developed in an increasingly specialised, dedicated and long-term direction. This is in order to contribute to the technological development while continuing to create new opportunities for the thriving and growing development departments of the wind turbine industry.

As a result of its special competence in atmospheric physics, the department has continued its efforts within atmospheric dispersion of substances as diversified as nuclear material, foot and mouth disease and manure spreading. Work has also continued on the exchange of trace substances, especially CO₂, between the atmosphere and terrestrial and oceanic ecosystems.

2.2 International evaluation

According to the four-year performance contract between Risø National Laboratory and the Ministry of Information Technology and Research an international evaluation of Risø including the department of wind energy was carried out in 2001. In total, the evaluation panel found that the goals set in the contract have by and large been met and that the research at Risø has a high international scientific value and that the activities are very relevant for the industry and for the society as a whole.

The following assessments and recommendations regarding the Wind Energy Department are presented in the report from the evaluation panel.

Assessment

The Wind Energy Department is today a very strong independent partner for the successful Danish wind power industry (manufacturers and power companies), and Risø deserves much credit for the success of this industry. Risø - incl. the testing facility at Høvsøre - has the potential to become a strong wind energy centre, provided that co-operation is established with expertise from other institutions e.g. in the field of wind tunnel simulations.

The panel found it very impressive how the department is able to cover the gap between basic and applied research, while maintaining a high quality in its work. The software work seems very relevant and may be one way of approaching industry (by selling and implementing these tools in the industry).

The work on meteorology is increasingly focused on areas of relevance for wind energy, and the wind atlases produced are widely used internationally. Also the testing and certification of wind turbines is an important activity.

Recommendations

This department could be a growth point at Risø, considering the rapid growth of this industry in Denmark and the large potential on the international market. It seems like the department's attitude towards the industry is too academic. They should be more pro-active towards the industry and also focus on the short-term needs of the industry, thus becoming a more customer-driven group. Increased exchange of personnel with industry is important in this connection. However, it is important also that the independent role of Risø's Wind Energy Department is secured. In future co-operations, Risø must be able to help the sector as a whole when it comes to solving long term problems as well as problems of shorter term nature. This demands that Risø continuously develops expertise, not only financed by consulting services or projects supported from research funds but also through Risø's own funding.

It should be considered how the co-operation with Aalborg University and DTU could be expanded with regard to the education of future engineers and PhD's.

The department holds a leading position in the wind energy research area, at a global level. In order to ensure that this position is maintained, an overall wind energy strategy should be developed, covering the whole range of subjects within the sector and including basic and applied research, technological development, education, training of various key staff categories, co-operation with industry, and market development.

The strategy should be formulated in co-operation between Risø, universities, industry, and government representatives. It could ensure the leading position of the department as well as the leading position of the industry in the wind energy market, and contribute to reducing Denmark's CO₂ emission in accordance with the targets of EU and the Kyoto agreement.

2.3 Collaboration with universities

The department is engaged in extensive collaboration with the Department of Energy Engineering at the Technical University of Denmark; this has been formalised in a framework agreement on strategic collaboration on numerical fluid mechanics. The agreement covers collaboration on research, joint development and exchange of software, collaboration on the Education of scientists and joint positions at the Technical University of Denmark and Risø.

In collaboration with the Department of Energy Technology at Aalborg University, the department has a strategic alliance on the development of the *Elektrisk Design og Styring* (Electrical Design and Control) programme, collaborative research within the programme area, development and exchange of software, collaboration on education and joint positions at Aalborg University and Risø.

Through an adjunct professorship (an appointment made in 1999) the department undertakes teaching assignment in Denmark on boundary layer meteorology at the Department of Geophysics, Niels Bohr Institute, the University of Copenhagen. Together with the Institute of Geography, the University of Copenhagen, the department works on the application of satellite data and other types of remote sensing in connection with meteorological and climatological problems.

2.4 Collaboration with other governmental research institutions

Collaboration between the department and the National Environmental Research Institute of Denmark (NERI) mainly relates to the Department of Atmospheric Environment and the Department of Marine Ecology and Microbiology at the National Environmental Research Institute of Denmark. Underlying the work is a common strategy, but increased joint project work is equally important, with the expertise of the National Environmental Research Institute of Denmark and the department being mutually complementary in a number of problem areas. Particularly this applies to the atmospheric exchange of pollutants with various ecosystems. Other governmental research institutions such as

the Danish Institute of Agricultural Sciences and the Danish Forest and Landscape Research Institute are also involved in this work.

The department has been engaged in collaboration with the Danish Meteorological Institute (DMI) for many years. In recent years, this work has reached a deeper level and a larger degree of focus through a number of joint projects in which the collaboration has typically involved dedicated use of meteorological fields supplied by the Danish Meteorological Institute's weather forecasting model. Its applications are typically 36-hour forecasts of wind turbine parks' production or the dispersion of long-distance airborne pollution from major accidents.

The department has intensified collaboration with the Danish Hydraulic Institute (DHI), where there are plans to replace a collaborative project work, which has been going on for many years, on the effects of waves and wind on constructions. Actual centre collaboration focusing on marine-based wind turbine parks in Denmark and abroad will succeed the project.

The department is part of Solar Energy Centre Denmark, operated by the Danish Technological Institute, the Technical University of Denmark, the Danish Building Research Institute (SBI) and Risø.

2.5 The Danish Research Consortia for Wind Energy

In line with the international evaluation panels recommendations, Risø and the department has taken an initiative to establish a national consortium for research and education of researchers in the wind energy field. The consortium in the form of a structured, formalised network, has four partners:

- Risø National Laboratory, a national laboratory under the Ministry of Research and Information Technology, with its own board of governors. The major part of the wind energy R&D takes place in Wind Energy Department, which has six research programmes: Atmospheric Physics, Wind Power Meteorology; Aeroelastic Design; Wind Turbines; Electric Design and Control, and Wind Turbine Diagnostics. In addition the department performs commercial and technical support services such as blade testing at the centre at Sparkær, wind turbine testing in the field and international consulting on wind energy. The System Analysis Department is involved in wind energy through their programs energy systems analysis, energy, environment and development planning, UNEP Centre, safety, reliability and human factors and technology scenarios, while the Materials Department does research on materials for wind turbines, in particular composites.
- Aalborg University (AAU) was inaugurated in 1974 as the fifth Danish university with now more than 12,000 registered students. The Institute of Energy Technology, Institute of Mechanical Engineering, Department of Civil Engineering and the Department of Development and Planning under the Faculty of Engineering and Science carry out research within the field of wind energy. The wind energy research comprises power electronics and generators, grid integration, energy system analysis and socio-economic evaluations as well as wind turbine structures and foundations, fluid dynamics and materials.

- The Technical University of Denmark (DTU) is a self-governing national university with about 5000 students and a permanent scientific staff of about 450. Research within the field of wind energy is at DTU focussed on aerodynamics and aero-elasticity (Section of Fluid Mechanics, Department of Mechanical Engineering), stochastic modelling (Department of Informatics and Mathematical Modelling) and power electronics (Department of Electric Power Engineering).
- DHI Water & Environment is an independent, self-governing research and consultancy organisation affiliated to the Danish Academy of Technical Sciences. Fields related to offshore wind are: Offshore structures and pipelines, Ports and coastal structures, Coastal hydraulics, Water environment and ecology, Coastal zone management, Environmental impact assessment, Laboratory services, Institutional capacity building and training, Water and environment informatics.

These partners comprise only a subset of organisations, institutes and industries in the field, and while the partners supplement each other in scientific competencies, tasks and networks, the intention is to strengthen collaboration with others outside the consortium.

During 2001 the partners have conducted workshops, mapped scientific expertise and developed plans for research and collaboration on education and training. It is expected that the formal agreement will be signed early 2002.

3 Summary of the Performances, Research Programmes and Tasks

The following one-page tables summarise the objectives and performance of the department and its research programmes and operational tasks.

The objectives of each unit are specified in terms of basic objectives, mid-term goals spanning several years and milestones for the specific year of the report, here 2001. The milestones are divided into milestones referring to different research projects and milestones referring to initiatives aimed at industry. The end of 2000 specified these milestones; furthermore the tables include a follow-up column, indicating to what extent the 2001 milestones has actually been achieved during the year.

Results 2001

Wind Energy Department

<u>Programme area</u> Wind Energy	<u>Abbr.:</u> VEA	<u>Head</u> Erik Lundtang Petersen	
<u>Departmental profile</u> <p>The Wind Energy Department is involved with R&D within boundary layer meteorology, fluid dynamics, structural mechanics, power and control engineering as well as loads and safety for wind turbines with the aim to meet the needs for knowledge, methods and consultancy assistance in relation to wind energy. This includes technology development, manufacturing, testing, operation and maintenance, certification and export of wind turbines as well as the solution of problems in relation to the application of wind energy. Hence the overall objective is to create new possibilities for technological development and the exploitation of wind energy through research, innovation, education, testing and consultancy. The department's activities also include research and environmental issues in the atmosphere and commercial activities within consultancy, software, accredited testing of wind turbines and blades as well as approval and certification in co-operation with Det Norske Veritas.</p>			
<u>Objective of the programme area</u> <p>To create opportunities for technological development and application of wind energy through research, innovation, education, testing and consultancy</p>			
<u>Programmes / tasks and important 2001 milestones</u> <p>Research programmes:</p> <ul style="list-style-type: none"> • Aeroelastic Design (AED) • Atmospheric physics (ATM) • Electric design & control (EDS) • Wind Power Meteorology (VKM) • Wind Turbines (VIM) • Wind Turbine Diagnostics (VMD) <p>Commercial programmes:</p> <ul style="list-style-type: none"> • The Test Station for Large Wind Turbines, Høvsøre (HØV) • Risø WindConsult (INR) • Wind Turbine Testing (PRV) • Sparkær Blade Test Centre (SPK) <p><u>Important 2001 milestones for the research programmes:</u></p> <ul style="list-style-type: none"> • Detailed nacelle dynamics in an aeroelastic model (AED) • International presentation of the Risø concept for Soil-Vegetation-Atmospheric-Transfer (SVAT) Modelling (ATM) • Establishment of framework to develop a simulation platform for electric design and control of wind turbines in collaboration with the Danish wind turbine enterprises (EDS) • WAsP Engineering: the programme is ready for presentation at the international wind energy conference in Copenhagen (VKM) • Development of a research based design basis for offshore wind turbines (VIM) • Verification of the site-calibration method for power performance measurements in complex terrain. Comparison of accuracy with respect to site calibration and modelling respectively 			
<u>Milestones 2001 for management, environment, safety, human resource development and external relations</u> <ul style="list-style-type: none"> • Planning and establishment of the wind energy centre at Risø • Preparing the integration of the department in the new wind energy centre • Education of new employees with regard to safety measures (fire preparedness, life-saving precautions in connection with work in masts etc.) • Action plan regarding new initiatives to improve the working conditions in the department • Further development of the departmental administration • Wind turbine testing at Høvsøre contracted with the wind-turbine industry • Invitation to authorities, the energy sector and the industry to participate in the research planning • Intensification of the collaboration with universities 			

Results 2001

Research programme

<u>Name of programme</u>	<u>Abbr.:</u>	<u>Head</u>	Department
Aeroelastic Design	AED	Flemming Rasmussen	VEA
<u>Objective</u> To develop new knowledge and models within aerodynamics, structural dynamics, aero-elasticity and design loads for application in design and optimisation, description of design basis and analysis of existing and new wind turbine concepts.			
<u>Mid-term goals</u> Through a long-term strategic and applied research and development in the fields of experimental and numerical aerodynamics as well as aero-acoustics (OFD and CAA), structural dynamics, aeroelasticity, stability and design basis to develop: <div>1. An analytical and numerical tool "the numerical wind tunnel" for aeroelastic design and optimisation of wind turbines as well as an experimental wind tunnel facility for verification; 2. An aeroelastic design tool to simulate detailed response and stability for flexible MW wind turbines with control; 3. A design complex for development of already existing as well as new concepts.</div>			
<u>Milestones for 2001 with reference to mid-term goals</u> Design of an airfoil series optimised for offshore wind turbines Guidelines for optimised blade dynamics An aeroelastic model with detailed nacelle dynamics Design tool for determination of dynamic stability Verified method to determine aerodynamic and structural damping under operation.			Follow-up: OK OK OK (Delayed) OK
<u>Initiatives towards industry with milestones for 2001</u> Publication of an airfoil catalogue Implementation of upgraded version of the aeroelastic code, HawC, in the wind turbine industry Test of a full-scale blade with Risø A1 airfoils Regular visits to manufacturers to discuss research topics and development projects			OK OK OK OK
<u>Important core customers (max 10) and other collaborators</u> <div>• Vestas Wind Systems A/S • Bonus Energy A/S • NEG-Micon A/S • LM-Glasfiber A/S • Technical University of Denmark • Det Norske Veritas • Netherlands Energy Resource Foundation (ECN) • National Renewable Energy Laboratory (NREL, USA) • Centre for Renewable Energy Sources (CRES, Greece)</div>			OK OK OK OK OK OK OK OK OK

Results 2001

Research programme

Name of programme Atmospheric Physics	Abbr. ATM	Head Søren E. Larsen	Department VEA
Objective To contribute with new knowledge of boundary-layer meteorology, climatology and atmospheric turbulence with respect to exploitation of wind energy and a description of the transport of airborne substances			
Mid-term goals Through a long-term theoretical and experimental research effort within boundary-layer meteorology, turbulence and climatology to: <ol style="list-style-type: none"> 1. develop measuring principles and models to study the atmospheric boundary layer with reference to wind energy and environmental problems; 2. develop, validate and apply atmospheric dispersion models; 3. develop a boundary-layer meteorological description of the near-shore area including wind, waves, roughness and thermal c conditions with reference to wind power, wind load and exchange 			
Milestones for 2001 with reference to mid-term goals Basic research <ul style="list-style-type: none"> • First version of LINCOM-Coast (model) • Integration of Risø's dispersion models and the NERI prognosis model • Feasibility of Risø's LIDAR as wind lidar evaluation • Publication of the Risø concept for SVAT (Soil-Vegetation-Atmosphere Transfer) models Joint research financing <ul style="list-style-type: none"> • Integration of Risø's aggregation in the DMI HIRLAM model (Danish Meteorological Institute) • Up-scaling validation of stress and heat point measurements for satellite footprints • Further development of Risø's concept for integrated SVAT models • Experimental assessment of the boundary-layer height above Christiansø (large Baltic Sea project, BALTEX) • Publication of the method and results of air-sea flux of CO₂ for inhomogeneous fields • Publication of papers on sea roughness and wave fields • Conclusion of project on development and test of an autonomous air-sea flux package, AutoFlux • Completion and reporting of project concerning AR41 gamma dispersion measuring from Risø reactor DR3 • Completion and reporting of odour project "Pigs in Space" • Up-grading of Ulborg CO₂ forest measuring station to EUROFLUX standard in co-operation with Botanical Institute (University of Copenhagen) and Danish Natural Science Research Council (SNS) • Publication of data for salt-particle deposition to sea surfaces Commercial research <ul style="list-style-type: none"> • Data analyses delivered to A/S Sund & Bælt 			Follow-up: OK (can be applied to WASP and ARGOS model systems) OK (Postponed till 2002) OK OK OK OK OK (OK, 1 of 3) (Postponed till 2002) OK Experiment in Belgium – reporting in 2002 OK OK (Postponed) OK - project completed
Initiatives towards industry with milestones for 2001 <ul style="list-style-type: none"> • Start of project in co-operation with industry and ATV institute concerning a world database for erection of offshore wind farms. Milestone: project application is prepared • Extended co-operation with Danish Bacon & Meat Council. Milestone: demonstration of Animal Farm RIMPUFF module 			(Postponed) OK – continued
Most important core customers (max 10) and other collaborators EC DG 12 (Renewable energy, radiation protection, climate & ecosystems, industrial hazards, marine systems) Danish research councils: Danish Natural Science Research Council (SNF); Nordic Council of Ministers (NMR); Danish Emergency Management Agency; International Atomic Energy Agency (IAEA); National Forest and Nature Agency (FSL); The Agricultural Council of Denmark Collaborators National Environmental Research Institute; Danish Meteorological Institute; Danish Forest and Landscape Research Institute; Danish Hydraulic Institute; FORCE Technology; University of Copenhagen; University of Odense; Danish Technical University; Royal Veterinary and Agricultural University; MetSupport ApS; Gill Instruments Ltd.; Danish Bacon & Meat Council; Several foreign research institutions and universities			OK OK

Results 2001

Research programme

<u>Name of programme</u> Electric Design and Control	<u>Abbr.:</u> EDS	<u>Head</u> Peter Hauge Madsen		<u>Depart- ment</u> VEA
<u>Objective</u> To contribute with new knowledge and computational models for analysis and development of wind turbines with respect to electric and control characteristics as well as grid integration. The aim is to develop new control methods and principles, to optimise the application of electrical machines and power electronics and to improve the wind turbine influence on power quality. Finally, to develop concepts and methods for the electrical integration of wind turbines in centralised and decentralised power systems to increase their value with respect to energy production and capacity value				
<u>Mid-term goals</u> In co-operation with Aalborg University, through a long-term strategic and applied research and development effort directed towards control principles for the operation and application of wind turbines, their electromechanical components and integration in power systems, to <ol style="list-style-type: none"> 1. develop new control concepts for optimisation of wind turbine loads, production and power quality; 2. assess and test possible applications of alternative electromechanical components for wind turbines including new advanced generators and power electronics; 3. develop methods and concepts for electrical integration of large shares of renewable energy, especially wind energy, in centralised and decentralised energy systems. 				
<u>Milestones for 2001 with reference to mid-term goals</u> Basic research <ul style="list-style-type: none"> • A summer school together with Institute of Energy Technology (IET), University of Aalborg (AAU) (1,2,3) • Research professor at IET, AAU within electrical wind turbine technology supported by Vestas Wind Systems (1,2,3) • New PhD study on control and application of power electronics in large wind farms (1,3) Programme research <ul style="list-style-type: none"> • Establishment of a project in collaboration with wind-turbine manufacturer to develop a more sturdy and comprehensive monitoring of offshore wind turbines in operation (Vestas Wind Systems) (1) • Establishment of framework to develop a simulation platform for electric design and control of wind turbines in collaboration with the Danish wind turbine enterprises (1,2) • Development and verification of a model to simulate stability and power quality in wind power utilities (1,3) • Design basis for a wind turbine with active control to reduce the mechanical and electric loads of the wind turbine as well as the electric grid (in collaboration with the AED Programme (1,2,3)) • Benchmark of wind turbine/grid simulation tools in collaboration with the power utilities (3) 			<u>Follow-up:</u> (recruitment trouble) OK OK (industrial PhD) OK OK OK (project to commence in 2002) (project started)	
<u>Initiatives towards industry with milestones for 2001</u> <ul style="list-style-type: none"> • Visits to manufacturers to discuss research topics, joint activities and research/development projects (F&U) • Industry course on electric design and control of wind turbines • Seminar for wind turbine manufacturers on the subject of power simulation of wind farms 			OK OK -	
<u>Important core customers (max 10) and other collaborators</u> Core customers Wind turbine and control system manufacturers (Vestas Wind Systems A/S; NEG-Micon A/S; Bonus Energy A/S; MITA; Dan-control etc.) Elkraft System; ELTRA; Danish Energy Agency Collaborators Wind turbine and control system manufacturers; University of Aalborg (AAU); Technical University of Denmark; ELSAM			OK OK OK	

Results 2001

Research programme

Name of programme	Abbr.:	Head	Department
Wind Power Meteorology	VKM	Lars Landberg	VEA
Objective To contribute with new knowledge on wind climatology, atmospheric flow and turbulence as a basis for development and application of methods and models to predict wind resources as well as wind loads on wind turbines and structures in all kinds of natural terrain.			
Mid-term goals Through a long-term research effort within wind climatology and atmospheric flow on meso- and micro scale to <ol style="list-style-type: none"> 1. further develop models and to extend the area of geographical application of the wind-atlas method for wind resource studies 2. further develop models for short-term prediction of wind farm production 3. develop and combine the wind-atlas method and models for atmospheric turbulence and extreme events with regard to wind load calculations and an estimation of extreme wind conditions in natural terrain 4. develop models for offshore wind flow including resources and extreme wind loads and to support these models by measurements 			
Milestones for 2001 with reference to mid-term goals Basic research First model ideas for a new flow model for WAsP (1) Programme research <ul style="list-style-type: none"> • Project "the new WAsP" commenced (1) • Analysis of the first countries in "The Global Wind Atlas" (1) • CleverFarm: First version implemented in a Danish wind farm (2) • Egypt: The Wind Atlas for Gulf of Suez updated and published (1) • The KAMM/WAsP method fully developed and reported (1) • The WAsP Engineering programme is ready for presentation at the wind energy conference in Copenhagen (3) • WEMSAR: Verification of satellite based off- and near-shore wind measurements (4) • ENDOW: Sketch for a new wake model for large off-shore wind farms (4) • POWER: Offshore discontinuity model for wind profiles fully developed and compared with WAsP (4) Commercial <ul style="list-style-type: none"> • WAsP version 8 launched (incl. tool for rapport generation) (1) • Set-up of web-site for meso-scale modelling and a further commercialisation of the concept (1) • Start and a first prognosis on short-term projects in the United States, Spain and Ireland (2) • Wind-resource analyses of the first large offshore wind farms in Denmark (4) • Second opinion studies on- and offshore are continuing or the activities are being increased (1 & 4) 			Follow-up OK OK (contract obtained) OK OK OK OK OK (delayed, framework) OK (Delayed) OK OK OK OK
Initiatives towards industry with mile stones for 2001 The wind energy industry, i.e. the wind turbine manufacturers and the power utilities are continuously briefed about WAsP, short-term prediction, WAsP Engineering and offshore wind resources. The information exchange occurs mainly through industry involvements in projects but also through information days and visits <ul style="list-style-type: none"> • WAsP courses • WAsP visits to the wind-energy industry • Publication of WAsP News Letters and e-mails tailored to meet WAsP users (i.e. manufacturers, wind-farm developers, etc.) Requirements describing new research results on WAsP and WAsP utilities • www.wasp.dk is used for frequent communication with the WAsP user group, marketing and sale of WAsP • www.prediktor.dk is used for marketing and sale to power utilities • www.cleverfarm.com is used mainly for marketing to wind-farm operators • 			OK OK OK OK OK OK
Important core customers (max. 10) and other collaborators SEAS, Elkraft, ELSAM, ELTRA, EPRI, the wind-turbine industry in general, Danish Energy Agency, the EFP research programme, DANIDA			OK
Follow-up First certification exam held for WAsP users			

Results

Research programme

<u>Name of programme</u> Wind Turbines	<u>Abbr.:</u> VIM	<u>Head</u> Peter Hjuler Jensen		<u>Depart- ment</u> VEA
<u>Objective</u> To develop new knowledge and methods to verify load and safety for wind turbines; develop new opportunities within structural design, technical and economical application and opportunities with regard to electric grids and hybrid energy systems.				
<u>Mid-term goals</u> 1. <i>Load and safety:</i> to establish a rational and empirical basis for a reliable and economic design of wind turbines with models based on probability theory 2. <i>Structural design:</i> to develop methods for modelling and optimal structural design of wind-turbine components including development of new testing methods for blades 3. <i>Wind power implementation:</i> to develop methods for verification of the technical/economical risks in wind-turbine projects; to verify the output of a wind turbine and to develop methods illustrating the technical/economical application and opportunities in relation to the electric grid and hybrid energy systems.				
<u>Milestones for 2001 with reference to mid-term goals</u> <ul style="list-style-type: none">• Development and testing of a laser instrument to measure wind-turbine power curves (together with Optics and Fluid Mechanics Dept.) (2)• Approval of Risø park turbulence model in Danish Approval Scheme for Wind Turbines and Danish Standard IEC 61400-1 (1)• Establishment of an expert group on load and safety analyses (1)• Development of a revised design basis for offshore wind turbines (1) • Implementation of IEC standards of certification and safety in the Danish Approval Scheme for Wind Turbines				<u>Follow-up</u> OK (OK) OK OK (English translation) (Ongoing)
<u>Initiatives towards industry with milestones for 2001</u> <ul style="list-style-type: none">• Publication of recommendation for design and approval of gear boxes (4) • Publication of a recommendation for blades (4)				(OK, 2 of 5, to be completed in 2002) OK
<u>Important core customers (max. 10) and other collaborators</u> Danish Energy Agency Det Norske Veritas (DNV) NEG-Micon A/S Bonus Energy A/S Vestas Wind Systems A/S ECN, Holland Germanischer Lloyd				OK OK OK OK OK OK OK

Results

Research programme

<u>Name of programme</u>	<u>Abbr.:</u>	<u>Head</u>	<u>Department</u>	
Wind Turbine Diagnostics	VMD	Jørgen Højstrup	VEA	
<u>Objective</u> Through a long-term and strategic research effort to develop methods for experimental determination of wind-turbine characteristics as well as meteorological measurements including testing methods for industrial application and communication of results to the wind-turbine industry				
<u>Mid-term goals</u> Development of experimental methods to define: 1. performance and its interaction with the energy system 2. loads, dynamics and stability 3. aerodynamic flow conditions on full-scale wind-turbine rotors 4. development and implementation of hardware and software for measuring and data management systems 5. meteorological and chemical processes and characteristics in the atmosphere				
<u>Milestones for 2001 with reference to mid-term goals</u> Basic research <ul style="list-style-type: none">• Verification of flow conditions including site calibration of a new test station in Western Jutland (1,2)• Strategy for verification of the flow on a full-scale rotor (3) Programme research <ul style="list-style-type: none">• Design of an optimised cup anemometer to meet the demands for the high accuracy required by wind energy measurements (1)• Modal analysis project to define modal shapes of a 40m blade (2)• Final verification results of the site calibration method for power performance measurements in complex terrain. The accuracy of the site calibration method compared to that of modelling (1)• Measurements of gearbox dynamics (2).• Measurements of offshore foundation loads (2)• Modelling and measurements of loads on wind turbines placed close to each other (2)• Completion of front-end data transmission unit for measuring projects (4,5)• Implementation of a new generation of software for data sampling (5)			<u>Follow-up</u> (postponed till 2002 - due to delay of Høvsøre) - OK OK OK OK OK OK OK OK OK (postponed till 2002)	
<u>Initiatives towards industry with milestones for 2001</u> <ul style="list-style-type: none">• Improved information communication of results to the industry through deployment of Risø employees and continuing education of engineers with manufacturers. Phase 1, planning and agreements• Documentation of test station in Western Jutland with respect to wind resources at the premises and the expected accuracy of the site measurements.				
<u>Important core customers (max 10) and other collaborators</u> Core customers NEG-Micon A/S, Vestas Wind Systems A/S, Bonus Energy, LM Glasfiber A/S, other wind-turbine manufacturers Collaborators Manufacturers, Utilities				

Results 2001

Commercial programme

<u>Name of programme</u> Test Station for Large Wind Turbines, Høvsøre	<u>Abbr.:</u> HØV	<u>Head</u> Peter Hjuler Jensen	<u>Department</u> VEA
<u>Objective</u> Establishment of a new test station at Høvsøre.			
<u>User funded services; users and service goals</u> Establishment of a meteorology mast			
<u>User paid services and users</u> Letting out of test beds for wind-turbine testing Implementation of wind-turbine testing at the test beds Users NEG-Micon A/S; Vestas Wind Systems A/S; Bonus Energy A/S; Nordex Energy GmbH and other wind-turbine manufacturers			<u>Follow-up:</u> - - OK - - -
<u>Milestones for 2001</u> • Establishment of a test station with showroom • Start testing of four wind turbines • Establishment and instrumentation of a meteorology mast			

Results

Commercial programme

<u>Name of programme</u>	<u>Abbr.: INR</u>	<u>Head</u>	<u>Department</u>
Risø WindConsult	INR	Jens Carsten Hansen	VEA
<u>Objective</u>			
The objective is to develop new opportunities for international consultancy in support of the wind power industry and international wind power development and in collaboration with relevant Danish and international parties to become an important party within international consultancy			
<u>User funded services, users and service goals</u>			
1. To contribute to the development of wind-power technology and its application to the energy supply of the future 2. To emphasize and contribute to creating attention to and export of sustainable Danish energy, supply technology and products 3. To participate in the development and implementation of projects and programmes on application of wind power interaction with a broad spectrum of energy systems world-wide 4. To develop methods and tools to analyse and undertake wind-power projects and wind-power plants 5. To reinforce the collaboration with other parties within consultancy to constitute a Danish centre of knowledge and consultancy within wind-power technology			
<u>User paid services and users</u>			<u>Follow-up</u>
Consultancy <ul style="list-style-type: none"> • Feasibility studies • Second opinion assessments/due diligence • Institutions/capacity building • Courses Clients <ul style="list-style-type: none"> • DANIDA • Other countries: India, Egypt, The People's Republic of China, South Africa, Cape Verde etc. • Danish consultants: Carl Bro A/S, COWI A/S, Rambøll, Techwise A/S etc. 			OK OK OK
<u>Milestones for 2001</u>			
<ul style="list-style-type: none"> • Implementation of routines for co-ordination and handling of ongoing international tasks • Completion of market analyses and marketing aimed at Asian Development Bank 			OK (presentation at World Bank meeting)
<ul style="list-style-type: none"> • The acquisition has resulted in new international commercial work in collaboration with one or more consultancy firms • Re-assessment of marketing possibilities and perspectives based on operation and results 			OK OK

Results

Commercial programme

<u>Name of programme</u>	<u>Abbr.:</u>	<u>Head</u>	<u>Department</u>
Wind Turbine Testing	PRV	Søren Markkilde Petersen	VEA
<u>Objective</u>			
Research based, international accredited testing of wind turbines in connection with type approval, documentation and support of the industrial development			
<u>User funded services; users and service goals</u>			
Extension of the accreditation activities to comprise: <ul style="list-style-type: none"> • Accreditation of wind measurements • Accreditation of power quality measurements (in collaboration with the Electric Design and Control programme) • Accreditation of noise measurements 			
<u>User paid services and users</u>			<u>Follow-up</u>
User paid services			
Accredited testing of wind turbines			
Determination of the wind-turbine power curve			OK
Determination of the wind-turbine yaw efficiency			OK
Determination of the structural eigen frequencies at stand-still			OK
Determination of the wind-turbine structural load			OK
Users			
NEG-Micon A/S; Vestas Wind Systems A/S, Bonus Energy A/S and other wind-turbine manufacturers			OK
<u>Milestones for 2001</u>			
<ul style="list-style-type: none"> • Development and initialisation of new software for data sampling • New test station in Western Jutland in normal operation • Accreditation of power-quality measurements (in collaboration with the Electric Design and Control Programme) • Accreditation of noise measurements 			OK - (collaboration started) -
<u>Follow-up</u>			
Our customer information has increased - the clientele has been enlarged.			

Results

Commercial Programme

<u>Name of programme</u>	<u>Abbr.:</u>	<u>Head</u>	<u>Department</u>
Sparkær Blade Test Centre	SPK	Carsten Skamris	VEA
<u>Objective</u> 1. Determination of dynamic characteristics, conclusion of static and fatigue tests of wind-turbine blades and other experimental investigations as a commercial enterprise for the wind-turbine industry 2. Development of new, more efficient and informative blade testing methods 3. Participation in other research projects at Risø involving experimental investigation of blades			
<u>User funded services, users and service goals</u> Development of the physical and professional capacity at the centre and participation in other programme research projects and research programmes at Risø With the industry as primary target and in co-operation with other Risø research programmes, the goal is to develop the basis for blade design and to offer efficient and informative testing methods of new blade types at an agreed price and time limit. The testing of blades may take place both at the Sparkær Centre and at the manufacturers' premises			
<u>User paid services and users</u> Accredited testing of wind-turbine blades. The Sparkær Centre is accredited by DANAK, and the testing activity is accomplished on commercial terms according to national as well as international recommendations Users are first of all: <ul style="list-style-type: none">• LM Glasfiber A/S• Vestas Wind Systems A/S			<u>Follow-up</u> OK OK (started – testing of 50m blades is now possible)
<u>Milestones for 2001</u> <ul style="list-style-type: none">• Establishment of a testing facility for static testing of wind-turbine blades with a length of about 60m assuming appropriate funding			

4 Projects of the Department

The activities of the department is mostly organised in projects, that each are individual accounting units, each with its own account number, denoted “psp” at Risø. The following pages contain the project descriptions extracted from the central Risø accounting system. Each project description summarises the project objectives, and identifies partners, sponsors and the Risø contact person.

4.1 Aeroelastic Design (AED)

Title: Various Commercial Tasks

Programme: AED, **project no.:** 1110001-00, **start date:** 1997.11.20 cont.

Description: The activity represents different commercial projects in Aeroelastic Design, performed mainly for the wind turbine industry. In general these are smaller projects in line with the research activities. The objectives are threefold: they represent a dedicated investigation; they act as an efficient way of transferring new knowledge, and give a direct and valuable feedback and inspiration for the research.

Partners: Confederation of Danish Industries

Sponsor: Confederation of Danish Industries

Contact: Flemming Rasmussen, flemming.rasmussen@risoe.dk +45 4677 5048

Title: Verification of European Wind Turbine Design Codes

Programme: AED, **project no.:** 1110019-00, **end:** 2001

Description: Throughout the European wind turbine industry, wind turbine analysis codes are used for the calculation of dynamic loads and energy yield. The codes are based on detailed aero-elastic and structural models. The methodology has been developed to a high level of complexity and the results of these codes are important for the design of wind turbine (components) and for certification purposes. In Europe different codes are used which are developed by several organisations. In the past some projects aimed at the determination of the accuracy and reliability of wind turbine codes. Nevertheless the level of confidence the industry and the certification institutes may have in the present codes are not known. The aim of the present project was to answer this question. The main results of the project were an assessment of the accuracy and reliability of the most widely used European wind turbine design codes for improved support of wind turbine design and certification and recommendations for improvement of the present wind turbine design codes and the required supporting experiments.

Partners: Netherlands Energy Research Foundation, ECN (NL), Co-ordinator; Risø National Laboratory (DK); Centre for Renewable Energy Sources, CRES (GR); Garrad Hassan and Partners, GH (UK); Stork Product Engineering, SPE (NL); The Technical University of Denmark (DK); Teknikgruppen AB, TG (SE); National Technical University of Athens, NTUA (GR); Lagerwey, The WindMaster B.V. (NL)

Sponsor: The European Commission; Danish Ministry of Energy and Technology (Risø part)

Contact: Kenneth Thomsen, kenneth.thomsen@risoe.dk +45 4677 5052

Title: Design of a Rotor/Airfoil Family for Active Stall-regulated Wind Turbines by Use of Multi-point Optimisation

Programme: AED, **project no.:** 1110023-00, **start date:** 1998.08.01, cont.

Description: This project involves design and experimental verification of a 600 kW rotor, which is optimised for active stall control. An optimisation study was carried out to determine optimum blade shape and optimum airfoil characteristics to obtain maximum possible energy within the limits of the design loads and the best possible active stall regulation. A blade was designed with the Risø-A1 airfoil family and the rotor was manufactured and installed on a 600 kW Nordwind wind turbine. Measurements are ongoing to evaluate the performance of the rotor.

Partners: WEA Engineering (DK); LM Glasfiber A/S (DK); NordWind (DK)

Sponsor: Danish Energy Agency

Contact: Peter Fuglsang, peter.fuglsang@risoe.dk +45 4677 5071

Title: Database on Wind Characteristics (<http://www.winddata.com>)

Programme: AED, **project no.:** 1110024-00, **start date:** 1999.01.01, cont.

Description: The objective of this project is to provide wind energy planners, designers and researchers, as well as the international wind engineering community in general with a source of reliable actual wind field time series observed in a wide range of different wind climates and terrain types. For the sake of convenience all available data are shown in a common format. The work with the database comprises the following activities: 1) to maintain the database in order to ensure that the data, as well as the hardware and software will be on-line and available; 2) to extend the database with meteorological data from countries outside Europe and from sites and wind climates that are not already well represented in the database; 3) to extend the database search and analysis facilities; 4) to disseminate the knowledge of the database and the possibilities for use of the data material.

Partners: Governmental institution in USA; Japan; Norway; Sweden and The Netherlands

Sponsor: IEA Annex

Contact: Gunner Larsen, gunner.larsen@risoe.dk +45 46775056

Title: Conversion of Danish Data for a Database on Wind Characteristics

Programme: AED, **project no.:** 1110026-00, **start date:** 2000.01.01, cont.

Description: The objective of this project is to make already existing meteorological measurements available for researchers and engineers through "Database on Wind Characteristics". Special attention is paid to offshore measurements and to measurements originating from high wind sites in California, USA.

Partners: Technical University of Denmark; Techwise A/S (DK); NEG-Micon A/S (DK)

Sponsor: Danish Ministry of Energy and Technology

Contact: Gunner Larsen, gunner.larsen@risoe.dk +45 4677 5056

Title: Damping of Blade and Tower Vibrations

Programme: AED, **project no.:** 1110027-00, **start date:** 2000.03.17, cont.

Description: The aerodynamic damping of the different wind turbine mode shapes is very important for load response. A method is developed to measure the damping at different wind speeds. The method can support the identification of input parameters for aero-elastic load calculations and thus decrease the uncertainty of the resulting loads.

Partners: Bonus Energy A/S (DK); LM Glasfiber A/S (DK); Technical University of Denmark

Sponsor: Danish Ministry of Energy and Technology.

Contact: Kenneth Thomsen, kenneth.thomsen@risoe.dk +45 4677 5052

Title: Programme for Aeroelasticity Research 2000-2001

Programme: AED, **project no** 1110028-00, **end:** 2001

Description: The project is part of a five-year research programme on aeroelasticity and carried out in close collaboration with the Danish wind turbine industry. The research work has been centred within the following five areas.

1) Status on 2D and 3D CFD calculations. 2) Implementation of improved sub models on structural dynamics and aerodynamics in the two aeroelastic codes HawC and FLEX4. 3) Design of an airfoil series with high maximum lift for application on off shore wind turbines. 4) Investigation of the potential to determine dynamic stability. 5) Uncertainties in computing the fatigue life of a wind turbine. 6) Guidelines for optimised blade dynamics.

Partners: Technical University of Denmark

Sponsor: Danish Ministry of Energy and Technology.

Contact: Helge Aagaard Madsen, helge.aagaard.madsen@risoe.dk
+45 4677 5047

Title: Gearbox Loadings and Wind Turbine Dynamics

Programme: AED, **project no.:** 1110029-00, **start date:** 2000.12.28

Description: Design loads for wind turbine gearboxes are usually established on the assumption that static external loads are applied only. The objective of the project is to investigate the importance of the gearbox as an integrated part of the wind turbine dynamic system and to clarify the importance of inertia loads due to gearbox accelerations. A detailed structural modelling of the gearbox in the nacelle is carried out with the ADAMS software. Simultaneously, measurements are carried out on a real wind turbine to identify the external loads on the gearbox. The expected results are recommendations for inclusion of inertia loads in gearbox design.

Partners: NEG-Micon A/S (DK)

Sponsor: Danish Energy Agency, contract no. ENS 1363/00-0025

Contact: Kenneth Thomsen, kenneth.thomsen@risoe.dk +45 4677 5052

Title: Model Rotor Experiments under Controlled Conditions (MEXICO)

Programme: AED, **project no.:** AED 1110030-00, **start date:** 2001.01.01

Description: The principal objective of the project is to significantly reduce the uncertainty in design calculations by providing an experimental database obtained through measurements on a 5-m diameter model rotor of a wind turbine under controlled wind conditions in a big wind tunnel. Detailed pressure measurements on one blade of the model rotor will be performed combined with flow field measurements and flow visualization. The increased physical insight resulting from the experiments will be used to improve and validate design tools.

Partners: National Aerospace Laboratory NLR (NL); Delft University of Technology DUT (NL); Polmarin BV (NL); Israel Institute of Technology

TECHNION (NL); Technical University of Denmark DTU (DK), Aeronautical Research Institute of Sweden FFA (SE), Centre for Renewable Energy Sources CRES (GR), National Technical University of Athens NTUA (GR)

Sponsor: Commission of the European Communities

Contact: Helge Aagaard Madsen, helge.aagaard.madsen@risoe.dk
+45 4677 5047

Title: DAMPBLADE: Wind Turbine Rotor Blades for Enhanced Aeroelastic Stability and Fatigue Life Using Passively Damped Composites

Programme: AED, project no.: 1110031-00, start date: 2001.01.30

Description: This project deals with design, manufacture, and test of passively damped composite wind turbine blades. The purpose is to utilize high structural damping of the blades to reduce vibrations of modern wind turbines, and thereby increase their lifetime. The project consists of different scientific tasks: Analytical and experimental investigations of structural damping mechanisms of composites, a development of theoretical models to predict the effect of the increased structural damping on the turbine response and stability, design and manufacture of blades with the desired properties, and finally a large scale field testing of their performance.

Partners: Centre for Renewable Energy Sources CRES (GR); Netherlands Energy Resource Foundation ECN (NL); Institute of Chemical Engineering and High Temperature Processes ICE/HT (GR); University of Patras UP (GR); Polymarin B.V. POL (NL); Geoviologiki S.A. Metal and Plastic Constructions GEO (GR) Technical University of Denmark/Fluid Mechanics

Sponsor: Commission of The European Communities

Contact: Morten Hansen, morten.hansen@risoe.dk +45 4677 5077

Title: Aeroelasticity EFP 2001

Programme: AED, **project no.:** 1110032-00, start date: 2001.07.01

Description: The project covers a one-year period from mid 2001 to mid 2002 of a continuously running five-year research programme on aero-elasticity. The main objectives for the present period are the following: a) development of a design tool for analysis of dynamic stability; b) investigations of blade tip aerodynamics and blade tip design on the basis of 3D CFD computations; c) publication of an airfoil catalogue; d) load reduction using new control strategies, and e) aero-acoustic modelling of noise propagation. The research work is carried out within close contact to industry, and in parallel to the main research areas a number of subjects representing problems and potential developments will be taken up for the industry.

Partner: Technical University of Denmark

Sponsor: Danish Energy Agency, Research Programme EFP

Contact: Helge Aagaard Madsen, helge.aagaard.madsen@risoe.dk
+45 4677 5047

4.2 Atmospheric Physics (ATM)

Title: Aujeszky's Virus

Programme: ATM, **project no.:** 1100006-00, **start date:** 1990.01.01, cont.

Description: On-line real-time Aujeszky pig disease airborne virus attack warning system Based on an on-line meteorology tower (Kegnæs, south-west Denmark)

Partners: Danish Bacon and Meat Council, Veterinarian, Ph.D. Sten Mortensen Axelborg, Copenhagen (DK)

Sponsor: Danish Bacon and Meat Council (DK)

Contact: Torben Mikkelsen, torben.mikkelsen@risoe.dk +45 4677 5009

Title: Ulborg

Programme: ATM, **project no.:** 1100007-00, **start date:** 190.09.01, cont.

Description: A study of forest productivity correlated to water balance (i.e. precipitation and evapo-transpiration), nutrient balance, micrometeorology and air pollution. The Risø component of the project is the micrometeorological part, which supports the flux estimates of water vapour, CO₂, and other constituent fluxes (dry deposition). The project is part of the Pan-European Programme for the Intensive Monitoring of Forest Ecosystems. Two other forest sites (Linnet and Frederiksborg) are equipped with less intensive meteorological instrumentation.

Partners: Botanical Institute, University of Copenhagen; DMU, National Environmental Research Institute (DK); FSL, Danish Forest and Landscape Research Institute, (DK), and similar research institutes from 32 other European countries.

Sponsor: EC Directorate-General Agriculture (DG VI F.II.2); National Forest and Nature Agency, SNS (DK)

Contact: Niels Otto Jensen, n.o.Jensen@risoe.dk +45 4677 5007

Title: EUROFLUX

Programme: ATM, **project no.:** 1100018-00, **start date:** 1996.01.01, cont.

Description: The main task of the project is to carry out long-term (Eddy-correlation) measurements of CO₂ and water vapour fluxes over European forests. Main objectives are as follows. 1) To provide useful parameters for global and regional scale modellers and to analyse the variables that determine energy partitioning by forests in different climatic zones; 2) to determine the sink strength of European forests for carbon and the factors that governs the gains and losses including differing vegetation composition in different climate regions. A specific Risø interest is to develop an improved Soil Vegetation Atmosphere Transfer (SVAT) model. The project is linked to the global FLUXNET: http://www-eosdis.ornl.gov/FLUXNET/-FLUX-_Plan.html

Partners: Dept. of Forest Science and Environment, University of Tuscia, Viterbo, project leader (IT) and about 20 other research institutes from EU countries.

Sponsor: EC Directorate-General Science, Research and Development (DG XII)

Contact: Niels Otto Jensen, n.o.jensen@risoe.dk +45 4677 5007

Title: SFINCS

Programme: ATM, **project no.:** 1100046-00, **end:** 2001

Description: The SFINCS project aims to improve the parameterisation of the atmospheric boundary layer in climate and weather forecasts models. The project is especially focused on strong stable and strong unstable conditions and on

aggregation. The work includes theoretical analysis, comparison with measurements and implementation in numerical models.

Partners: University of Uppsala, SMHI (SE); Max Planck Institute, Hamburg (DE); NOAA, Athens (GR); Institute of Atmospheric Physics, Moscow (Russia)

Sponsor: EC RTD Environment and Climate ENV4-CT97-0573

Contact: Søren E. Larsen, soeren.larsen@risoe.dk +45 4677 5012

Title: AutoFlux.

Programme: ATM, **project no.:** 1100051-1, **end:** 2001

Description: The AutoFlux project aims to develop and test an autonomous flux measuring station for atmospheric fluxes of momentum, latent and sensible heat, and CO₂. The stations are planned for unattended operation from remote stations or from Voluntary Observing Ships (VOS) from commercial sea transport. The project involves both instrument and system development and construction. The fluxes are mainly from turbulence measurements by the dissipation method.

Partners: Uppsala University (SE); Southampton Oceanic Centre (UK); Gill Instruments (UK); Royal Dutch Met. Institute (NL); CETP/CNRS France

Sponsor: EU RTD Environment and Climate Programme MAS3-CT97-0108

Contact: Morten Nielsen, n.m.nielsen@risoe.dk +45 4677 5022

Title: Understanding the Role of Vehicle Emissions in the Formation of Secondary Organic Aerosols (DMI Wind Climate)

Programme: ATM, **project no.:** 1100053-1, **start date:** 1999.01.01, cont.

Description: This grant (held together with Sara Pryor) is to foster research innovation in collaboration with Ford Research Centre in Aachen. The main focus of the project is to develop explicit chemistry modules to describe the production of condensable molecules through atmospheric oxidation of volatile organic compounds. These modules are being evaluated against two-parameter absorption approaches currently used in atmospheric chemistry modules.

Partners: None

Sponsor: Ford Research Centre, Aachen (DE)

Contact: Rebecca Barthelmie, r.barthelmie@risoe.dk +45 4677 5020

Title: SAT-MAP-CLIMATE

Programme: ATM, **project no.:** 1100054-1, **start date:** 1999.04.01, cont.

Description: Satellite Based maps of land surface roughness, albedo and vegetation state will be area-averaged and input to the HIRLAM model. The project concerns validation of wind and temperature data at synoptic weather stations, validation of surface flux data from land and ocean meteorological masts in Denmark. The possibility of surface flux climatology mapping will be evaluated. Furthermore a one-year climate prediction will be carried out with the seasonal land surface effects included in the input conditions. This work is basic to improvements in global climate change predictions.

Partners: Danish Meteorological Institute; University of Copenhagen

Sponsor: Danish Research Agency (DK), ESA-Follow Res. no.5006-00-0063

Contact: Charlotte Bay Hasager, charlotte.hasager@risoe.dk +45 4677 5014

Title: LSMC 2000

Programme: ATM, **project no.:** 1100055-3/4, **start date:** 1999.10.01, cont.

Description: Enhancement of the ARGOS version Local Scale Model Chain (LSMC) such that it can be applied to "Danish national scale" (horizontal: 400 km x 400 km, vertical: 2 km). The work includes several model enhancements: Trifurcating, vertical shear rise, improved treatment of inversion layer effects, new resistance method for dry deposition, a new plume rise module and coupling to the GSF food chain module and restructuring of RIMPUFF.

Partners: Danish Emergency Management Agency; Prolog Development Centre (DK); Danish Meteorological Institute; GSF (German National Research Centre for Environment and Health)

Sponsor: Danish Emergency Management Agency

Contact: Søren Thykier-Nielsen, soeren.thykier@risoe.dk +45 4766 5026

Title: EU-MEAD

Programme: ATM, **project no.:** 1100062-1, **start date:** 2000.02.01, cont.

Description: The overall objective is to describe the effects of atmospheric nitrogen deposition on coastal water biogeochemistry. To achieve this goal a high-resolution atmospheric model describing the complex meteorology and atmospheric nitrogen chemistry of the coastal zone and a coupled hydrodynamic biogeochemical model of the Kattegat to assess the impact of atmospheric deposition events is being developed. To parameterise the models sampling of fluxes in field experiments are conducted. Furthermore a retrospective analysis of existing atmospheric deposition, phytoplankton abundance and satellite imagery data takes place to investigate any links between atmospheric nitrogen deposition and bloom development.

Partners: National Environmental Research Institute (DK); East Anglia University (UK); Stockholm University (SE); Göteborg University (SE)

Sponsors: EC RTD Environment and Sustainable Development Programme EVK3-CT-1999-00014.

Contact: Lise Lotte Sørensen, lotte.geern@risoe.dk +45 4677 5015

Title: DERA - Coastal Effects

Programme: ATM, **project no.:** 1100063-1, **start date:** 2000.03.01, cont.

Description: A new sea-breeze wind model is being developed based on the LINCOM linearized flow model equations for conservation of momentum, mass and heat. The model will be used for coastal dispersion assessment and for coastal wind resource estimation.

Partners: DERA- Porton Down (UK)

Sponsor: DERA (UK)

Contact: Torben Mikkelsen, torben.mikkelsen@risoe.dk +45 4677 5009

Title: CEPROS Airborne Disease Spread

Programme: ATM, **project no.:** 1100064-1, **start date:** 1999.06.16, cont.

Description: 1) Establishment of a simple design tool based on Rimpuff for optimal piglet farmhouse layout in order to minimise airborne disease transmission between units. 2) Maintenance of real-time on site meteorological measurements from a small Met tower during field tests with disease spread between containers with piglets.

Partners: Danish Veterinary Serum Institute

Sponsor: CEPROS - Danish Ministry of Agriculture

Contact: Torben Mikkelsen, torben.mikkelsen@risoe.dk +45 4677 5009

Title: WATERMED

Programme: ATM, **project no.:** 1100066-1, **start date:** 2000.02.01, cont.

Description: Water use efficiency in natural vegetation and agricultural areas by remote sensing in the Mediterranean basin. The micro-scale aggregation model will be run for heterogeneous land surfaces to estimate areal heat and water vapour flux based on high-resolution satellite remote sensing data and compare to field data and low-resolution satellite data results in Mediterranean climates.

Partners: Valencia University (ES); INRA (FR); Centre Royal de Télédétection Spatial (Morocco); National Authority for Remote Sensing and Space Sciences (Egypt)

Sponsor: EC INCO-MED shared cost contract no. ICA3-CT-1999-00015

Contact: Charlotte Bay Hasager, charlotte.hasager@risoe.dk +45 4677 5014

Title: Random Walk Models for the Footprint Problem in the Turbulent Atmosphere

Programme: ATM, **project no.:** 1100068-1, **start date:** 2000.06.08

Description: The project is aimed at the development of new computational stochastic models and measurement techniques for simulating the transport of gases and aerosol particles in the turbulent atmosphere, with specific applications to the footprint problem. This problem deals with the evaluation of the concentrations and its fluxes at a certain receptor site as contributed from different surface and volume sources. The main investigation instruments are the stochastic differential equations, which after an appropriate approximation, result in random walk algorithms for simulating direct and backward Lagrangian trajectories of the parcels of the gas flow and aerosol particles. The results from modelling are verified and applied for ongoing field measurements of concentrations and fluxes of gases and aerosol particles.

Partners: Department of Physical Sciences, University of Helsinki (FI); Siberian Branch RAS, Novosibirsk (Russia); Weierstrass Institute, Berlin (DE); University of Bayreuth (DE); Institute of Atmospheric Physics, RAS, Moscow (Russia); Physico-Technical Centre 'Climate', Ashgabad (Russia)

Sponsor: International association for the promotion of co-operation with scientists from the new independent states of the former Soviet Union (EU)

Contact: Niels Otto Jensen, n.o.jensen@risoe.dk +45 4677 5007

Title: ENSEMBLE

Programme: ATM, **project no.:** 1100069-1, **start date:** 2000.10.01, cont.

Description: ENSEMBLE addresses the problem of achieving a common coherent strategy across European national emergency management when national Long-range dispersion forecasts differ from one another during an accidental atmospheric release of radioactive material. ENSEMBLE produces new Web-based software tools for real-time reconciliation and harmonisation of dispersion forecasts from meteorological and emergency centres across Europe during an accident. ENSEMBLE software tools will be set available to participating national emergency and meteorological forecasting centres, which may choose to integrate them directly into operational emergency information systems, or possibly use them as a basis for future system development.

Partners: German Weather Service (DE); Royal Netherlands Meteorological Institute (NL); National Institute of Public Health and Environmental Protection (NL); Royal Meteorological Institute (BE); Meteo-France (FR); The British Meteorological Office (GB); Finnish Meteorological Institute (FI); Swedish Meteorological and Hydrological Institute (SE); Danish Meteorological Institute (DK); Austrian Meteorological and Geophysical Office (AT); ENVIROWARE-SRL (IT); Polish Atomic Energy Institute (Poland); Norwe-

gian Meteorological Office (NO); Greece National Research Centre "Demokritos" (GR); JRC-Ispra - Environment Institute (IT); European Commission; University of Manchester (GB); Savannah River National Laboratory (USA); Danish Emergency Management Agency (DK)

Sponsor: European Community Research - Nuclear Sciences and Technologies

Contact: Torben Mikkelsen, torben.mikkelsen@risoe.dk +45 4677 5009

Title: DAONEM

Programme: ATM, **project no.:** 1100070-1, **start date:** 2000.10.01

Description: The objective of DAONEM is to improve the predictive capabilities of the RODOS system by developing and implementing data assimilation tools. In the development of a data assimilation capability for the early phase, a Gaussian-puff meso-scale RIMPUFF atmospheric dispersion model will be used. This model provides a realistic description of the different processes associated with the atmospheric dispersion of radioactive material, without requiring too much computing time. The complexity of the model will not prove advantageous, since in even more complex models, e.g., a particle model, the implementation of the Kalman filter would be at least an order of magnitude more difficult. Since the original dispersion model was not tailored for data assimilation purposes, it will be necessary to modify its architecture to satisfy the requirements imposed by the data assimilation approach. Almost all work by Risø will be undertaken within the first project year 1 October 2000 through 30 September 2001.

Partners: MOL (BE); University of Warwick (UK)

Sponsor: European Community Research - Nuclear Sciences and Technologies

Contact: Torben Mikkelsen, torben.mikkelsen@risoe.dk +45 4677 5009

Title: Dispersion of Fertilizer from Water Cannons

Programme: ATM, **project no.:** 1100071-1, **start date:** 2000.10.03

Description: Risk has been assessed from applying big volume irrigation guns to spread manure/slurry diluted with water. The work has concentrated on the human health risks directly associated with exposure to aerosols originating from the irrigation. Authorities has been precarious about the risk of airborne transmitted pathogenic bacteria, virus and protozoan (agens), that might arise from applying irrigation guns to spread manure/slurry diluted with water, and implemented the present risk assessment of the probability of human exposure to aerosols. Aerosols from the irrigation may contain pathogenic agens and will, depending on the size of the aerosols and the climatic conditions, drift over greater or smaller distances, thereby posing a risk of causing airborne infections of humans and animals. A number of factors are important for the drift of aerosols. Most important is the wind movement; furthermore temperature, relative humidity and atmospheric stability are important factors for the possible drift of the aerosols generated. Dispersion has been calculated using of version of RIMPUFF that includes a model for dispersion and evaporation of droplets. A large number of relevant dispersion scenarios have been studied. It is concluded that the application of irrigation guns to spread manure/slurry pose a substantial increase in human and animal risk compared to traditional techniques.

Partners: Danish Zoonosis Centre, Copenhagen, Denmark

Sponsor: Danish Zoonosis Centre, Copenhagen, Denmark

Contact: Søren Thykier-Nielsen, soeren.thykier@risoe.dk +45 4766 5026

Title: DSSNET

Programme: ATM, **project no.:** 1100072-1, **start date:** 2000.10.01, cont.

Description: DSSNET will establish an effective and accepted framework for better communication and understanding between the operational community and the many and diverse disciplines involved in R&D to make well informed and consistent judgements with respect to practical improvements of emergency response in Europe. DSSNET will establish a close interaction between the users of decision support systems; in particular of RODOS, and the R&D community to understand the needs of each other and to feed back the experience with the practical application of the systems

Partners: FZK/ Karlsruhe (DE)

Sponsor: European Community Research - Nuclear Sciences and Technologies

Contact: Torben Mikkelsen, torben.mikkelsen@risoe.dk +45 4677 5009

Title: EU-SAMEN

Programme: ATM, **project no.:** 1100073-1, **start date:** 2001-01-01

Description: The SAMEN EU cluster objectives are: **i)** to ensure the effective and timely exchange of data, information and results between the respective EU FP5 radiation protection projects, thus avoiding duplication, maximising synergy and promoting coherence; **ii)** to provide a forum to review and monitor progress within each project and advise on the direction of research in subsequent period; **iii)** to maintain focus on the broader objectives of the programme area to which the separate projects are subservient; **iv)** to ensure each of the projects retains a practical focus (i.e. is undertaken in a manner that will facilitate it finding practical effect); **v)** to provide better feedback between the research and potential user communities, and **vi)** to facilitate and promote the timely use of the results/developments in practical decision support systems for off-site emergency management and restoration (in particular in the RODOS system).

Partners: FZK (GR); NRPB (UK); SCKCEN (BE)

Sponsor: European Community Research - Nuclear Sciences and Technologies

Contact: Torben Mikkelsen, torben.mikkelsen@risoe.dk +45 4677 5009

Title: SOLA Review

Programme: ATM, **project no.:** 1100074-1, **start date:** 2001.01.15

Description: The project encompasses review series of external persons, institutions or research programmes

Partners: None

Sponsors: Various – mostly the European Commission

Contact: Søren Larsen, soeren.larsen@risoe.dk +45 4677 5012

Title: NOJE Review

Programme: ATM, **project no.:** 1100074-2, **start date:** 2001.01.15

Description: The project encompasses review series of external persons, institutions or research programmes

Partners: None

Sponsors: Various – mostly the European Commission

Contact: Niels Otto Jensen, n.o.jensen@risoe.dk +45 4677 5007

Title: PhD Lise Frohn - Modelling, Performance Optimisation for Ultra High Resolution, Inhomogeneous Conditions

Programme: ATM, project no.: 1100075-1, start date: 2001.01.17

Description: PhD project, development of a regional scale atmospheric chemistry transport model

Partners: National Environmental Research Institute (NERI)

Sponsors: National Environmental Research Institute (DK); Danish Research Academy (DK)

Contact: Torben Mikkelsen, torben.mikkelsen@risoe.dk +45 4677 5009

Title: Ar-41 Lidar Experiment

Programme: ATM, project no.: 1100077-1, start date: 2001.01.01

Description: Experimental exercise to evaluate the coupled near-range atmospheric dispersion and dose rate module in RIMPUFF, as it is used by both the RODOS and ARGOS_NT nuclear emergency decision support systems at present. Based on the small but traceable amount of routine released AR-41 from the SCKCEN research reactor in MOL Belgium, the vent plumes centreline and its dispersion parameters are determined experimentally from lidar scans together with simultaneously measured ground radiation fluxes. The resulting data base will be used to provide valuable experimental validation data for the simultaneous ongoing data assimilation modules being developed for the local scale.

Partners: Nuclear Safety Research Department, NUK, Risø National Laboratory (Bent Lauritzen, Martin Drews); SCKCEN MOL Belgium; Danish Emergency Management Agency; Technical University of Denmark

Sponsor: Nordic Nuclear Safety Research

Contact: Torben Mikkelsen, torben.mikkelsen@risoe.dk +45 4677 5009

Title: 3D-Extreme Loads

Programme: ATM, **project no.:** 1100078-1, **start date:** 2001-03-01

Description: The objective of the project is an improved design base for extreme and fatigue loads on wind turbine in flat or mountainous terrain. The main activity is the development of models for non-Gaussian 3D turbulence fields and extreme gusts or change of direction. Furthermore information will be collected on extreme event probabilities and turbulence probability distribution. Read more at www.risoe.dk/vea-atu/extreme-fatigue

Partners: Technical University of Denmark; NEG-Micon A/S (DK)

Sponsor: Danish Energy Agency

Contact: Morten Nielsen, morten.nielsen@risoe.dk +45 4677 5022

Title: EO-FLUX-BUDGET- Earth Observation Data for Up-scaling Carbon Flux and Water budget at Zealand

Programme: ATM, **project no.:** 1100079-1, **start date:** 2001.01.01

Description: Measurements of CO₂ emission and deposition at Zealand are collected at 5 sites representing major Danish biotypes. While these measurements provide information on the temporal variability of ecosystem fluxes and their longer-term trends, EO-FLUX-BUDGET combines Earth Observation (EO) data and a GIS-based soil-vegetation-atmosphere transfer model (Daisy-GIS) for the spatial upscaling of such data at Zealand. Because of the landscape heterogeneity, the surface conditions responsible for the atmospheric fluxes vary with the scale of modeling. In EO-FLUX-BUDGET, "effective" (or aggregate) surface variables are computed directly at the scale of interest using multiple-resolution EO data including vegetation quantity and chlorophyll contents which are particularly important for evaluating the carbon sink (absorption) on Earth. Maps of CO₂ exchange and evapotranspiration rates will be produced

and validated in time and space using tower fluxes and air-borne flux measurements.

Partners: Institute of Geography, University of Copenhagen, co-ordinator; Plant Research Department, Risø National Laboratory; Danish Hydraulic Institute (DHI) Water & Environment; Royal Veterinary and Agricultural University (DK)

Sponsor: Danish Research Agency (DK), ESA-Follow Res. no. 5006-00-0042

Contact: Charlotte Hasager, charlotte.hasager@risoe.dk +45 4677 5014

Title: CIBA

Programme: ATM, **project no.:** 1100080-1, **start date:** 2001.06.06

Description: The project concerns a joint co-operation to make the 100-m meteorological tower of CIBA operational with new instruments and a data acquisition system that enables data to be presented on the Internet in the future. The tower has been mounted with instruments to measure turbulence at four levels as well as temperature profiles, wind speed and direction. The aim is long-term studies of the atmospheric surface layer parameterisations. This gives the opportunity of testing different surface layer schemes on data taken over long periods and thereby test their statistic validity when used in climate models. Furthermore the purpose is to make the met-station a scientific background station for future atmospheric investigations.

Partners: Spanish Meteorological Institute (INM); University of Valladolid (ES)

Sponsors: University of Valladolid and INM

Contact: Hans E. Jørgensen, hans.e.jørgensen@risoe.dk +45 4677 5034

Title: Investigation of Lagrangian Properties of Turbulence

Programme: ATM, **project no.:** 1100081-1, **start date:** 2001.06.22

Description: New techniques are used to measure all terms in the Navier-Stokes equations, except from the pressure gradient, which can be calculated from the other terms. This requires the measurements of velocity gradients and acceleration at scales of the order of the Kolmogorov scale. One way of doing this is by three-dimensional particle tracking by four digital cameras. The other option considered is use of an ultra-fast position sensitive diode and a sweeping laser sheet. Second parts of the project concentrate on measuring the movements of groups of particles.

Partners: None

Sponsor: Danish Research Agency

Contact: Jakob Mann, jakob.mann@risoe.dk +45 4677 5019

Title: Investigation of a New Bi-static SODAR Remote Sensing Concept for Wind Profile Measurements in Connection with Large Wind Turbines

Programme: ATM, **project no.:** 1100082-1, **start date:** 2001.08.01

Description: Ground based remote sensing of the vertical wind speed profile using sound is investigated in connection with the new generation of big wind turbines. At high wind speeds and during near-neutral stratifications, a bi-static SODAR configuration possesses inherent advantages over the traditional mono-static configurations. This project investigates the theoretical potentials in bi-static acoustic SODAR systems for better accuracy with remote sensing of vertical wind profiles. A pilot bi-static SODAR instrument is developed and tested for performance during various meteorological conditions and inter-compared with the 123-meter tall met tower at Risø. The bi-static SODAR concept will be investigated with the aim to replace met-tower based wind profile measurements at ranges between 50 meters and 150 meters height.

Partners: Torben Mikkelsen (principal investigator); Leif Kristensen (consultant)

Sponsor: Danish Research Agency

Contact: Torben Mikkelsen, torben.mikkelsen@risoe.dk +45 4677 5009

4.3 Electric Design and Control (EDS)

Title: Solar Energy Centre Denmark, Hybrid Systems Part

Programme: EDS, **project no.:** 1115003-00, **start date:** 1998.01.01, cont.

Description: Participation in the work of the Solar Energy Centre Denmark who performs the main part of the research in the field of solar energy in Denmark. The particular responsibility of Risø in this centre is in the field of stand-alone pv-systems and hybrid system (pv-wind-diesel-battery). The work involves development of technology, controls and tools for system analysis.

Partners: Danish Technological Institute (TI); Technical University of Denmark (DTU); Danish Building Research Institute (SBI)

Sponsor: Danish Energy Agency

Contact: Henrik Bindner, henrik.bindner@risoe.dk +45 4677 5050

Title: IRENE2010

Programme: EDS, **project no.:** 1115017-00, **start date:** 1999.05.01, cont.

Description: The focus of the project is on the implications of the targets of the EU white paper on renewable energy of the European power system. Through an analysis of the state-of-the-art of current practices in the fields of production and transmission capacity planning, stability analysis, security assessment and scheduling and dispatch practices, points have been identified that need change when large amounts of renewable energy are being included in the power production.

Partners: Tractebel (BE); EDF (FR); PPC (GR); Iberdrola (ES); Techwise A/S (DK); Eurec Agency (BE)

Sponsor: EU ALTERNER

Contact: Henrik Bindner, henrik.bindner@risoe.dk, +45 4677 5050

Title: Simulation of Wind Power Plants

Programme: EDS, **project no.:** 1115018-00, **start date:** 2000.04.01, cont.

Description: The objective of this project is to develop models for simulation of wind farms and their interaction with the grid, as a first step to support the development of large wind farms that can contribute to the regulation and stabilisation of the grid, and therefore are able to replace other power plants. As a case, a model for the 6×2 MW wind farm in Hagesholm have been developed in the commercial tool for power system simulation DIgSILENT. The model has been verified for stationary conditions considering the influence of turbulence, and it has been demonstrated that the model is capable to predict a number of power quality characteristics as defined in the IEC 61400-21 standard for measurement and assessment of power quality of grid connected wind turbines.

Partners: Aalborg University (DK); Dancontrol Engineering A/S (DK)

Sponsor: Danish Energy Agency EFP 2000, contract no. 1363/00-0003

Contact: Poul Sørensen, poul.soerensen@risoe.dk +45 4677 5075

Title: Condition Monitoring of Wind Turbine

Programme: EDS, **project no.:** 1115019-00, **start date:** 2000.04.04, cont.

Description: The objective of the project is to further develop the condition monitoring system of modern wind turbines in order to reduce down time and maintenance cost by monitoring rotor operating conditions and generator/bearings/gearbox operating conditions and state of health in order to avoid operation in conditions that consume much life time and to reduce or stop production before serious failures of main components.

Partners: Vestas Wind Systems A/S (DK); Institute of Energy Technology, Aalborg University (DK)

Sponsor: None

Contact: Henrik. Bindner, henrik.bindner@risoe.dk +45 4677 5050

Title: Wind Plus

Programme: EDS, **project no.:** 1115020-00, **start date:** 2000.04.04, cont.

Description: The project is concerned with the development of operating and control strategies for storage systems in wind diesel power systems. The key objective is to develop control strategies for lead-acid battery based energy storage systems in order to obtain both a long battery life time and improvements in fuel saving and overall system power quality. Important project tasks are development of power electronics, development and implementation of control strategies and testing of the technology in real power systems.

Partners: None

Sponsor: None

Contact: Henrik Bindner, henrik.bindner@risoe.dk +45 4677 5050

Title: Research and Development

Programme: EDS, **project no.:** 1115021-01, **start date:** 2000.07.07, cont.

Description: Research and development activities within the EDS programme that are not directly related to the research and development activities of any individual project including collaboration with Aalborg University.

Partners:

Sponsor: Internal

Contact person: Peter Hauge Madsen, peter.hauge@risoe.dk +45 4677 5011

Title: Gaia Wind Turbine for Use in Wind Diesel Systems and as Stand-alone

Programme: EDS, **project no.:** 1115022-1 **start date:** 2001.01.18

Description: The 11kW Gaia wind turbine will be modified to operate in a wind diesel system. The operation in the system will be documented through measurements. The other major part of the project involves further development of the wind turbine in order to make it possible for the wind turbine to operate without other generating units such as diesel generator sets. The stand-alone version of the wind turbine will also be tested and the performance will be documented.

Partners: None

Sponsor: None

Contact: Henrik Bindner, henrik.bindner@risoe.dk +45 4677 5050

Title: Integration VEA/SYS

Programme: EDS, **project no.:** 1115023-00 **start date:**

Description: The objective of this project is to identify required research tasks in the area of integration of renewable energy in order to obtain a cost-effective energy system with a very large proportion of renewable energy. This will be done on the basis of a state-of-the art report. Special emphasis is on how the large variety of expertise at Risø can be exploited in this area.

Partners: System Analysis Department and Materials Research Department, both Risø National Laboratory

Sponsor: Internally funded project

Contact: Henrik Bindner, henrik.bindner@risoe.dk +45 4677 5050

Title: Simulation and Verification of Transient Events in Large Wind Power Installations

Programme: EDS, **project no.:** 1115024-1, **start date:** 2000.07.01, cont.

Description: The objective of this project is to assess the ability of dedicated power system simulation tools to predict the response of wind farms to transient events like grid faults in the power system. Simulation of this response is required by the Danish transmission system operators for connection of large (offshore) wind farms directly to the transmissions system. As a case, models for the 6x2 MW wind farm in Hagesholm developed in the power system simulation tools DIgSILENT and EMTDC are used.

Partners: North-West Zealand Energy Supply Company (NVE) (DK); Aalborg University (DK); Dancontrol Engineering A/S (DK)

Sponsor: Elkraft System PSO-F&U 2001, contract no. Bro-91.054 (FU 1103)

Contact: Poul Sørensen, poul.soerensen@risoe.dk +45 4677 5075

Title: Investire

Programme: EDS, **project no.:** 1115027-00, **start date:** 2000.06.08, cont.

Description: The main objectives of the network are to review and assess existing storage technologies in the context of renewable energy applications, to facilitate exchange of information between the main actors and to propose appropriate RTD actions for the future. More detailed objectives include (1) To review possible storage technologies suited to renewable energy systems, (2) To help identify research priorities and publish a 5/10 years RTD roadmap, (3) To encourage the formation of new RTD partnerships and (4) To foster cooperation between battery manufacturers and renewable energies system designers and suppliers.

Partners: CEA GENEC (FR) co-ordinator and 34 partners from Europe and outside

Sponsor: EC, Directorate General Research, FP5

Contact: Per Lundsager, per.lundsager@risoe.dk +45 4677 5045

Title: PSO-Green Power Konverter

Programme: EDS, **project no.:** 1115028-1, **starting date:** August 2001

Description: The objective of the project is to develop new and cost-effective power converters for connection of photovoltaic (pv) panels to the grid. Special emphasis will be on low cost, high reliability and suitability for mass production. The tasks of the project include: specification, modelling and simulation of new converter topologies, selection of best topology and testing both in laboratory and in the field.

Partners: Aalborg University (DK); Danish Technological Institute (TI); Danfoss A/S (DK)

Sponsor: Elkraft System a.m.b.a. (DK)

Contact: Henrik Bindner, henrik.bindner@risoe.dk +45 4677 5050

Title: Benchmarking

Programme: EDS, **project no.:** 1115029-00, **starting date:** 2002.01.02, cont.

Description: The project aims at the development of test procedures for benchmarking tests for energy storage systems and other components. The project results will enable users to select the most suitable energy storage product for their specific application. Manufacturers can use the results to clearly define

the category of RES for which their product is most suited and to estimate the expected lifetime for a well-defined category of use. The project is in the pre-normative and pre-competitive domain. In close contact with the IEC and their relevant committees, the project will provide a framework for defining more detailed technical standards, which are appropriate for a maturing industry. It is the intention of the project to be technology neutral so that future technologies and applications of RES can be incorporated.

Partners: Fraunhofer-Institut für Solare Energiesysteme ISE, co-ordinator (DE) and 10 European contractors including Risø National Laboratory; NREL (USA)

Sponsor: Commission of the European Communities Directorate-general Research, FP5, Contract no ENK6-CT2001-80576

Contact: Per Lundsager, per.lundsager@risoe.dk +45 4677 5045

4.4 Wind Power Meteorology (VKM)

Title: European Wind Atlas

Programme: VKM, **project no.:** 1105 001-00, **start date:** 1989.01.01, cont.

Description: Distribution of the European Wind Atlas published in 1989.

Partners: None

Sponsors: Various

Contact: Niels G. Mortensen, niels.g.mortensen@risoe.dk +45 4677 5027

Title: Wind Atlas Analysis and Application Program (WAsP)

Programme: VKM, **project no.:** 1105002-01/02, **start date:** 1987.07.01, continuous

Description: Development, implementation and verification of software tools intended for wind data analysis, map Editing and digitisation, wind atlas generation, wind climate estimation, wind power production prediction, micro-siting of wind turbines, wind farm production calculations, wind farm efficiency evaluation as well as wind climate and wind resource mapping. Furthermore the project includes software support, courses and training.

Partners: None

Sponsor: Various

Contact: Niels G. Mortensen, niels.g.mortensen@risoe.dk +45 4677 5027

Title: Wind Atlas for the Gulf of Suez

Programme: VKM, **project no.:** 1105005-00, **start date:** 1995.01.01, cont.

Description: Distribution of the Wind Atlas for the Gulf of Suez 1991-95 and the associated database.

Partners: None

Sponsor: Various

Contact: Niels G. Mortensen, niels.g.mortensen@risoe.dk +45 4677 5027

Title: Wind Atlas for Russia

Programme: VKM, **project no.:** 1105007-00, **start date:** 1997.11.20, cont.

Description: The project aims at developing a wind atlas for Russia. The methodology used is that of the European Wind Atlas (the Risø Wind Atlas Methodology). The project will analyse data from more than 300 stations distributed all over the Russian territory. Each station will be analysed with respect to meteorological data (wind speed and direction), terrain (orography and roughness) and obstacles.

Partners: RDIEE, Istra, Moscow Region, Russia

Sponsor: Danish Energy Agency, contract: 2136/97075-0018
Contact: Lars Landberg, lars.landberg@risoe.dk +45 4677 5024
Title: Instrumentation of Offshore Masts
Programme: VKM, **project no.:** 1105011-00, **start date:** 1997.08.01, cont.
Description: This project involves instrumentation of a number of offshore masts (Gedser), Land, Gedser Rev, Rødsand and Omø Stålgrunde) and running of the necessary meteorological instrumentation to provide a database for wind resource assessment.
Partners: None
Sponsor: SEAS/ELKRAFT (DK)
Contact: Rebecca Barthelmie, r.barthelmie@risoe.dk +45 4677 5020

Title: WAsP Consulting
Programme: VKM, **project no.:** 1105026-01, **start date:** 1997.11.20, cont.
Description: This project covers all consulting done in connection with wind resource estimation. This includes second opinion studies, due diligence, offshore wind farm production estimation, measuring programs and so on.
Partners: Various commercial and international institutions
Sponsor: Various
Contact: Lars Landberg, lars.landberg@risoe.dk +45 4677 5024

Title: Predicting Offshore Wind Energy Resources (POWER)
Programme: VKM, **project no.:** 1105036-1, **start date:** 1998.08.01, cont.
Description: To date the focus of the project is the mapping of thirteen years of near-surface offshore wind speeds based on pressure gradients (geostrophic wind) for the whole sea area of the European Union. Two approaches are being compared: the WAsP model and a newly developed Coastal Discontinuity Model (CDM) that accounts for stability variations in coastal regions using temperature differences. The main results indicate that stability is a very important factor in predicting wind profiles up to 20 km from the coast. Initial comparisons with SODAR data (collected by ECOFYS at the Measurement Platform Noordvik) also indicate substantial variations from the classic 'log-profile' even during the winter period.
Partners: CLRC, Rutherford Appleton Laboratory (UK); ECOFYS (NL), KEMA Sustainable (NL); University of East Anglia (UK)
Sponsor: European Commission, the JOULE programme
Contact: Rebecca Barthelmie, r.barthelmie@risoe.dk +45 4677 5020

Title: EFP99 - Zephyr
Programme: VKM, **project no.:** 1105039-1, **start date:** 1999.04.01, cont.
Description: The project aims at developing a new system for short-term prediction of the output from wind farms, Zephyr. Zephyr combines the physical approach of Risø with the statistical approach of IMM at the Technical University of Denmark. The model is to be developed and installed at all the Danish utilities with wind energy. The HIRLAM model of the Danish Meteorological Institute drives the predictions.
Partners: IMM, Technical University of Denmark; Danish Meteorological Institute; SEAS (DK); ELKRAFT (DK); ELSAM (DK); ELTRA (DK);
Sponsor: Danish Energy Agency, EFP99 contract: 1363/99-0017
Contact: Lars Landberg, lars.landberg@risoe.dk +45 46775024

Title: Transfer of Wind-resource Know-how to the Czech Republic
Programme: VKM, **project no.:** 1105042-1, **start date:** 1999.11.01, cont.
Description: The project aims at increasing the Czech capacity to estimate domestic wind resources. A training workshop for about 10 target persons is

established; The project performs in general terms a survey of the wind resources in the C.R., clarifying and possibly seeking to propose a solution for an existing less successful wind farm project.

Partners: None

Sponsor: DANCED, case no. 124/043-0056

Contact: Ole Rathmann, ole.rathmann@risoe.dk +45 4677 5003

Title: EPRI-Prediktor Texas

Programme: VKM, project no.: 1105043-1, start date: 2000.10.01, cont.

Description: Confidential

Partners: Confidential

Sponsor: EPRI/DOE (USA)

Contact: Lars Landberg, lars.landberg@risoe.dk +45 4677 5024

Title: Efficient Development of Offshore Wind Farms (ENDOW)

Programme: VKM, project no.: 1105044-1, start date: 2000.03.01, cont.

Description: ENDOW is a new research project being co-ordinated at Risø and is funded under the European Commission Fifth Framework. The objectives of the proposal are to evaluate the performance of a variety of wake models in the offshore environment; to enhance these models and link them to improved boundary layer models. This is in order to provide tools to enable offshore wake effects to be compared with other factors impacting design and economics of offshore wind farms.

Partners: University of Uppsala (SE), Garrad Hassan and Partners (UK), Robert Gordon University (UK), University of Oldenburg (D), SEAS (DK), ELSAM (DK), NEG-Micon A/S (DK), ECN (NL), ECOFYS (Sub-contractor to ECN) (NL)

Sponsor: European Commission, Fifth Framework

Contact: Rebecca Barthelmie, r.barthelmie@risoe.dk +45 4677 5020

Title: Baltic Wind Atlas

Programme: VKM, project no.: 1105045-1, start date: 2000.01.01, cont.

Description: The project aims at establishing a wind atlas for relevant areas in the Baltic countries by reviewing and analysing existing wind measurements and by establishing new measurements in especially prospective (coastal) areas. The Risø contribution is mainly consultancy on selecting new measurement sites and on purchase and installation of measuring equipment.

Partners: UNDP Global facility (project leader); Lars Mach (free-lance wind energy consultant), Germany

Sponsor: UNDP / UNOPS, RER /99/G41

Contact: Ole Rathmann, ole.rathmann@risoe.dk +45 4677 5003

Title: Prediktor

Programme: VKM, **project no.:** 1105046-1, **start date:** 2000.10.01, cont.

Description: Sale, marketing and implementation of the Prediktor short-term prediction system

Partners: Various

Sponsor: Various

Contact: Lars Landberg, lars.landberg@risoe.dk +45 4677 5024

Title: EPRI-Prediktor California

Programme: VKM, **project no.:** 1105047-1, **start date:** 2000.10.01, cont.

Description: Confidential

Partners: Confidential

Sponsor: EPRI/Californian Energy Commission, USA

Contact: Lars Landberg, lars.landberg@risoe.dk +45 4677 5024

Title: UNEP-SWERA Global Wind Atlas

Programme: VKM, **project no.:** 1105048-1, **start date:** 2000.03.02, cont.

Description: The project is developing a full-scale project with the purpose of creating a solar and wind atlas for 10-15 countries around the globe. The project will output a proposal to UNEP for this full-scale project

Partners: NREL, USA; TERI, India

Sponsor: UNEP/GEF and Risø/VKM own funds

Contact: Lars Landberg, lars.landberg@risoe.dk +45 4677 5024

Title: WAsP Engineering 2000

Programme: VKM, **project no.:** 1105049-1, **start date:** 2000.03.01, cont.

Description: The purpose of the project is to verify, refine and develop micro-meteorological tools for the estimation of load-critical wind conditions in landscapes in Denmark and Europe, where wind turbines are likely to be situated. These conditions include turbulence; both natural and turbine wake generated; shear and extreme winds. Among the goals of this project are to establish connections between measured storms in Denmark and a global meteorological database; computer implementations of turbine wake models; construction of an extreme value analysis module of meteorological records, and to investigate the limits of the applicability of the models.

Partners: Svend Ole Hansen ApS (DK); Vestas Wind Systems A/S (DK)

Sponsor: Danish Energy Agency, Contract ENS-1363/00-0015.

Contact: Jakob Mann, jakob.mann@risoe.dk +45 4677 5019

Title: CDMED

Programme: VKM, **project no.:** 1105050-1, **start date:** 2000.03.01, cont.

Description: Scenarios and strategies for the implementation of the Clean Development Mechanism of the Kyoto Protocol in the Mediterranean region.

Partners: OME, Observatoire Méditerranéen de L'énergie, co-ordinator (FR), IPTS (JCR), ENEL (IT), NREA (Egypt).

Sponsor: EU Research DG. Project no.: NNE5-1999-00351

Contact: Erik Lundtang Petersen, erik.lundtang@risoe.dk +45 4677 5001

Title: CleverFarm

Programme: VKM, **project no.:** 1105051-1, **start date:** 2000.04.01, cont.

Description: The goal of the project is to construct an "intelligent" computer system, which integrates a large variety of different monitoring approaches. The system includes short-term prediction of the wind farm electricity production, video camera surveillance of the wind farm, information on the current running conditions and wind turbine fault prediction. This combination enables the wind farm owner to effectively plan the maintenance of the wind farm. Furthermore the short-term predictions add extra value to the wind farm produced electricity.

Partners: Gram & Juhl/Aarhus (DK), Danish Meteorological Institute (DK); SET/Kassel (DE); RES/London (UK); SEAS/Haslev (DK); EHF/University of Oldenburg (DE)

Sponsor: EC EESD Programme ERK6-CT-1999-00006.

Contact: Gregor Giebel, gregor.giebel@risoe.dk +45 4677 5095

Title: WEMSAR

Programme: VKM, **project no.:** 1105052-1, **start date:** 2000.03.01, cont.

Description: Wind energy mapping using Synthetic Aperture Radar. To develop, validate and demonstrate the potential use of satellite-based Synthetic Aperture Radar, scatterometer and altimeter data combined with meteorological

observations for the mapping of wind resources in offshore and near-coastal regions for sites located in Norway, Denmark and Italy. For regional scale calculations the Karlsruhe Atmospheric Mesoscale Model (KAMM) will be used and for the local scale calculations WASP.

Partners: Nansen Environmental and Remote Sensing Centre (NO); NEG-Micon A/S (DK); Terra Orbit AS (NO); ENEA (IT)

Sponsor: EC RTD Energy, Environment and Sustainable Development ERK6-CT1999-00017

Contact: Charlotte Bay Hasager, charlotte.hasager@risoe.dk +45 4677 5014

Title: Improved Description of the Wind Climate in Denmark Regarding Determination of the Wind Resource

Programme: VKM, **project no.:** 1105053-1, **start date:** 2000.01.04, cont.

Description: The Danish Meteorological Institute is further developing HIRLAM (High Resolution Limited Area Model) to improve the prediction of wind and weather in general. One goal is to investigate the possibility of using the electricity production of wind turbines as a measure of wind speed, i.e. to use the wind turbines similar to huge anemometers. Risø derives the wind speed information from the power generation using the wind farm model in WASP. ELTRA provides power data.

Partners: Danish Meteorological Institute (DMI), ELTRA (DK)

Sponsor: Danish Energy Agency (EFP 2000)

Contact: Lars Landberg, lars.landberg@risoe.dk +45 4677 5024

Title: UVE-2000, Calculation of Energy Production

Programme: VKM, **project no.:** 1105054-1, **start date:** 2000.0.01, cont.

Description: Establishment of a database of case studies containing data and information required to evaluate the accuracy and reliability of wind power production estimations using different approaches and computer models. Case studies are established for different wind climatologies and topographical settings. Comparison of predictions and actual power productions from wind turbines and wind farms serve to evaluate and map the uncertainties involved and, possibly, improve the prediction skill.

Partners: Energy- and Environmental Data (DK); Elsamprojekt (DK); WEA Engineering (DK); Bonus Energy A/S (DK); NEG-Micon A/S (DK); Nordex (DK); Vestas Wind Systems A/S (DK); Wincon (DK)

Sponsors: Danish Energy Agency (UVE), WEA Engineering (DK); Bonus Energy A/S (DK); NEG-Micon A/S (DK); Nordex (DK); Vestas Wind Systems A/S (DK); Wincon (DK)

Contact: Niels G. Mortensen, niels.g.mortensen@risoe.dk +45 4677 50 27

Title: SNF-WINDENG

Programme: VKM, **project no.:** 1105055-1, **start date:** 2000.05.25, cont.

Description: This is a small project for writing a proposal to the European Commission for a research network in wind power meteorologically related subjects.

Partners: None

Sponsor: The National Research Council (SNF) (DK)

Contact: Lars Landberg, lars.landberg@risoe.dk +45 4677 5024

Title: Wind Atlas for South Africa

Programme: VKM, **project no.:** 1105056-1, **start date:** 2000.06.06, cont.

Description: Consultancy to ESKOM in the task to produce a wind atlas for South Africa. The work includes a WASP course in South Africa, assistance in the analysis and quality control of the wind atlas.

Partners: None
Sponsor: ESKOM
Contact: Ole Rathmann, ole.rathmann@risoe.dk +45 4677 5003

Title: RB Consulting
Programme: VKM, project no.: 1105057-1, start date: 2000-05-01
Description: Consulting relating to offshore wind energy development.
Partners: None
Sponsor: Various commercial companies
Contact: Rebecca Barthelmie, r.barthelmie@risoe.dk +45 4677 5020

Title: EFP – The New WAsP
Programme: VKM, project no.: 1105058-1, start date:
Description: The purpose of the project is to develop the next generation flow model in the WAsP context
Partners: Energy and Environmental Data (DK)
Sponsor: Danish Energy Agency; UVE
Contact: Lars Landberg, lars.landberg@risoe.dk +45 4677 5024

Title: EU-MED2010
Programme: VKM, project no.: 1105059-1, start date: 2001.01.09
Description: Large scale integration of solar and wind power in Mediterranean countries.
Partners: OME (France, co-ordinator), ECYR (Spain), BP Solar (Spain), CIEMAT (Spain), EDF (France), ARMINES/Ecole de Mines (France), CESI (Italy), CDER (Morocco), STEG (Tunisia), NREA (Egypt), EIE (Turkey)
Sponsor: EC under the “ENERGIE” Programme (1998-2002), contract no. ENK5-2000-00307
Contact: Erik Lundtang Petersen, erik.lundtang@risoe.dk +45 4677 5001

Title: Prediktor in Ireland
Programme: VKM, project no.: 1105060-1, start date: 2001.02.06
Description: Confidential
Partners: Confidential
Sponsor: Confidential
Contact: Lars Landberg, lars.landberg@risoe.dk +45 4677 5024

Title: SEAS Offshore Mast Analysis
Programme: VKM, project no.: 1105064-1, start date: 2001-10-01
Description: Analysis of wind resources at Rødsand, Omø Stålgrunde and Gedser based on measurements from the in situ mast from the period 1996-present.
Partners: None
Sponsor: SEAS
Contact: Rebecca Barthelmie, r.barthelmie@risoe.dk +45 4677 5020

4.5 Wind Turbines (VIM)

Title: Consulting
Programme: VIM, **project no.:** 1120006 **start date:** 1997-11-19, cont.
Description: Consulting services are carried out for the private sector when required: Assistance to NEG Micon A/S in assessing wind farm production data. The result of measurements is used to decide whether or not production

warranties have been met. Design calculations for the offshore wind farm, Rødsand, for SEAS. For the computations, the aero-elastic computer code HAWC has been amended to include hydraulic loads.

Partners: None

Sponsor: Private sector

Contact: Sten Frandsen, sten.frandsen@risoe.dk +45 4677 5072

Title: Response Calculations for the Rødsand Offshore Wind Farm

Programme: VIM & AED, **project no.:** 1120006-04, **start date:** 2001.07.01

Description: A number of load cases were analysed in order to determine how the loading from winds, waves and sea-ice act on an offshore wind turbine foundation. Special emphasis was put on investigating the effect of extrapolating extreme loads during 10 minutes of operation to lifetime extremes.

Partners: SEAS (DK); Carl Bro A/S (DK)

Sponsor: SEAS

Contact: Sten Frandsen, sten.frandsen@risoe.dk +45 4677 5072

Title: Education Programme for Staffs at The Energy & Environment Offices

Programme: VIM, **project no.:** 1120051-05, **start date:** 01.01.2000, cont.

Description: A series of courses in renewable energy technologies is designed. It has been prepared and by the project partners for the staffs at the Energy & Environment Offices in Denmark as well as at The National Danish Energy Information Centre - both having public information in energy and environmental subjects as their main activities. The overall objective is to develop the quality of the services provided by the centres by strengthening the staff capabilities in their role as renewable energy advisors to the public. The immediate objective of the courses is to strengthen the staff's knowledge in renewable energy technologies, including bio fuel, solar heating, wind power and heat pumps. The following courses are provided both in 2000 and in 2001. Bio fuels, basic (two days); Bio fuels, extended (one day); Wind power, basic (two days); Wind power, extended (one day); Solar Energy, basic (two days); Solar Energy, extended (one day); Heat pumps, basic (two days) and Heat pumps, extended (one day). The aim is to develop (a structure for and) input to valuable handbooks in the selected renewable energy technologies, course material are developed, collected and organised in binders, one for each of the participants. The courses are provided in Danish only.

Partners: DTI (Danish Technological Institute, project co-ordinator); SEK (Association of Energy Offices); DV (Danish Windmill Association)

Sponsor: Danish Energy Agency; The Association of Energy Offices

Contact: Per Nørgaard, per.norgaard@risoe.dk +45 4677 5068

Title: Isolated Systems with Wind Power

Programme: VIM, **project no.:** 1120084-00, **completed:** 2001-03-31

Description: The main objective of the project is to establish an operational set of engineering methods for design and evaluation of isolated electric power supply systems with a large proportion of wind power. The methodology will be developed based on practical experience using existing analysis and simulation models. The project includes a literature review as well as measurements and examples from isolated systems in Egypt, and it will result in a set of guidelines and an outline of an implementation strategy.

Partners: NREA - National Renewable Energy Agency, Egypt

Sponsor: Danish Energy Agency, Energy Research Programme EFP-97, case no. 1363/97-0007

Contact: Per Lundsager, per.lundsager@risoe.dk +45 4677 5045

Title: Pre-Project: Development of New Blade Test Methods

Programme: VIM, **project no.:** 1120098-00, **start date:** 1997.11.20, cont.

Description: This project includes investigations in better determination of blade properties using modal analysis, investigations in use of thermo graphic techniques especially in fatigue testing and investigation of the number of cycles required to test a wind turbine blade in fatigue.

Partners: LM Glasfiber A/S (DK)

Sponsor: Danish Energy Agency 511+71/97-0043.

Contact: Erik R. Jørgensen, erik.r.joergensen@risoe.dk + 45 4677 5064

Title: European Wind Turbine Certification

Programme: VIM, **project no.:** 1120099-00, **start date:** 1999.05.01, cont.

Description: Comparison of wind turbine certification carried out by four different certifying bodies. The objective is to establish a basis for harmonisation of certification procedures for wind turbines in EU.

Partners: CRES (GR); Det Norske Veritas, DNV (DK); ECN (NL); GL (DE)

Sponsor: EC, contract JOR3CT980265

Contact: Peter Hjuler Jensen, peter.hjuler@risoe.dk +45 4677 5037

Title: Probability Distribution of Fatigue Strength of Rotor Blades (PROFAR)

Programme: VIM, **project no.:** 1120100-00, **start date:** 1997.11.20, cont.

Description: The PROFAR project aims to give a deeper understanding of the blade-to-blade variation of the fatigue strength of rotor blades and determination of the statistical distribution function by which this variation can be described. The statistical parameters for this distribution function are calculated. The project includes fatigue test of 40 small blades and test of the materials used in the project.

Partners: TU-Delft (NL); ECN (NL); CRES (GR)

Sponsor: EC JOR3-CT95-0266; Danish Energy Agency 51171/98-0021.

Contact: Erik R. Jørgensen, erik.r.joergensen@risoe.dk +45 4677 5064

Title: Laser Anemometry for Control and Performance Measurements on Wind Turbines

Programme: VIM, **project no.:** 1120102-00, **start date:** 1997.11.20, cont.

Description: The current project is focused on designing a cost effective laser anemometer to provide information on the wind speed approaching the wind turbine and to implement this information into the turbine control system to regulate the blade pitch and rotor speed. The anemometer is planned to be mounted on the nacelle of the turbine and to focus a laser beam at a distance in front of the turbine. The wind speed is determined from the Doppler shift induced on the light scattered off the airborne aerosols in the focus region of the laser beam. Theoretical investigations are in progress on the correlation between the wind speed measured in the small volume of the focus region and the total wind as seen by the whole rotor. Also, strategies to control the turbine using this new information are discussed and implemented. By implementing the laser anemometer together with the control system, the main benefits are foreseen to be reduced mechanical stresses due to wind gusts in strong winds and an increased energy yield at low wind speeds.

Partners: NEG Micon A/S (DK); Howden Laser Division (UK); Wind Engineering APS (DK)

Sponsor: EU

Contact: Sten Frandsen, sten.frandsen@risoe.dk +45 4677 5072

Title: Operation and Maintenance Economics of Wind Turbines

Programme: VIM, **project no.:** 1120105-00, **start date:** 1998.01.01, cont.

Description: The purpose of the project is as follows: an update of data and statistics on establishment, operation and maintenance costs with specific weight on the 500-750 kW generation; to highlight questions regarding technical and economical lifetime of wind turbines using the data on operation and maintenance costs; to disseminate the results in Denmark as well as on an international basis.

Partners: The wind turbine industry (DK); ELSAM (DK); Elkraft (DK); the Danish Windmill Association

Sponsors: Danish Energy Agency, case no 51171/96-0039 (UVE).

Contact: Peter Hjuler Jensen, peter.hjuler@risoe.dk 045 4677 5037

Title: Guidelines for Design of Wind Turbines

Programme: VIM, **project no.:** 1120110-00, **start date:** 1999.01.01, cont.

Description: The knowledge of wind turbine design gained within the last decades is immense and often available only in the form of scattered publications and various notes. The project 'Guidelines for the Design of Wind Turbines' was initiated in order to collect and compile this knowledge and to present it in a clear and easily accessible publication. The publication is produced through a co-operation between Risø National Laboratory and Det Norske Veritas; both parties are involved in wind turbine certification. Thus an important part of the guidelines is to outline current design requirements to be met by a new turbine in order to achieve a type approval.

Partners: Det Norske Veritas (DNV) (DK)

Sponsor: Danish Energy Agency 'Development programme for renewable energy', case no. 51151/98-0036.

Contact: Jesper H. Schaarup, jesper.schaarup@risoe.dk +45 4677 5065

Title: Type Approval of Domestic Wind Turbines 2000

Programme: VIM, **project no.:** 1120112-00, **start date:** 2000.01.01, cont.

Description: Commercial type approval (HC- and HB-Approval) according to "Technical basis for approval of wind turbines with rotor diameter between 2 and 13 meters". 1) HB-Type approval of Calorius type 37 version 3

Partners: None

Sponsor: None

Contact: Poul Højholdt, poul.hoejholdt@risoe.dk +45 4677 5063

Title: Availability of Offshore Wind Farms

Programme: VIM, **project no.:** 1120117-00, **end:** 2001

Description: The purpose of the project is to analyse the availability of offshore wind farms considering the difficulties in order to maintain the farm. The availability is analysed accounting for the influence of environmental conditions (winds, waves, temperatures etc). The project seeks to include the preventive and corrective maintenance as well as the accessibility for the personnel.

Partners: Systems Analysis Dept. (Risø); SEAS Wind Energy Centre (DK)

Sponsor: Danish Energy Agency 'Development programme for renewable energy', case no 51171/98-0033.

Contact: Thomas Krogh, thomas.krogh@risoe.dk, +45 4677 5062

Title: Certification of Wind Turbines

Programme: VIM, **project no.:** 1120120-00, **start date:** 2000.01.16, cont.

Description: Certification of wind turbines is made by Det Norske Veritas, Denmark (DNV) in a technical co-operation with Risø. Through its foundation in DNV and Risø organisations and on the basis of their experienced and

highly qualified staffs, this co-operation will cover all technological areas necessary for design verification of wind turbines.

Partners: Det Norske Veritas, Denmark (DNV)

Sponsor: a private firm

Contact: Erik R. Jørgensen, erik.e.joergensen@risoe.dk +45 4677 5064

Title: Consultancy to Danish Energy Agency

Programme: VIM, **project no.:** 1120122-00, **start date:** 2000.02.28, cont.

Description: Assistance to Danish Energy Agency in formulating the strategy and action plan for research and development in the period 2000 to 2004. Evaluation of individual applications for R&D funding under the wind energy research programmes EFP and UVE.

Partners: Danish Energy Agency

Sponsor: Danish Energy Agency

Contact: Egon T.D. Bjerregaard, egon.bjerregaard@risoe.dk +45 4677 5086

Title: Fatigue Strength and Life of Wind Turbine Components

Programme: VIM, **project no.:** 1120124-00, **start date:** 2000.05.01, cont.

Description: The aim of the project is to develop probabilistic tools that are useful in assessing the fatigue strength and service lifetime of large wind turbine components. Applying these tools it is possible to evaluate the uncertainties related to the computations of service life times which are necessary when judging the economical risks associated with the establishment of new offshore wind turbine sites.

Partners: Elsamprojekt (DK); some factories (DK); Materials Research Department (AFM), Risø

Sponsor: ELTRA (DK)

Contact: C.P. Debel (AFM), c.p.debel@risoe.dk +45 4677 5061 or Niels Jacob Tarp-Johansen (VIM), niels.jacob.tarp-johansen@risoe.dk +45 4677 5078

Title: Environmentally Sound Design and Recycling of Wind Turbines

Programme: VIM, **project no.:** 1120127-00, **start date:** 2000.12.20

Description: The aim of the project is to develop methodologies that can be applied for Life cycle assessment studies of future wind turbines. Technology forecast methods are applied in the project.

Partners: Systems Analysis Department, Per Dannemand Andersen

Sponsor: Danish Energy Agency

Contact: Egon T.D. Bjerregaard, egon.bjerregaard@risoe.dk +45 46775086

Title: Recommendations for Design of Offshore Wind Turbines, RECOFF

Programme: VIM, **project no.:** 1120129-00, **start date:** 2001.01.24

Description: The objective is to prepare guidelines and recommendations for design of offshore wind turbines. The main intended use of these guidelines and recommendations are to serve as a basis for development of European and national standards and certification rules for offshore wind turbines. The project aims to undertake the crucial background work required to form the basis of a design standard. Existing knowledge will be reviewed and new applied research undertaken where necessary. Additionally, the results of the project may be used directly by manufacturers and consultants in their design process. These results may be of assistance in setting up tender documents for future offshore wind energy projects. The project relates complementarily to the Danish project 'Combination of external loads' (no.: 1120133-00).

Partners: GarradHassan & Partners Ltd (UK), Germanischer Lloyd AG (DE), Netherlands Energy Research Foundation (NL) and Centre for Renewable Energy Sources (GR)

Sponsor: EU

Contact: Sten Frandsen, sten.frandsen@risoe.dk +45 4677 5072

Title: Improved Design Rules for Large Wind Turbine Blades

Programme: VIM, **project no.:** 1120130-00, **start date:** 2001.03.13

Description: A research and development based effort is carried out, leading to more rational design rules regarding large wind-turbine blades, based on materials research, structural analysis and experiments.

Partners: The Materials Research Department at Risø; Technical University of Denmark; Aalborg University (DK); LM Glasfiber A/S (DK); Vestas Wind Systems (DK)

Sponsor: EFP, Ministry of Energy and Technology (DK)

Contact: Christian Debel, christian.debel@risoe.dk +45 4677 5061

Title: Optimised and Uniform Safety and Reliability of Offshore Wind Turbines (an account)

Programme: VIM, **project no.:** 1120132-00, **start date:** 2001.05.29

Description: The project is an account. The aim is to make a survey of how the total safety of wind turbines against structural failure depends on the turbines' structural safety and on the reliability of the control and safety system.

Partners: Systems Analysis Dept., Risø; Det Norske Veritas; Energy Centre of the Netherlands; Aalborg University (DK)

Sponsor: ELKRAFT (DK)

Contact: Niels Jacob Tarp-Johansen, niels.Jacob.tarp-johansen@risoe.dk +45 4677 50 5078

Title: Combination of External Loads on Wind Turbine Structures

Programme: VIM, **project no.:** 1120133-00, **start date:** 2001.06.21

Description: When offshore projects become large, and when wave and ice loads become of more importance, compared to wind loads, in the design of offshore turbines optimal design depends heavily on optimal design regulations, i.e. on the precise specification of the combined external loads. The project deals with the surveying of the environmental loads on offshore turbines situated in the Danish seas. Emphasis is put on the concerted action of the loads and safety levels. The project relates complementarily to the European RECOFF project (no.: 1120129-00).

Partners: SEAS Distribution AmbA (DK); Carl Bro (DK); Danish Hydraulic Institute (DK); Techwise A/S (DK)

Sponsor: PSO (DK); ELTRA (DK)

Contact: Sten Frandsen, sten.frandsen@risoe.dk +45 4677 5072

Title: Fundamentals for Remote Condition Monitoring of Wind Turbine Blades

Programme: VIM, **project no.:** 1120134-00, **start date:** 2001.06.25

Description: Since in the future large wind turbines will be located in large wind farms placed offshore, they will be relatively inaccessible. Consequently remote on-shore monitoring of the blade integrity is desirable. In this project the potential of various sensors is investigated to assess the initiation and extension of structural blade damage.

Partners: The Materials Research Department at Risø; Force; Innospection (DK); LM Glasfiber A/S (DK)

Sponsor: Programme: Public Service Obligation – PSO (DK)

Contact: Christian Debel, c.p.debel@risoe.dk +45 4677 5061 or 5819

Title: Contract Concerning Services to Danish Energy Agency (DEA)

Programme: VIM, **project no.:** 1120299 **start date:** 2001.01.10

Description: The primary task is to assist DEA in managing the Danish Approval Scheme for Wind Turbines. In 2001 the activities have been within the following three categories. 1) Information and management support to DEA on technical and economical matters. 2) Maintenance and development of rules and regulations for the technical approval of wind turbines. 3) Development of test methods and preparation of test facilities for a new test station at Høvsøre. The programme consists in total of 13 defined activities with individual scopes. The contract is based on a long-term agreement between DEA and Risø.

Partners: A number of companies and institutions in Denmark and abroad are involved in the activities as members of an advisory committee, a technical committee and ad hoc special interest groups.

Sponsor: Danish Energy Agency

Contact: Egon T.D. Bjerregaard, egon.bjerregaard@risoe.dk +45 4677 5086

Title: Sodar Measurements

Programme: VIM, **project no.:** 1120299-3-2, **start date:** 2001.01.10

Description: Test of commercially available acoustic wind sensor

Partners: None

Sponsor: None

Contact: Jørgen Højstrup, jorgen.hojstrup@risoe.dk +45 4677 5092

Title: General Programme for Information Activities, International Cooperation, and R&D Related to Standardisation and New Test Methods

Programme: VIM, **project no.:** 1120301, **start date:** 2001.01.10

Description: The programme covers activities that are supplementary to the activities sponsored by DEA and others. A total of eight different tasks are defined under this internal programme, where most sections of the Wind Energy Department participate.

Partners: None

Sponsor: None

Contact: Egon T.D. Bjerregaard, egon.bjerregaard@risoe.dk +45 4677 5086

Title: Blade Test Development

Programme: VIM, **project no.:** 1120301-7, **start date:** 2000.11.01, cont.

Description: Development of new and more informative methods for blade testing

Partners: None

Sponsor: Danish Energy Agency

Contact: Carsten Skamris, c.skamris@risoe.dk +45 4677 5066

4.6 Wind Turbine Diagnostics (VMD)

Title: Confidential

Programme: VMD, **project no.:** 1125003-01, **start date:** 2000.08.17

Description: Consultancy regarding wind resources, turbulence problems and power performance

Partners: None

Sponsor: Confidential

Contact: Jørgen Højstrup, jorgen.hojstrup@risoe.dk +45 4677 5092

Title: Experimental Investigation of Ultimate Loads

Programme: VMD, **project no.:** 1125086-00, **start date:** 1997.01.01, cont.

Description: The purpose of the project is to measure both wind field and structural response on wind turbines under extreme conditions (high wind and large wind gusts) and to describe extreme events in order to support and improve codes and standards.

Partners: NEG-Micon A/S (DK)

Sponsor: None

Contact: Søren Markkilde Petersen, soeren.m.petersen@risoe.dk
+45 4677 5043

Title: Identification of Variables for Site Calibration and Power Curve Assessment in Complex Terrain (Sitepariden)

Programme: VMD, **project no.:** 1125101-00, **start date:** 1998.08.01, cont.

Description: The Sitepariden project aims to contribute to a better understanding of the parameters that affect the power curves in complex terrain as compared to the parameters in flat terrain. The project consists of two major components: 1) Site calibration and power curve assessment in flat and complex terrain on geometrically identical turbines and 2) Inter-comparison of the response of some of the partner-used cup anemometers in natural conditions both in flat and complex terrain. Most of the tasks are completed and data analysis is commenced.

Partners: Center for Renewable Energy Sources CRES (GR); DEWI; Windtest (DK); Netherlands Energy Resource Foundation ECN (NL); NEG-Micon A/S (DK); Bonus Energy A/S (DK)

Sponsor: EU; The Danish Energy Research Programme (EFP)

Contact: Ioannis Antoniou, ioannis.antoniou@risoe.dk +45 4677 5082

Title: CLASSCUP

Programme: VMD, **project no.:** 1125103-00, **start date:** 1998.09.01, cont.

Description: The primary objective is to produce a cup anemometer design with a combined inherent uncertainty of less than 0.5 % or 0.05 m/s, related to a developed classification system. A secondary objective is to prepare a classification system, which will allow users of anemometry in the wind energy field to select anemometers suited to specific applications required. For known ranges of environmental operational conditions, for wind turbines and cup anemometers, the user of the system shall be able to assess the accuracy of cup anemometers, and to compare different designs.

Partners: FFA (SE); DEWI (DE).

Sponsor: EU RTD, Non Nuclear Energy Programme JOULE III JOR3-CT98-0263

Contact: Troels Friis Pedersen, troels.friis.pedersen@risoe.dk +45 4677 5042

Title: CLASSCUP

Programme: VMD, **project no.:** 1125103-00, **end:** May 2001

Description: The primary objective is to produce a cup anemometer design with a combined inherent uncertainty of less than 0.5 % or 0.05 m/s, related to a developed classification system. A secondary objective is to prepare a classification system, which will allow users of anemometry in the wind energy field to select anemometers suited to specific applications required. For known ranges of environmental operational conditions, for wind turbines and cup anemometers, the user of the system shall be able to assess the accuracy of cup anemometers, and to compare different designs.

Partners: FFA (SE); DEWI (DE).

Sponsor: EU RTD, Non Nuclear Energy Programme JOULE III JOR3-CT98-0263.

Contact: Troels Friis Pedersen, troels.friis.pedersen@risoe.dk +45 4677 5042

Title: ADAPTURP

Programme: VMD, **project no.:** 1125108-00, **start date:** 1998.12.01, cont.

Description: The purpose is to examine the total design envelope criteria of selected wind turbines for complex terrain operation, and to quantify and verify the performance of the adapted stall, pitch and variable speed wind turbines through detailed wind, load, power and machine condition measurement programs.

Partners: CRES (GR); CIEMAT (ES); TG (SE); Gamesa (ES); ECN (NL)

Sponsor: None

Contact: Søren Markkilde Petersen, soeren.m.petersen@risoe.dk
+45 4677 5043

Title: Performance and Load Measurements on Land and Offshore Installed Wind Turbines without a Meteorological Mast (SODAR)

Programme: VMD, **project no.:** 1125114-00, **start date:** 2000.01.16

Description: The SODAR project aims to study the possibility of the Sonic Detection And Ranging Devices to measure the wind velocity by means of remote sensing. The reason for this is that wind turbines still grow larger and so do the costs associated with the installation of meteorological masts for the measurement of the wind characteristics. In this phase of the project a SODAR was situated close to the Risø 123m meteorological mast. The goal of the project was to study the instrument itself and to compare the results to cup anemometer measurements. Encouraging results have been obtained.

Partners: -

Sponsor: Danish Energy Agency

Contact: Ioannis Antoniou, ioannis.antoniou@risoe.dk +45 4677 5082

Title: Confidential

Programme: VMD, project no.: 1125115-00, start date:

Description:

Partners:

Sponsor:

Contact: Søren Markkilde Petersen, soeren.m.petersen@risoe.dk
+45 4677 5043

Title: Confidential

Programme: VMD, project no.: 1125116-00 start date:

Description:

Partners:

Sponsor:

Contact: Søren Markkilde Petersen, soeren.m.petersen@risoe.dk
+45 4677 5043

Title: Confidential

Programme: VMD/PRV, project no.: 1155017-01 start date:

Description:

Partners:

Sponsor:

Contact: Søren Markkilde Petersen, soeren.m.petersen@risoe.dk
+45 4677 5043

Title: Power Performance Measurements

Programme: VMD/PRV, project no.: 1155017-02, start date: 2001.02
Description: Power performance measurements on two wind turbines in Italy
Partners: -
Sponsor: Wind turbine manufacturer (DK)
Contact: Troels Friis Pedersen, troels.friis.pedersen@risoe.dk +45 4647 5042

Title: Confidential

Programme: VMD/PRV, project no.: 1155017-03, start date: 2001.02
Description:
Partners:
Sponsor:
Contact: Troels Eske Nielsen, troels.eske.nielsen@risoe.dk, +45 4677 5081

Title: Confidential

Programme: VMD/PRV, project no.: 1155019-01 start date:
Description:
Partners:
Sponsor:
Contact: Uwe Schmidt Paulsen, uwe.schmidt.paulsen, +45 4677 5055

Title: Small Measuring Stations

Programme: VMD, project no.: 1160001-00, start date: 1997.11.20, cont.
Description: Establishment, service and data management for a number of small meteorological measuring stations, typically managed for specific projects or as part of the long term strategic measurements of the department.
Partners: None
Sponsor: Internal, and various external sponsors
Contact: Jørgen Højstrup, jorgen.hojstrup@risoe.dk +45 4677 5092

Title: Risø Mast.

Programme: VMD, project no.: 1160 003-01, start date: 1957.06.06, cont.
Description: Monitoring of meteorological conditions at Risø (nuclear facility) and establishment of a climatological reference data set for Denmark. Profiles of wind speed, direction, air temperature. Also included are measurements of direction variance, relative humidity, barometric pressure, precipitation, duration of sunshine, and solar insolation. Occasional testing of various meteorological sensors.
Partners: None
Sponsor: None
Contact: Jørgen Højstrup, jorgen.hojstrup@risoe.dk +45 4677 5092

Title: Minor Contracts

Programme: VMD, project no.: 1160007-1, start date: 2000-01-01
Description: The project comprises smaller commissioned work and supply of measurement equipment. The customers are mainly companies or institutions working with wind energy, meteorology or environmental protection. An example is the supply of measurement equipment for the technical authorities of the Faroe Islands.
Partners: None
Sponsor: Various
Contact: Ole Frost Hansen, ole.frost@risoe.dk +45 4677 5525

Title: DMU-LMP Measuring Stations

Programme: VMD, **project no.:** 1160011-1, **start date:** 1999.12.01, cont.

Description: The project comprises supply of one meteorological station for the LMP national environmental programme. The station is based on a newly developed data acquisition unit, which digitises analogue and pulse frequency modulated inputs locally, and transfers data serially to a central computer. In addition three existing stations are updated to the level of the new station.

Partners: None

Sponsor: National Environmental Research Institute, NERI (DK)

Contact: Ole Frost Hansen, ole.frost@risoe.dk +45 4677 5525

Title: Confidential

Programme: VMD, **project no.:** 1160012-1 **start date:**

Description:

Sponsor:

Contact: Ole Frost Hansen, ole.frost@risoe.dk +45 4677 5525

Title: South Africa Wind Station

Programme: VMD, **project no.:** 1160013-01 **start date:** 2001.04.05

Description: The project comprises supply of a state-of-the-art automatic battery-powered wind-measuring stations for a 30 m mast recording wind speed statistics, wind direction, air pressure and temperature. The station includes sensors; signal conditioning units, data logger, data storage and data reading equipment. The station is supplied to project no 1170113-00, Wind Farm Project Design, which in turn supplies the station to DANCED.

Partners: None

Sponsor: DANCED

Contact: Ole Frost Hansen, ole.frost@risoe.dk +45 4677 5525

Title: Cape Verde Wind Stations

Programme: VMD, **project No.:** 1160014-01 **start date:** 2001.04.03

Description: The project comprises supply of four state-of-the-art automatic battery-powered wind-measuring stations for 30 m masts recording wind speed statistics and wind direction only. The stations include sensors; signal conditioning units, data logger, data storage and data reading equipment. The stations are supplied to project no 1170003-00, Cape Verde Wind Farms 2, which in turn supplies the stations to The World Bank.

Partners: None

Sponsor: The World Bank

Contact: Ole Frost Hansen, ole.frost@risoe.dk +45 4677 5525

Title: Management of Wind Turbines and Workshop (at The Test Station)

Programme: VMD, **project no.:** 1250002-00, **start date:** 2000.01.17

Description: The aim of the project is to check the income and expenditure in connection with operation of the wind turbines erected at Risø and some parts of expenditures at the workshop.

Partners: None

Sponsor: NESA (DK)

Contact: Per Harvøe, per.harvøe@risoe.dk +45 4677 5038

4.7 International Consulting (INR)

Title: Review of EIA Report for a Wind Farm in Namibia

Programme: INR, **project no.:** 1170002-00, **start date:** 2001.01.10, completed 2001.01.31.

Description: Review of an Environmental Impact Assessment report for a 10 MW wind farm made by a local company. Comparison with international standards and practice for environmental impact assessment.

Partners: Ornis Consult A/S (DK)

Sponsor: DANCED

Contact: Niels-Erik Clausen, niels-erik.clausen@risoe.dk +45 4677 5079

Title: Grid-Connected Wind Farm Extension Project, Cape Verde

Programme: INR, **project no.:** 1170003-00, **start date:** 2001.03.15

Description: Consulting services and technical assistance to the privatised power company, ELECTRA, and the Government of Cape Verde to develop and monitor the project in achieving Electra's obligation towards the Government of Cape Verde and the World Bank regarding the wind power capacity expansion - installation of additional wind generation capacity on the main grids of the islands of Santiago, Sao Vicente and Sal of up to 4.8MW, 1.8MW and 1.2MW, respectively, (Step 2 Wind Farms). The project includes 5 tasks:

Task 1: Meteorological Measurements; **Task 2:** Power System Analyses

Task 3: Consulting Services for an EPC Contract; **Task 4:** Project Performance Evaluation; **Task 5:** First Year Operation and Maintenance Assistance

Partners: Carl Bro A/S (DK); Techwise A/S (DK)

Sponsor: Programa, Energia, Água e Saneamento, Praia, Cape Verde with support from the World Bank/GEF

Contact: Jens Carsten Hansen, carsten.hansen@risoe.dk +45 4677 5074

Title: Wind Resource Assessment in the Dominican Republic

Programme: INR, **project no.:** 1170006-00, **start date:** 2001.09.15

Description: Consulting services regarding siting of masts, selection of equipment, instrumentation and data processing of four masts for wind measurements in the Dominican Republic. Wind climate documentation after one year of operation at four potential wind farm sites.

Partners: MetSupport ApS (DK)

Sponsor: Consorcio Energetico Punta Cana-Macao S.A. (CEPM)

Contact: Niels-Erik Clausen, niels-erik.clausen@risoe.dk +45 4677 5079

Title: Wind Energy Study (for HELCO) for the Big Island of Hawaii

Programme: INR, **project no.:** 1170007-00, **start date:** 2001.10.01

Description: To perform general assessments of the technological and related issues to incorporate increasing levels of wind energy in the isolated electric grid of the island.

Partners: Techwise A/S (DK)

Sponsor: Hawaii Electric Light Co., Inc.

Contact: Jens Carsten Hansen, carsten.hansen@risoe.dk +45 4677 5074

Title: Wind Energy Study in Bermuda.

Programme: INR, **project no.:** 1170008-00, **start date:** 2001.10.20

Description: As a sub-supplier to Tech-wise to review and assess the wind measurements made by the client. To elaborate a wind resource mapping of the

potential sites and review the proposed layout and annual energy production of a proposed offshore wind farm.

Partners: Techwise A/S (DK)

Sponsor: Bermuda Electric Light Company (BELCO)

Contact: Niels-Erik Clausen, niels-erik.clausen@risoe.dk +45 4677 5079

Title: Assessment of Layout and IEC Wind Turbine Class

Programme: INR, **project no.:** 1170009-00, **start date:** 2001.12.10

Description: For a wind farm project in Spain Risø will provide consulting services regarding layout of the wind farm and selection of wind turbine IEC class suitable for the wind climate at the site. The wind measurements will be analysed by WASP Engineering to estimate the turbulence intensity and extreme winds serving as input to the analysis. The analysis of wind turbine class will be made according to the expected new version of IEC 61400-1.

Partners: -

Sponsor: NEG Micon Spain

Contact: Niels-Erik Clausen, niels-erik.clausen@risoe.dk +45 4677 5079

Title: From Wind to Power – A Two-Day Course

Programme: INR, **project no.:** 1170051-01, **start date:** 2001.01.01

Description: In the form of a combined course and workshop, RISØ offered an introduction to the technical matters of wind power during the weekend Saturday 30/6 and Sunday 1/7, immediately prior to the 2001 European Wind Energy Conference & Exhibition in Copenhagen. First day is formed as a half-day general introduction to wind power. Second day is organised as a full-day workshop on selected subjects and problems relevant to the conference.

Partners: None

Sponsor: None

Contact: Per Nørgård, per.norgaard@risoe.dk +45 4677 5076

Title: Site Calibration, 60-MW Wind Farm at Zafarana, Egypt

Programme: INR, **project no.:** 1170076-02, **start date:** 1996, cont.

Description: The project provides a calibration of terrain descriptions of the 60-MW wind farm site at Zafarana, Egypt, for wind flow modelling using an adaptation of the IEC site calibration methodology. It will transfer knowledge of and experience in the methodology and the on-site wind conditions for accurate wind turbine micro siting and information on wind conditions before and after wind farm installation, including turbulence characteristics. Only activity 2001 is data collection. The further data analyses are awaiting the completion of installation of wind farms after which the wind conditions can be compared with conditions before installation.

Partners: -

Sponsor: DANIDA

Contact: Jens Carsten Hansen, carsten.hansen@risoe.dk +45 4677 5074

Title: Capacity Building on Technological and Economic Integration of Wind Energy and other Relevant Renewable Energy Technologies into the Electricity Systems of Pacific Island Countries (PICs)

Programme: INR, **project no.:** 1170089-00, **start date:** 2000.01.25

Description: Potential sites for windmills will be visited as an expansion of the South Pacific Wind Monitoring Programme. A curriculum and proposals for course material will be developed in close collaboration with the institutions and educators from within the region, assuring that the curriculum is applicable to the conditions of the region. The material developed will be used for the training at University of South Pacific. Based on the findings in the former ac-

tivities and the installation of a prototype wind turbine for experimental studies with capacity building purpose, a technical-economic and environmental analysis will be performed for selected wind power cases. Tools for this type of analysis will be provided and demonstrated.

Partners: UNEP Collaborating Centre on Energy and Environment (UCCEE) located at Risø National Laboratory, Denmark

Sponsor: United Nations Environment Programme (UNEP) with the energy and ozone unit as responsible programme.

Contact: Per Nørgård, per.norgaard@risoe.dk +45 4677 5068

Title: Wind Atlas for Egypt

Programme: INR, **project no.:** 1170104-00, **start date:** 1997.12.19, cont.

Description: The objective is to improve the conditions for large-scale wind power development in Egypt through the following. 1) To establish a wind atlas for Egypt with emphasis on those parts where the wind regimes are attractive.

2) To establish an extended and updated wind atlas for the Gulf of Suez. 3) Provision of a decision tool for environmental impacts (especially on bird migration). 4) Provision of recommendations for a common framework of wind farm planning in the Gulf of Suez. 5) Transfer knowledge of and experience in the methodology applied in establishing a wind atlas.

Partners: Ornis Consult A/S (DK); National Environmental Research Institute, NERI, (DK)

Sponsor: DANIDA

Contact: Jens Carsten Hansen, carsten.hansen@risoe.dk +45 4677 5074

Title: NREA/DANIDA 60-MW Wind Farm Project at Zafarana, Egypt

Programme: INR, **project no.:** 1170106-00, **start date:** January 1998, cont.

Description: As Sub-Consultant to COWI A/S to provide consulting services as follows. 1) Pre-award phase: to define scenarios for siting of wind turbines, calculate energy outputs, recommend an optimum use of land, review of power performance estimates submitted by the tenders. 2) Design phase: to prepare a detailed layout of the wind farm including optimisation of annual energy output. 3) Construction phase: to define and review the power curve verification performed by an independent third party.

Partners: COWI A/S (DK)

Sponsor: DANIDA

Contact: Jens Carsten Hansen, carsten.hansen@risoe.dk +45 4677 5074

Title: National Wind Turbine Test Station, India

Programme: INR, **project no.:** 1170111-00, **start date:** 1999.01.01, cont. (VIM project no. 1120111 in 1999)

Description: The main objective of the project is to promote and accelerate wind utilisation in India by establishing national facilities for testing and certification of wind turbines, for the preparation of standards and certification rules and for monitoring of the technical performance of wind turbines in India. During phase 1 of the project, covered by the existing contract for 1999 and 2000, a core professional organisation and facilities for stationary and field power performance measurements have been established and a preliminary type approval system has been developed. Major components in the project include institutional development, training in the form of workshops as well as on-the-job training during testing and certification, and technical assistance with equipment and facilities.

Partners: Det Norske Veritas (India); PEM Consult (DK); NIRAS A/S, (DK)

Sponsor: DANIDA - Danish International Development Agency, Contract no. 1363/503, File no. 104.Indien.179

Contact: Per Lundsager, per.lundsager@risoe.dk +45 4677 5045

Title: Demonstration Wind Farm Project Design, South Africa

Programme: INR, **project no.:** 1170113-00, **start date:** 1999.01.22, cont.

Description: The objective of the assignment is as sub-consultant to Rambøll to assist DANCED in support to initiation of a demonstration wind farm project in Darling, Western Cape, South Africa. During 2001 an on-site wind measurement programme has been initiated with equipment supplied from Risø. Other activities include assistance in preparing plans for the wind farm tendering and implementation.

Partners: Rambøll (DK), CSIR (SA), DARLIPP (SA)

Sponsor: DANCED

Contact: Jens Carsten Hansen, carsten.hansen@risoe.dk +45 4677 5074

Title: Energy Management in Lesotho – Wind Energy Advisor

Programme: INR, **project no.:** 1170116-00, **start date:** 2000.01.25, cont.

Description: Objectives are as follows. **1)** Assistance in selecting areas with potential wind energy resources in Lesotho. **2)** To make wind resource assessment for selected areas of Lesotho and to present results in a wind atlas format. **3)** To apply wind resource assessment results in selected wind-power project feasibility study. **4)** To recommend inputs to a wind energy programme as part of the Lesotho Energy Master Plan. Three sets of measurement equipment are supplied and installed. Measurements are carried out at selected sites for one year after which data analyses and feasibility study are performed.

Partners: Rambøll (DK)

Sponsor: DANCED

Contact: Jens Carsten Hansen, carsten.hansen@risoe.dk +45 4677 5074

Title: Wind Measurements and Wind Power Feasibility at Selected Sites in Tanzania

Programme: INR, **project no.:** 1170118-00, **start date:** 2000.01.01, cont.

Description: The objectives of the assignment are as follows. a) To provide tools and build the capacity in Tanzania to enable wind resource assessment at selected locations, adequate for determining the feasibility of wind power utilisation. b) To determine the feasibility of establishing a pilot wind farm connected to the public power supply system in one of four pre-selected localities. Four sets of measurement equipment are supplied and installed. Measurements are carried out at the pre-selected sites for one year after which data analyses and feasibility study are performed.

Partners: Tanzania Ministry of Energy, TANESCO

Sponsor: DANIDA

Contact: Per Nørgård, per.norgaard@risoe.dk +45 4677 5068

Title: Ghana Wind Resource Assessment Project

Programme: INR, **project no.:** 1170119-00, **start date:** 2001.01.19

Description: The primary aim of the Wind Resource Assessment Project is to consolidate the on-going efforts for identifying and assessing in a proper way the wind energy potentials based on a strengthening of the national stakeholders capability through support to MSD and to other relevant national institutions including the Energy Commission, (EC), The Ministry of Mines and Energy, (MME), and the Kwame Nkrumah University of Science and Technology Kumasi (KNUST) and possibly relevant private consultants.

Partner: Ghana Ministry of Energy, Ghana Energy Commission, KNUST

Sponsor: DANIDA

Contact: Per Nørgård, per.norgaard@risoe.dk +45 4677 5068

4.8 Wind Turbine Testing (VMD/PRV)

Title: Confidential

Programme: VMD/PRV, **project no.:** 1155008-00 **start date:**

Description:

Partners:

Sponsor:

Contact: Søren Markkilde Petersen, soeren.m.petersen@risoe.dk
+45 4677 5043

Title: Confidential

Programme: VMD/PRV, **project no.:** 1155008-08

Description:

Partners:

Sponsor:

Contact: Søren Markkilde Petersen, soeren.m.petersen@risoe.dk
+45 4677 5043

Title: Confidential

Programme: VMD/PRV, **project no.:** 1155016-01 **start date:**

Description:

Partners:

Sponsor:

Contact: Ioannis Antoniou, ioannis.antoniou@risoe.dk +45 4677 5082

Title: Confidential

Programme: VMD/ PRV, **project no.:** 1155016-02

Description:

Partners:

Sponsor:

Contact: Allan Vesth, allan.vesth@risoe.dk +45 4677 5049
Søren Markkilde Petersen, soeren.m.petersen@risoe.dk +45 4677 5043

Title: Confidential

Programme: VMD/PRV, **project no.:** 1155016-03 **start date:**

Description:

Partners:

Sponsor:

Contact: Ioannis Antoniou, ioannis.antoniou@risoe.dk +45 4677 5082

Title: Confidential

Programme: VMD/PRV, **project no.:** 1155016-04 **start date:**

Description:

Partners:

Sponsor:

Contact: Uwe S. Paulsen, uwe.schmidt.paulsen +45 4677 5055

Title: Confidential

Programme: VMD/PRV, **project no.:** 1155016-08 **start date:**

Description:

Partners:

Sponsor:

Contact: Ioannis Antoniou, ioannis.antoniou@risoe.dk +45 4677 5082

Title: Confidential

Programme: VMD/PRV, **project no.:** 1155016-09, **start date:** 2000.10

Description:

Partners:

Sponsor:

Contact: Troels Eske Nielsen, troels.eske.nielsen@risoe.dk, +45 4677 5081

Title: Confidential

Programme: VMD/PRV, **project no.:** 1155016-10 **start date:**

Description:

Partners:

Sponsor:

Contact: Ioannis Antoniou, ioannis.antoniou@risoe.dk +45 4677 5082

Title: Confidential

Programme: VMD/PRV, **project no.:** 1155016-12 **start date:**

Description:

Partners:

Sponsor:

Contact: Ioannis Antoniou, ioannis.antoniou@risoe.dk +45 4677 5082

Title: Confidential

Programme: VMD/PRV, **project no.:** 1155016-14 **start date:**

Description:

Partners:

Sponsor:

Contact: Ioannis Antoniou, ioannis.antoniou@risoe.dk +45 4677 5082

Title: Confidential

Programme: VMD/PRV, **project no.:** 1155016-15 **start date:**

Description:

Partners:

Sponsor:

Contact: Søren Markkilde Petersen, soeren.m.petersen@risoe.dk
+45 4677 5043

Title: Improved verification of productive capacity of wind turbines in wind farms and complex terrain

Programme: VMD/PRV, **project no.:** 1155016-16, **start date:** February 1998 to December 2001

Description: Assessment of problems with verification of power performance measurements in wind farms and complex terrain

Partners: Tripod (DK); Intercon (DK); Bonus Energy A/S (DK); Vestas Wind Systems A/S (DK); NEG-Micon A/S (DK)

Sponsor: Danish Energy Agency

Contact: Troels Friis Pedersen, troels.friis.pedersen@risoe.dk +45 4647 5042

Title: Confidential

Programme: VMD/PRV, **project no.:** 1155016-17 **start date:**

Description:

Partners:

Sponsor:

Contact: Søren Markkilde Petersen, soeren.m.petersen@risoe.dk

+45 4677 5043

Title: Confidential

Programme: VMD/PRV, **project no.:** 1155016-18 **start date:**

Description:

Partners:

Sponsor:

Contact: Ioannis Antoniou, ioannis.antoniou@risoe.dk +45 4677 5082

Title: Confidential

Programme: VMD/PRV, **project no.:** 1155017-01 **start date:**

Description:

Partners:

Sponsor:

Contact: Søren Markkilde Petersen, soeren.m.petersen@risoe.dk

+45 4677 5043

Title: Power Performance Measurements

Programme: VMD/PRV, **project no.:** 1155017-02, **start date:** 2001.02

Description: Power performance measurements on two wind turbines in Italy

Partners: -

Sponsor: Wind turbine manufacturer (DK)

Contact: Troels Friis Pedersen, troels.friis.pedersen@risoe.dk +45 4647 5042

Title: Confidential

Programme: VMD/PRV, **project no.:** 1155017-03, **start date:** 2001.02

Description:

Partners:

Sponsor:

Contact: Troels Eske Nielsen, troels.eske.nielsen@risoe.dk, +45 4677 5081

Title: Confidential

Programme: VMD/PRV, **project no.:** 1155019-01 **start date:**

Description:

Partners:

Sponsor:

Contact: Uwe Schmidt Paulsen, uwe.schmidt.paulsen, +45 4677 5055

4.9 Type Approval and Certification (SPK)

Title: Blade Testing, LM Glasfiber A/S

Programme: SPK, project no.: 1165001, **start date:** 2000.01.14

Description: Sparkær Centre is an accredited testing laboratory for wind turbine blades. The strength of the blade static as well as fatigue is tested. Furthermore the dynamic behaviour, such as natural frequencies and damping is measured. The tests are carried out on the facilities in Sparkær and as field measurements.

Partners: LM Glasfiber A/S

Sponsor: None

Contact: Carsten Skamris, c.skamris@risoe.dk +45 4677 5066

Title: Blade Testing, Vestas Wind Systems A/S

Programme: SPK, **project no.:** 1165002, **start date:** 2000.01.14

Description: The Sparkær Centre is an accredited testing laboratory for wind turbine blades. The strength of the blade static as well as fatigue is tested. Furthermore the dynamic behaviour, such as natural frequencies and damping, is measured. The tests are carried out at the facilities in Sparkær.

Partners: Vestas Wind Systems A/S

Sponsor: None

Contact: Carsten

Skamris, c.skamris@risoe.dk +45 4677 5066

5 Committees and Group Memberships

- Aagaard Madsen, H. Science Panel, NREL-NASA Ames Unsteady Aerodynamics 10m HAWT Wind Tunnel Test
- Barthelmie, R. Technical Committee for the Offshore Wind Energy in Mediterranean and Other European Seas
- Barthelmie, R. American Association of Aerosol Research, Atmospheric Aerosols Working Group
- Barthelmie, R. Technical Committee Conference Offshore Wind Energy in Mediterranean and Other European Seas (and Poster Award Committee member)
- Barthelmie, R. European Aerosol Society Modelling, Working Group EWEA Offshore Wind Energy Special Topic Conference Technical Committee
- Bjerregaard, E. Danish Energy Agency, Task Group for Wind Energy R&D
- Bjerregaard, E. *Secretary*, Danish Energy Agency, Approval Scheme for Wind Turbines
- Clausen, N.-E. Corps of External Examiners, Technical University of Denmark
- Frandsen, S. International Electro-technical Committee (IEC), Technical Committee TC88, Working Group 6, Test procedures for Wind Turbine Testing
- Frandsen, S. Dansk Elektroteknisk Komite, DEK. Teknisk Udvalg 88 (TU88), Sikkerhed af Elproducerende Vindmøller (Danish Electro-technical Committee, Technical Committee TU88, Safety on Wind Turbine Generator Systems)
- Frandsen, S. International Electro-technical Committee, Technical Committee 88 (TC 88), Safety of Wind Turbine Generator Systems, Working Group 3, Offshore Issues
- Gryning, S.E. *Honourable Secretary*, European Association for the Science of Air Pollution (EURASAP)
- Gryning, S.E. *Chairman*, Executive Committee, NOPEX
- Gryning, S.E. International Scientific Committee on the International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes
- Gryning, S.E. Scientific Steering Committee on NATO/CCMS International Technical Meetings on Air Pollution Modelling and Its Application, Conference Series
- Gryning, S.E. *Guest Editor*, Theoretical and Applied Climatology. Special issue on "Land-surface/atmosphere exchange in high-latitude landscapes"
- Gryning, S.E. *Editorial Advisory Board*, Bulgarian Geophysical Journal
- Hasager, C.B. Corps of External Examiners, University of Copenhagen
- Hasager, C.B. Corps of External Examiners, Roskilde University Centre (RUC)
- Hasager, C.B. *Convenor*, European Geophysical Society, Symposium on Land Surface Parameterisation in Global Hydrological and Atmospheric Models
- Hasager, C.B. *Co-convenor*, European Geophysical Society, Symposium on Surface Fluxes - Local Scale Over Land
- Hasager, C.B. Organizing *-representative*, DG VI, Working Group on Remote Sensing Applications Committee, COSPAR Scientific Assembly, USA
- Hasager, C.B. *National EC-representative*, DG VI, Working Group on Remote Sensing Applications on Forest Health Assessment
- Hasager, C.B. Steering Committee, MEAD, EU RTD project
- Hasager, C.B. Steering Committee, WEMSAR, EU RTD project
- Hasager, C.B. *Treasurer*, Erdas Imagine, Danish User Group

Hasager, C.B. *Associate Scientist*, European Space Proposal: surface processes and ecosystems changes through response analysis (SPECTRA). A land surface satellite space mission proposal for the years 2005-

Hauge Madsen, P. *Chairman*, Dansk Standard (DS). Teknisk Udvalg S588, Sikkerhed af Elproducerende Vindmøller (Danish Standard, Technical Committee S588, Safety of Wind Turbine Generator Systems)

Hauge Madsen, P. *Chairman*, International Electro-technical Committee, Technical Committee 88 (TC 88), Safety of Wind Turbine Generator Systems, Working Group 7, Revision of Part 1: Safety Requirements

Hauge Madsen, P. *Chairman*, International Electro-technical Committee (IEC). Technical Committee 88 (TC88), Safety of Wind Turbine Generator Systems, Working Group 9: Certification Procedures of Wind Turbines

Hauge Madsen, P. International Electro-technical Committee (IEC). Technical Committee 88 (TC88)

Hauge Madsen, P. European Standards for Wind Turbines, CENELEC BTTF 83-2

Hauge Madsen, P. *Board Member*, Fuel and Combustion Technology Association, Danish Society of Chemical, Civil, Electrical and Mechanical Engineering (IDA)

Hauge Madsen, P. *Editorial Board*, "Wind Energy", Wiley & Sons

Hauge Madsen, P. Wind Energy Advisory Committee, Danish Energy Agency

Hauge Madsen, P. Danish Energy Agency, Committee on Implementation of IEC-standards in the Danish Type Approval Scheme

Hauge Madsen, P. *National Member*, IEA R&D Wind Executive Committee

Hjuler Jensen, P. Det Norske Veritas (DNV), Expert Committee for Wind Turbines

Hjuler Jensen, P. Germanischer Lloyd, Expert Committee for Wind Turbines,

Hjuler Jensen, P. International Electro-technical Committee (IEC). Technical Committee 88 (TU88), Safety of Wind Turbine Generator Systems

Hjuler Jensen, P. Dansk Elektroteknisk Komite, DEK. Teknisk Udvalg 88 (TU 88) Sikkerhed af Elproducerende Vindmøller (Danish Electro-technical Committee, Technical Committee TU 88 Safety on Wind Turbine Generator Systems)

Hjuler Jensen, P. Committee on Criteria for Design and Certification of Wind Turbines, Danish Energy Agency

Hjuler Jensen, P. International Electro-technical Committee (IEC), Technical Committee 88 (TC 88) Safety on Wind Turbine Generator Systems, MT-14

Hjuler Jensen, P. *Vice President*, European Wind Energy Association (EWEA)

Hjuler Jensen, P. European Standards for Wind Turbines, CENELEC BTTF 83-2

Højholdt, P. Technical Committee for Domestic Wind Turbines

Jensen, N.O. European Geophysical Society. *President*, Oceans and Atmosphere (OA) Section

Jensen, N.O. National Committee of IUTAM (International Union of Theoretical and Applied Mechanics)

Jensen, N.O. National Committee for the International Geosphere-Biosphere Programme (IGBP)

Jensen, N.O. *Editorial Board*, Boundary-Layer Meteorology

Jensen, N.O. *President*, International Commission of Dynamic Meteorology (ICDM) under IAMAS, International Association of Meteorology and Atmospheric Science

Jensen, N.O. *Associate Editor*, Quarterly Journal of Royal Meteorological Society

Jensen, N.O. Scientific Advisory Group, Pan European Programme for the Intensive Monitoring of Forest Ecosystems

Jørgensen, E.R. Steering Committee DNV Wind Turbine Certification
 Jørgensen, H.E. *Vice President*, Danish Meteorological Society
 Kristensen, L. *Associate Editor*, Quarterly Journal of Royal Meteorological Society
 Krogsgaard, J. *Editorial Committee*, European Small Hydro Power Association (ESHA), Atlas of European Small-Scale Hydropower Potential
 Krogsgaard, J. *Editorial Committee*, European Small Hydro Power Association (ESHA), Layman's Guidebook on how to develop a small hydro site
 Krogsgaard, J. *Governing Board*, European Small Hydropower Association (ESHA)
 Krogsgaard, J. *Editorial Committee*, EU Alternner II Program Energy for a Free Europe
 Landberg, L. Steering Committee of Offshore Wind Energy Network, UK
 Landberg, L. Supervisory Committee of the EFP project "Effective siting of wind farms"
 Landberg, L. *Editorial Board*, Wind Engineering
 Landberg, L. Steering Committee, DSAR (Danish Society of Atmospheric Research), Meteorology and Wind Energy
 Larsen, S.E. National Committee for the International Geosphere-Biosphere Programme (IGBP)
 Larsen, S.E. Committee on the Marine Aerosol and Gas Exchange (MAGE) Subproject of the International Global Atmospheric Chemistry Programme IGBP
 Larsen, S.E. National Committee for Climate Research. Danish Committee of the World Climate Programme (WCRP)
 Larsen, S.E. Scientific Committee of EUROTRAC2, a EUREKA Environmental Project.
 Larsen, S.E. Steering Committee, EUROTRAC2-CAPP (Coastal Air Pollution Processes) Project
 Larsen, S.E. Steering Committee DSAR (Danish Society of Atmospheric Research)
 Larsen, S.E. Advisory Board, Vejr2.
 Lundsager, P. *Board Member*, Fuel and Combustion Technology Association, Danish Society of Chemical, Civil, Electrical and Mechanical Engineering (IDA)
 Lundsager, P. International Electro-technical Committee (IEC), On behalf of Technical Committee TC88: Joint Coordination Group for IEC/PAS 62111, Decentralised Hybrid Systems
 Mann, J. Scientific Committee on Boundary Layers and Turbulence, American Meteorological Society
 Mikkelsen, T. *Board Member*, Board of Governors, Risø National Laboratory (elected by Risø's academic personnel)
 Mikkelsen, T. *Board Member*, Risø Strategic Advisory Panel for Nuclear Safety
 Mikkelsen, T., *Board Member*, RODOS Management Group RMG, Radiation Protection Research Programme EU, DG-XI/XII
 Mikkelsen, T. *Work Group Leader* for Atmospheric Dispersion within the RODOS real-time Decision Support System, Community Research
 Mikkelsen, T., *Project Co-ordinator*, Fifth Framework Program on Nuclear Science and Technology "ENSEMBLE", European Commission
 Mikkelsen, T., *Convenor*, European Geophysical Society (EGS) - Mesoscale Transport and Diffusion
 Mikkelsen, T. *Guest Editor*, Journal of Physics and Chemistry of the Earth, 1996 ff.

Mikkelsen, T. *Guest Editor* Physics and Chemistry of the Earth, Part B: Hydrology, Oceans and Atmosphere, Open Session on Mesoscale Transport of Air Pollution

Mortensen, N.G. Nordic TeX Committee

Mortensen, N.G. Quality Control Committee on Exhibition on Energy Production and Environment

Mortensen, N.G. Corps of External Examiners, University of Copenhagen

Mortensen, N.G. Corps of External Examiners, Cairo University

Nielsen, M. *Webmaster Assistant and Alternating member*, The Executive Committee, Danish Meteorological Society

Nørgård, P. Science and Technology Committee, The Society of Danish Engineers

Nørgård, P. *Chairman*, Society for Technology Assessment, The Society of Danish Engineers

Nørgård, P. Corps of External Examiners, Aalborg University, Denmark

Pedersen, T.F. Technical Committee on Certification and Type Approval, Danish Energy Agency

Pedersen, T.F. *Convenor*, International Electro-technical Committee (IEC), Technical Committee 88, Maintenance Task MT12, Power Performance Measurement Procedures

Pedersen, T.F. Dansk Standard (DS). Teknisk Udvalg (S588), Sikkerhed Elproducerende Vindmøller (Danish Standard, Technical Committee S588, Safety on Wind Turbine Generator Systems)

Pedersen, T. F. *Secretary*, MEASNET Expert Group on Power Performance Measurements

Pedersen, T.F. Underudvalg under Teknisk Udvalg vedrørende godkendelse af vindmøller, krav til anemometri, Energistyrelsen (Subcommittee under Technical Committee on wind-turbine approval, demands for anemometry)

Petersen, E.L. EUREC-Agency EEIG

Petersen, E.L. *Editorial Board*, International Journal of Solar Energy

Petersen, E.L. *Editor*, "Wind Energy", Wiley & Sons

Rasmussen, F. *Editorial Board*, "Wind Energy", Wiley & Sons

Rasmussen, F. Science Panel, NREL-NASA Ames Unsteady Aerodynamics 10m HAWT Wind Tunnel Test

Schaarup, Jesper H. *Secretary*, Danish Energy Agency, Approval Scheme for Wind Turbines

Skamris, C. International Electro-technical Committee (IEC), Technical Committee TC88, Working Group 9: Certification Procedures of Wind Turbines

Skamris, C. Danish Energy Agency, Technical Committee (IEC), Technical Committee on Certification and Type Approval

Skamris, C. Danish Energy Agency, Advisory Board. Working Group: Certification and Testing of Blades for Wind Turbines

Skamris, C. Dansk Standard (DS). Teknisk Udvalg S588, Sikkerhed af Elproducerende Vindmøller (Danish Standard, Technical Committee S588, Safety of Wind Turbine Generator Systems)

Sørensen, L.L. Scientific Committee of the Nordic Network for Research and Education Project "Integrated approaches to drainage basin nutrient inputs and coastal eutrophication"

Sørensen, P. International Electro-technical Committee (IEC), Technical Committee TC88, Working Group 10

Sørensen, L.L. . Steering Committee, MEAD, EU RTD project

Thomsen, C.L. Danish Energy Agency, Advisory Board. Working Group: Certification and Testing of Blades for Wind Turbines

Thykier-Nielsen, S. Ad Hoc Group on the NEA/CEC Intercomparison Exercise on PCA Codes

6 Publications

6.1 International publications

- Astrup, P.; Mikkelsen, T.; Deme, S. (2001) METRODOS: Meteorological pre-processor chain. *Phys. Chem. Earth (B)*, **26**, 105-110
- Barthelmie, R.J. (2001) Evaluating the impact of wind induced roughness change and tidal range on extrapolation of offshore vertical wind speed profiles. *Wind Energy*, **4**, 99-105
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- Dahlberg, J.-Å.; Gustavsson, J.; Ronsten, G.; Pedersen, T.F.; Paulsen, U.S.; Westermann, D. (2001) Development of a standardized cup anemometer suited to wind energy applications. Publishable final report, Contract JOR3-CT98-0263, June 2001
- Dannemand Andersen, P.; Bjerregaard, E. (2001) Prospective life-cycle assessment on wind power technology by 2020. *TA-Datenbank-Nachrichten*, **10**, 100-106
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- Tarp-Johansen, N.J. (2001) Design and safety. Visit by the Finnish Wind Power Association Group, Risø National Laboratory, 20 September 2001. Unpublished
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- Thomsen, K. (2001) Aeroelasticity - status and results (in Danish). Danish Energy Agency: Technical wind energy conference, Billund (DK), 26-27 March 2001. Unpublished

6.7 Patent applications

- Rasmussen, F.; Aagaard Madsen, H. (2001) DK patent application PA 2001 00641

6.8 Educational activities

- Bak, C. (2001) Aerodynamics and loads. Aeroelastics, safety and performance. Risø course: from wind to power (in connection with the EWEC 2001 European wind energy conference), Copenhagen (DK), 1 July 2001. Unpublished
- Bak, C.; Hansen, M.H. (2001) Aeroelasticity, lifelong education. University of Aalborg (DK), 21 August 2001. Unpublished
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- Bak, C. (2001) Wind turbine aerodynamics. Education programme for the National Wind Turbine Test Station, India, Risø National Laboratory, 7 November 2001. Unpublished
- Bindner, H. (2001) Integration of various renewable technologies. Risø course: From wind to power (in connection with the EWEC 2001 European wind energy conference), Copenhagen (DK), 30 June - 1 July 2001. Unpublished
- Dellwik, E. (2001) Evapotranspiration in Soil-Vegetation-Atmosphere-Transfer (SVAT) models. Lecture, The Technical University of Denmark, Lyngby (DK), 23 February 2001. Unpublished
- Hansen, A.D. (2001) Electrical components, control strategies and grid integration. Risø course: From wind to power (in connection with the EWEC 2001 European wind energy conference), Copenhagen (DK), 30 June - 1 July 2001. Unpublished
- Hansen, A.D. (2001) Wind energy and wind turbines. Lecture, University of Aalborg, Aalborg (DK), 24 October 2001. Unpublished
- Hansen, A.M. (2001) Finite element method. C-WET expert training, Risø National Laboratory (DK), November 2001. Unpublished
- Hansen, J.C. (2001) Wind power projects: Feasibility analysis, wind farm siting, performance verification, and institutional aspects. Risø course: From wind to power (in connection with the 2001 European wind energy conference), Copenhagen (DK), 30 June - 1 July 2001. Unpublished
- Hjuler Jensen, P. (2001) Market and policies. Risø course: From wind to power (in connection with the EWEC 2001 European wind energy conference), Copenhagen (DK), 30 June - 1 July 2001. Unpublished
- Landberg, L. (2001) Wind prognostics. NIF Course 2001, Trondheim (NO), 10 January 2001. Unpublished
- Landberg, L. (2001) Wind turbine technology and aerodynamics. Four lectures at The Technical University of Denmark, Lyngby (DK), March 2001. Unpublished

- Landberg, L. (2001) Wind resources: Overview of methods and tools to estimate the wind resources and the wind design conditions. Risø course: From wind to power (in connection with the EWEC 2001 European wind energy conference), Copenhagen (DK), 30 June - 1 July 2001. Unpublished
- Larsen, S.E. (2001) Patterns and processes in atmospheric dispersion. Two lectures at the NorFa Summer School on coastal eutrophication, Tallinn (Estonia), 31 August – 3 September. Unpublished
- Mann, J. (2001) Resource assessment: wind resource estimation, short-term prediction, and design wind conditions. Risø course: From wind to power (in connection with the EWEC 2001 European wind energy conference), Copenhagen (DK), 30 June - 1 July 2001. Unpublished
- Markkilde Petersen, S. (2001) Measurement methods: reference tests, wind turbine and blade tests, materials and fatigue. Risø course: From wind to power (in connection with the EWEC 2001 European wind energy conference), Copenhagen (DK), 30 Jun - 1 Jul 2001. Unpublished
- Nørgård, P. (2001) From wind to power. Risø course: From wind to power (in connection with the EWEC 2001 European wind energy conference), Copenhagen (DK), 30 June - 1 July 2001. Unpublished
- Schaarup, J. (2001) Wind turbine design: Design basis, methods and concepts, aeroelastic design, wind turbine certification. Risø course: From wind to power (in connection with the EWEC 2001 European wind energy conference), Copenhagen (DK), 30 June - 1 July 2001. Unpublished
- Sørensen, P. (2001) Wind energy development and research. Lecture, Institute of Industrial Science, University of Tokyo, Tokyo (JP), 19 October 2001. Unpublished
- Tarp-Johansen, N.J. (2001) Offshore wind turbines. Risø course: From wind to power (in connection with the EWEC 2001 European wind energy conference), Copenhagen (DK), 30 June - 1 July 2001. Unpublished
- Thomsen, K. (2001) Aerodynamic damping and HAWCDAMP (in Danish). Two-day course, LM Glasfiber, Lunderskov (DK), 27-28 September 2001. Unpublished
- Thomsen, K. (2001) Aeroelastic load simulations, FLEX5 sample. C-WET expert training, Risø National Laboratory (DK), November 2001. Unpublished
- Thomsen, K. (2001) Wind turbine fatigues. C-WET expert training, Risø National Laboratory (DK), November 2001. Unpublished
- Thomsen, K. (2001) Wind turbine aeroelasticity. C-WET expert training, Risø National Laboratory (DK), November 2001. Unpublished
- Thomsen, K. (2001) Wind turbine structural mechanics/dynamics. C-WET expert training, Risø National Laboratory (DK), November 2001. Unpublished
- Thomsen, K. (2001) Wind characteristics. C-WET expert training, Risø National Laboratory (DK), November 2001. Unpublished

6.9 Seminars held in the department

- Deme, Sandor “Concentration and radiation fields near buildings”, May
- Lyons, Tom “Land-atmosphere interaction in a semi-arid region”, October
- Soriano, Cecilia “Meteorological prognostic models and Lidar remote sensing for the investigation of the atmosphere: the Barcelona experience”, August
- Zielinski, T. “Aerosol extinction and optical thickness in the coastal areas”, August

6.10 Assignments and Awards

Gryning, S.E. (2000) ITM Scientific Committee Award 2000 for providing outstanding leadership in organizing and conducting five NATO/CCMS international technical meetings on air pollution modelling and its application: 1993 (Spain); 1995 (Maryland, USA); 1997 (France); 1998 (Bulgaria), and 2000 (Colorado, USA)

7 Staff and Guests

7.1 Staff

Administration (LAM)

Clausen, Gitte, *Project Administrator* (maternity leave till 12 December)

Hyllested, Karen, *Administrative officer*

Harvøe, Per, *Administrative Officer*

Madsen, Peter Hauge, *Deputy Department Head*

Petersen, Erik Lundtang, *Department Head*

Secretaries

Andreasen, Mette F. (Trainee, till 1 April 2001)

Christiansen, Ulla Riis

Sørensen, Else Holst, (Temporary Assistant)

Programme: Aeroelastic Design (AED)

Scientific staff

Bak, Christian

Bertagnolio, Franck

Fuglsang, Peter

Hansen, Anders Melchior

Hansen, Morten, Hartvig

Johansen, Jeppe

Larsen, Gunner

Larsen, Torben Juul

Madsen, Helge Aagaard

Nim, Erik (till 1 October 2001)

Petersen, Jørgen Thistrup (on leave 01.06.01 – 31.05.02)

Flemming Rasmussen, *Programme Head*

Sørensen, Niels Nørmark

Thomsen, Kenneth

PhD students, graduates and postdoctoral researchers

None

Secretary

Madsen, Tina Precht

Programme: Atmospheric Transport and Exchange (ATM)

Scientific staff

Astrup, Poul

Gryning, Sven Erik

Hasager, Charlotte Bay

Jensen, Niels Otto

Jørgensen, Hans

Larsen, Søren, *Programme Head*

Mikkelsen, Torben (*Research Expert*)
Nielsen, Morten
Pryor, Sara (8 May 2001 – 31 August 2002)
Sørensen, Lise Lotte
Thykier-Nielsen, Søren

PhD students, graduates and postdoctoral researchers

Dellwik, Ebba (on maternity leave from 24 September)
Dunkerley, Fay
Frohn Lise (in a collaboration with NERI)

Secretary

Skrumsager, Birthe

Programme: Electric Design and Control (EDS)

Scientific staff:

Bindner, Henrik W.
Hansen, Anca Daniela
Hansen, Lars Henrik (till 15 May 2001)
Hauge Madsen, Peter, *Programme Head*
Nørgaard, Per (from 1 September 2001)
Pulle, Duco W.J. (19 November 2001 – 19 April 2002)
Sørensen, Poul

PhD students, graduates and postdoctoral researchers

De Barros, Eliza Medeiros (till 20 June 2001)
Rasmussen, Mikkel Hjortshøj
Rosas, Pedro André

Secretary

Madsen, Jytte

Programme: International Consulting (INR)

Clausen, Niels Erik
Hansen, Jens Carsten, *Head*
Jørgensen, Lars (guest scientist 1 October 01 – 30 September 02)
Lundsager, Per

Secretary

Kiler, Diana

Programme: Wind Power Meteorology (VKM)

Scientific staff

Badger, Jake
Barthelmie, Rebecca
Giebel, Gregor (from 1 July)
Frank, Helmut (till 1 August)
Jørgensen, Bo Hoffmann (from 1 February)
Kristensen, Leif (retired 1 April 2001)
Landberg, Lars, *Programme Head*
Mann, Jakob
Mortensen, Niels Gylling
Nedaud, Cyril (10 December 2001 – 10 July 2002)
Ott, Søren (from 1 November 2001)
Rathmann, Ole
Sempreviva, Anna Maria

PhD students, graduates and postdoctoral researchers

None

Sales Co-ordinator

Nielsen, Rikke

Secretary

Werner, Anette

Programme: Wind Turbines (VIM)**Scientific staff**

Bjerregaard, Egon

Debel, Christian

Frandsen, Sten Tronæs

Højholdt, Poul

Jensen, Peter Hjuler, *Programme Head*

Jørgensen, Erik Rosenfeldt

Krogh, Thomas

Noe Poulsen, Peter (till 1 November 2001)

Preem, Mikkel (till 30 April)

Schaarup, Jesper

Tarp-Johansen, Niels

Thøgersen, Morten Lybech (till 1 March)

PhD students, graduates and postdoctoral researchers

None

Technical staff

Hagensen, Flemming (retired 8 October 2001)

Lange, Rolf

Secretaries

Bødker, Bodil

Westermann, Kirsten

Programme: Wind Turbine Diagnostic (VMD)**Scientific staff**

Antoniou, Ioannis

Enevoldsen, Karen

Hansen, Ole Frost

Højstrup, Jørgen, *Programme Head*

Krogsgaard, Jørgen

Møller, René

Nielsen, Troels Eske

Paulsen, Uwe Schmidt

Pedersen, Troels Friis, *Research Expert*

Petersen, Søren Markkilde, *Task Leader*

Sanderhoff, Peter

Vesth, Allan

Technical staff

Andersen, Anker Bruun

Borchsenius, Jens

Christensen, Kurt

Christensen, Lars

Clemmensen, Kaspar

Hansen, Arent (retired 6 April 2001)

Hansen, Finn

Hansen, Per

Høst, Oluf

Jensen, Gunnar

Larsen, Gert

Lund, Søren

Nielsen, Finn Linke

Nielsen, Jan

Rasmussen, Michael

Secretaries

Hansen, Anne-Marie

Henriksen, Mette Porsdal (on maternity leave till 1 November 2001)

Sparkær Centre (Type Approval and Certification)

Eisenberg, Yoram

Hornbech, Jan

Kristensen, Ole Dahl

Pedersen, Henrik Broen

Skamris, Carsten, *Head*

Thomsen, Christian Leegaard

Technical staff

Foget, Mads Holler (from 1 January)

Lind, Peter Henrik, *Works Foreman*

Stæhr, Jimmy Holm

Thinggaard, Jesper (till 1 March)

Vestergaard, Anders Ramsing (from 1 January)

Secretary

Kristensen, Bente Hangaard

7.2 Guests (for one week or more)

Jørgensen, Lars

01.10.01-20.09.02

DANIDA

Pryor, Sara

08.05.01-31.08.02

Indiana University, USA

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Birthe Skrumsager, Søren E. Larsen and Peter Hauge Madsen (Eds)

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Abstract (max. 2000 characters)

The report describes the work of the Wind Energy Department at Risø National Laboratory in 2001. The research of the department aims to develop new opportunities in the exploitation of wind energy and to map and alleviate atmospheric aspects of environmental problems. The expertise of the department is utilised in commercial activities such as wind turbine testing and certification, training programmes, courses and consultancy services to industry, authorities and Danish and international organisations on wind energy and atmospheric environmental impact. A summary of the department's activities in 2001 is shown, including lists of publications, lectures, committees and staff members.

Descriptors INIS/EDB

AIR POLLUTION; METEOROLOGY; PROGRESS REPORT; RISØE NATIONAL LABORATORY; RESEARCH PROGRAMMES; WIND TURBINES