



Wind Energy and Atmospheric Physics Department annual progress report 1999

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Annual Progress Report for 1999 Wind Energy and Atmospheric Physics Department

Søren E. Larsen and Birthe Skrumsager

Abstract The report describes the work of the Wind Energy and Atmospheric Physics Department at Risø National Laboratory in 1999. 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 1999 is presented, including lists of publications, lectures, committees and staff members.

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Annual Progress Report for 1999

Resources and Results

Søren E. Larsen and Birthe Skrumsager

**Risø National Laboratory, Roskilde
June 2000**

1 Introduction

The department's research activities on wind energy and atmospheric processes have the overall objective to advance

- the competitiveness of the Danish wind power industry, setting the scene for implementation of the national energy policy in the area of wind energy and furthering the global application of wind power, and
- the atmospheric physics basis of assessment and forecast of wind effects, transport, conversion and exchange of atmospheric gases and particles in relation to climate studies, air pollution and accidents.

Hence the department aims to meet the need for new knowledge and consultancy assistance on wind turbine technology and the exploitation of wind energy, as well as to map atmospheric processes and alleviate airborne pollution. The research is carried out in co-operation with industry and other users of the research results and in close collaboration and in alliances with national and foreign universities and research organisations.

The activities of the department fall within the Risø program area *Wind Energy and Atmospheric Processes*. It has the objective to develop methods for design; test and siting of wind turbines, prediction of wind loads and wind resources as well as methods to determine the dispersion, transformation and effect of air pollution. The department is organised in programs and special tasks according to its main research and technical activities.

Research programmes:

- [*Aeroelastic Design*](#)
- [*Atmospheric Transport and Exchange*](#)
- [*Electrical Design and Control*](#)
- [*Wind Power Meteorology*](#)
- [*Wind Turbines*](#)

Special tasks:

- [*Experimental Meteorology*](#)
- [*Type-Approvals and Certification*](#)
- [*Wind Turbine and Blade Testing*](#)

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 Transport & Exchange 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.

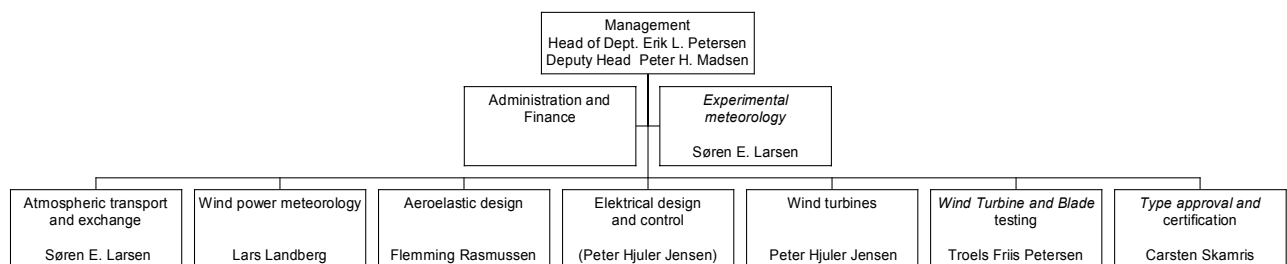
The “Wind Turbine” program conducts strategic and applied research in load and safety, experimental verification, technical/economical analysis of wind energy’s utilisation in grids and in hybrid energy systems. Our research within this program supports our consultancy activities for Danish and international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

The special task “Experimental Meteorology” serves as a departmental expert in organising and conducting field meteorological measurements, providing instruments, data systems, data management and organisation. It serves the research programs of the department and also external customers.

The special task “Wind turbine and blade testing” offers its expertise in measuring techniques for wind turbines and blade testing. The latter is performed at the new blade test facility at the Sparkær test centre we are now able to test blades with a length of up to 40m, both statically and dynamically.

The “Type approval and Certification” task offers type approvals, recommended for wind turbine types in serial production. Type approval is a verification of the wind turbine design according to an approval scheme. This scheme may be extended to cover specific national requirements. This means that Risø can issue type approval certificates according to national rules in Denmark, Germany (Gutachten) and in the Netherlands.

In 1999 the department engaged 91 man-years, 7 of which involved PhD students and post-doctoral researchers. The departmental structure is illustrated in the block diagram below.



The key areas of scientific expertise in the department are boundary layer meteorology, aerodynamics, aero-acoustics, and machine and construction technology. The fields are advanced exploiting full-scale field tests, laboratory tests and advanced numerical simulation.

This annual report presents the department and the results in 1999, 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 departments web pages are constantly updated.

2 The Department of Wind Energy and Atmospheric Physics 1999

The department's achievements in the wind-energy field were commented very favourably by IEA in their evaluation of the EFP program 1992 - 1997. The balance between *long-term fundamental research and good flexibility for solving urgent problems* and a *bottom-up R&D research* based on industrial needs as well as a strong interaction with departmental user groups has been pointed out as an example. Together with the world-wide and especially the nation-wide growth of our wind-energy activities, this has led to an increased demand for the department's services also in 1999, ranging from research results to purely commercial tasks. The positive development of the department's results, economy and presentation of research results is still being continued.

All of our research programs have achieved significant technical-scientific results, and in 1999 we took decisive steps towards fulfilment of the demand for results in Risø's contract for 1999-2001 with the Ministry of Research and Information Technology. Thus the wind turbine industry displayed an interest in WAsP Engineering (a wind-power meteorological prototype design tool) when introduced. Our "numerical wind tunnel" has now reached a development level where applicable results are in a current generation, e.g. in 1999 an answer to the double-stall problem, a nuisance to industry for a long time. A set-up of dynamic profile data for technical aeroelastic calculations has been introduced. The European model system for decision support in case of large nuclear accidents has been finalised and delivered, and Risø is responsible for the central atmospheric dispersion module. Last not least, theoretical and experimental breakthroughs have been obtained in connection with our research activities within soil/vegetation exchange (SVAT).

Through aggressive recruitment and investment initiatives in 1999, the market-controlled business has been a success in several areas for the department, i.e. initiatives such as the blade testing activities in Sparkær and wind-turbine testing in Denmark as well as abroad. The market-controlled approval of wind turbines has been brought into more efficient and innovative continuity through an agreement on co-operation with Det Norske Veritas and a joint implementation of the activity. Also consultancy on wind energy is on the increase, and based on a strategic analysis performed in 1999, we have decided to intensify and co-ordinate our achievement by establishing a new special task. Last not least, the marketing and sale of 214 copies of the latest version of the WAsP wind resource program have strengthened the department's leading international position in the wind-energy field.

This development has been a great challenge to the departmental management as well as the staff. This is illustrated by the employment of about 20 more persons in 1999 among whom three persons came from the IT Service Department. The latter have re-vitalised the development of advanced measuring systems for research and testing in our department.

3 Status for the Department 1999

The Department is responsible for Risø's program area "Wind Energy and Atmospheric Processes". This program area has the following objective: Development of methods for design, testing and siting of wind turbines, determination of wind loads and wind resources, as well as methods for determining the dispersion, conversion and effects of airborne pollution.

The department is responsible for a number of the performance requirements listed within the performance contract between the Ministry of Research and Information Technology and Risø National

Laboratory. At mid-term, by the end of 1999, the fulfilment of the performance requirements of the department was as indicated in the table below.

3.1 Social and industrial relevance in Denmark and abroad

Danish wind power enjoys tremendous success. Expansion in Denmark has exceeded the objectives of Danish energy policy. Denmark is at the forefront of development and expertise; an industry has been established on a scale that provides 15,000 jobs in Denmark, supplying more than one-half of the world market. World-wide, as 1999 drew to a close, wind turbines having a capacity of 14,000 MW had been set up, producing 30 TWh, equivalent to Denmark's electricity production.

The Danish wind energy industry has more than 20 years' experience in research, development, production and use of wind energy, and wind power has become a distinctive and accepted part of the Danish electricity supply. The Danish wind turbine industry has seen growing volume of business and market share, with a volume of approx. DKK 14,000 million in 1999, equivalent to a 50–60% share of the world market. This trend in Denmark has been made possible through sustained political and public support and close interaction of government support of the market, research programmes, research and industry. Risø has played a crucial part in this development.

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.

Performance requirements of the contract and degree of fulfilment midway in the contract period:

1	Wind power meteorological dimensioning tool, the Wind Atlas Analysis and Application Program (WASP Engineering)	
	Development of an IT-based complex of user-friendly, commercially available wind power meteorological dimensioning tools that enable global prediction and assessment of dimensioning wind conditions for wind turbines and other structures on land, on non-homogenous and complex terrain as well as in near-shore waters.	80%
2	Establishment of a "numerical wind tunnel"	
	Setting up a coherent collection of numerical tools to determine flows around wind turbines and to enable fundamental studies of the aerodynamic properties of blades/wind turbines, as well as to interpret field experiments and improve empirical methods.	75%
3	Basic design of a new concept for a three-bladed wind turbine	
	Development, in collaboration with industry, of the next generation of a flexible three-bladed wind turbine concept with extended design and optimisation possibilities in relation to the existing Danish concept, resulting in continued improvement of the yield/cost ratio.	80%
4	Establishment of a database for advanced blade profiles	
	Development of a method for determining blade profile data and establishment of a database for blade profiles to describe the static and dynamic properties of the profiles in question before and after stalling; for use in aeroelastic calculations.	50%
5	Decision support system for nuclear emergencies (RODOS 2000)	
	In collaboration with European emergency management organisations, demonstration of a real time decision support system based on models recognised at European level. It provides multi-scale dispersion descriptions of airborne pollution from point sources with on-line use of meteorological networks and terrain descriptions and allows greater certainty in identifying areas at risk and, thus, more targeted protective measures. The decision support system has been adopted by European emergency management organisations	100%
6	Model for soil-vegetation exchange (SWAT)	
	Development of a verified two-dimensional model for the purpose of calculating the exchange of water vapour, CO ₂ and other trace gases between the atmosphere and vegetated surfaces, having more extensive application in realistic heterogeneous situations, compared with current one-dimensional models	65%

With atmospheric physics and knowledge of nuclear matters as a basis, Denmark has had a research environment in the area of nuclear safety since the establishment of Risø. Following the Chernobyl accident in 1986, this area of research attracted renewed attention and gave rise to the initial development of a European decision support system - *Real-time On-line DecisiOn Support (RODOS)* – intended as a decision support system for emergency management in Europe in the event of major nuclear accidents. Risø has been responsible for the central atmospheric physics dispersion module of the EU-funded project – a joint venture of 40 institutions in 20 countries. The decision support system was delivered in 1999 and Risø is continuing its work of adapting the dispersion module to the Danish Emergency Management Organisation's decision support system *ARGOS-NT*.

Dissemination of research results and collaboration with Danish industry, including the participation of industry in advisory research committees

The department is continuing and intensifying its long tradition of dialogue with the wind turbine industry. The most important interaction takes the form of joint financing of collaborative projects where the long-term R&D needs of industry are taken into account. In major projects, such as the aeroelasticity programme in the *Aeroelastic Design* research programme funded by the Danish Energy Research Programme, reference groups have been appointed with R&D managers and senior industrial engineers participating.

Since 1998, the department has completed a round of visits to the six largest enterprises in the wind turbine industry for the purpose of presenting a draft three-year plan and discussing ideas and requests for future research strategies and assignment with the executives and development managers of the enterprises. These visits have resulted in positive dialogue with the industry and both parties appear to be satisfied with this type of dialogue on the content and nature of collaboration.

The department has discussed appointing a formalised industrial contact committee with selected representatives from the wind turbine industry, but this suggestion was not received with much enthusiasm. In the experience of the department, for reasons of competition, representatives from the industry would be too reticent to allow for free dialogue. Points of view continue to be exchanged with the Danish Wind Turbine Manufacturers' Association.

The department endeavours to disseminate its research results effectively to the wind turbine industry, paving the way for subsequent and more detailed discussions with the individual enterprises. This is done through R&D info sheets, topical meetings, participation in the annual wind energy conference of the Danish Energy Agency and organising the annual departmental wind energy day. Market-managed activities play a significant role in disseminating research results from the department. Consultancy, testing of wind turbines, the operation of the Sparkær wind turbine blade testing facility, certification and approvals, patenting, sales of software, organisation of courses and other market-managed activities to a high degree contribute to substantiate the department's research and strategy. These activities have grown from DKK 5 million in 1997 to DKK 21 million in 1999.

As a result of its special competence in atmospheric physics, the department has expanded and intensified its collaboration with the agricultural sector. The Danish Bacon & Meat Council and the agricultural associations collaborate with the department on the matter of the airborne transmission of pathogens among pigs as well as on assessing and minimising malodour in pig production.

3.2 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 prepared a joint strategy for 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.

3.3 Collaboration with other governmental research institutions

Collaboration between the department and the National Environmental Research Institute of Denmark 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. This applies particularly to the atmospheric exchange of pollutants with various eco-systems. 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), which has been going on for many years, on the effects of waves and wind on constructions. The intention is to establish a centre collaboration focusing on marine-based wind turbine parks in Denmark and abroad.

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.

4 Summary of the performance of the department and its 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 1999. The milestones are divided into milestones referring to different mid-term goals and milestones referring to initiatives aimed at industry. The end of 1998 specified these milestones; furthermore the tables include a follow-up column, indicating to what extent the 1999 milestones has actually been achieved during the year.

The lower parts of the tables summarise resource allocation for each unit and output statistics, both in terms of income (K Danish kroner, KDKK), publications, educational activities and co-operation with different sectors of society. For 1999 both planned and resulting figures by the end of the year are shown.

**Wind Energy and Atmospheric Physics Department
Objectives, resources and results 1999**

Wind Energy and Atmospheric Physics Department

<u>Programme field</u> Wind Energy and Atmospheric Physics	<u>Head</u> Erik Lundtang Petersen	<u>Abbreviation</u> VEA
<u>Departmental profile</u> The Wind Energy and Atmospheric Physics Department is concerned with R&D within boundary layer meteorology, fluid dynamics, structural mechanics, power and control engineering as well as loads and safety of wind turbines. The research aims to meet the needs for new knowledge and consultancy assistance in relation to the following. 1) Wind energy, including technological development, manufacturing, testing, operation, approval and export of wind turbines as well as solution of the technical problems in connection with the application of wind energy; 2) dispersion, transport and exchange of compounds of interest to environmental issues in the atmosphere. Finally, activities comprise accredited testing and approval of wind turbines.		
<u>The objective of the programme area</u> Development of methods for design, testing and siting of wind turbines; prediction of wind loads and wind resources as well as methods to determine dispersion, chemical transformation and effects of air pollution.		
<u>Programmes, tasks and important milestones in 1999</u>		<u>Follow-up</u>
<p>Programmes:</p> <ul style="list-style-type: none"> • Aeroelastic design • Atmospheric transport and exchange • Electric design and control • Wind power meteorology • Wind turbines • <p>Tasks:</p> <ul style="list-style-type: none"> • Experimental meteorology • Type approval and certification • Wind turbine and blade testing • <p>The department's milestones for 1999 are as follows:</p> <ul style="list-style-type: none"> • Validation of flux measurements over heterogeneous terrain for the remote-sensing model project • Implementation and the first prognoses for short-term prediction projects in Denmark and Germany • Aero-elastic model for flexible blades with large deflections • Establishment of a co-operation with the electrical utilities to develop a design basis for offshore wind turbines • Study of the transmission of harmonic grid distortions 		
<u>1999 mile stones for the environment, safety, human resource development and external relations</u> Involvement of authorities and industry in the research planning		

Total programme effort	Commercial	Programme research	Own research	Risø funded objectives	Overhead	Total
Man months, result for 1998	(98)	722	57	65	118	
Man months, planned for 1999	(145)	677	73	63	148	1.106
Man months, result for 1999	78	784	33	86	180	1.161

Know-how/research field	Result 1998	Planned 1999	Result 1999	Commercial exploitation of results	Result 1998	Planned 1999	Result 1999
Programme income (KDKK)	40.285	43.700	46.268	Commercial turnover (KDKK)	9.997	10.800	21.431
Articles in international journals and books (number)	43	45	48	Core customers (number)			
International books and reports (number)	19	7	15	New licenses (number)			
Danish books and reports (number)	(76)	(43)	18	Co-operation with industry (man months)	152	195	234
Conference contributions with proceedings (number)	65	63	108	Commercial Post.Docs (man months)			
Patent applications (number)	1	2	2	Educational activities			
Co-operation with research institutions (man months)	488	380	390	Total number of PhD students	8	7	8
				Industry researchers, incl. total number of "industry" PhD's			
Assistance to authorities				Master students (number)	5	4	3
Co-operation with authorities (man months)	115	77	118	Courses (weeks)		3	4

Objectives, resources and results 1999

Research programme

<u>Programme</u> Atmospheric Transport and Exchange (ATU)	<u>Head</u> Søren Larsen	<u>Department</u> VEA
<u>Objective</u> To contribute with new meteorological knowledge about transport of airborne substances and energy as well as exchange between the atmosphere and terrestrial and aquatic eco-systems aiming at environmental evaluations, emergency preparedness and environmental recommendations.		
<u>Mid-term goals</u> Through long- term research effort within boundary-layer meteorology, including wind climatology, atmospheric turbulence and experimental meteorology, to:		
<ol style="list-style-type: none"> 1. Develop boundary-layer meteorological models for dispersion, transport, exchange and variability of environmentally active substances, to forecast, describe and reduce environmental effects of airborne material. 2. Develop, utilise and improve atmospheric sensor and data systems used for validation and documentation of atmospheric models for atmospheric transport, dispersion and exchange. 3. Participate in the development of a national centre with respect to the atmospheric research. 4. To develop multi-scale dispersion models for airborne pollution from point sources, with extended use of meteorological and geographical information systems and databases, and to integrate these systems in computer-based emergency preparedness systems. 		
<u>Milestones for 1999 with references to mid-term goals</u>		<u>Follow-up</u>
Own Research:		
1. Re-establishment of DCAR-like air-environmental co-operation (3)		1. OK
2. Experimental validation of Risø's LIDAR boundary layer sensor (2)		2. Delayed
Programme Research:		
3. Development of flux parameterisation for heterogeneous physical/chemical conditions in co-operation with National Environmental Research Institute, NERI (1)		3. OK
4. Construction of a coupled N-CO ₂ flux-model across the air-sea interface in co-operation with NERI(1)		4. +
5. Validation of flux-determination method for the Remote-Sensing-Model project over heterogeneous terrain (1)		5. OK
6. Publication of method to determine the regional heat flux from measurements of the boundary layer height (1)		6. OK
7. First test of prototype autonomous flux packet for marine measurements (2)		7. OK
8. Publication of diffusion coefficients for relative diffusion of isotropic turbulence (4)		8. OK
9. Release of the RODOS2000 emergency preparedness system (4)		9. OK
10. Implementation of local model chain in ARGOS-NT with coupling to the DERMA model (4)		10. OK
<u>Initiatives aimed at industry with milestones for 1999</u>		
11. Continuation of projects for the Great Belt Bridge and Danish Slaughterhouses.		11. OK
12. Establishment of a new project with the Danish Slaughterhouses concerning odour problems.		12. OK
13. Development of LIDAR project with contact to industry.		13. OK
14. Joint venture with consulting engineering company to develop emergency preparedness model for Singapore.		14. +
15. Development of sonic-instrument project in co-operation with Gill Instruments Inc. Start of projects concerning a corrosion-atlas and dispersion of airborne virus.		15. OK
16. Development of local-scale risk evaluation concept with Risø's Safety Secretariat.		16. partly OK
17. Marketing of EME databases data sampling systems.		17. +
18. General marketing of the ATU systems for dispersion modelling.		18. OK
		19. OK

Total programme effort	Commercial	Programme research	Own research	Risø-funded objectives	Overhead	Total
Man months, result for 1998	2	165	33		16	216
Man months, planned for 1999	6	143	26		17	192
Man months, result for 1999	1	150	15		25	191

Know-how/research field	Result 1998	Planned 1999	Result 1999	Commercial exploitation of results	Result 1998	Planned 1999	Result 1999
Programme income (KDKK)	7.399	8.500	7.065	Commercial turnover(KDKK)	93	200	51
Articles in international journals and books (number)	22	18	23	Core customers (number)			
International books and reports (number)	8	3	1	New licenses (number)			
Danish books and reports (number)	(9)	2	3	Co-operation with industry (man months)		30	33
Conference contributions with proceedings (number)	26	18	29	Industry Post.Docs (man months)			
Patent applications (number)				Educational activities			
Co-operation with research institutions (man months)	165	160	150	Total number of PhD students		1	2
				Industry researchers incl. "industry" PhD's (number)			
Assistance to authorities				Master students (number)		2	2
Co-operation with authorities (man months)	4	4	17	Courses (weeks)		1	1

Objectives, resources and results 1999

Research programme

<u>Programme</u> Wind Power Meteorology (VKM)	<u>Head</u> Lars Landberg	<u>Dept.</u> VEA
<u>Objective</u> 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.		
<u>Mid-term goals</u> Through a long-term research effort within boundary-layer meteorology including wind climatology, atmospheric flow on meso- and micro scale, atmospheric turbulence and experimental meteorology to 1. further develop models and to extend the area of geographical application of the wind-atlas method for wind resource studies and models for short-term prediction of wind farm production, 2. 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, 3. develop models for off-shore wind flow including resources and extreme winds and to support these models by measurements		
<u>Milestones for 1999 with reference to the mid-term goals</u> Own research: 1. Determination of the geostrophic wind variation over Denmark, end of 99 (2) Programme research 2. Start and the first prognoses within short-term projects in Denmark and Germany, mid 99 (1) 3. Draft of wind atlas for Egypt, mid 99 (1) 4. Based on stationary simulations to find the best resolution of KAMM for use in the WAsP/KAMM model (1) 5. A simple MCP model for comparison with a neural network, mid 99 (1) 6. Verification and possible adjustment of a model for turbulence spectra in complex terrain for spectra measured in a number of sites, mid 99 (2) 7. Verification of the models in WAsP Engineering, end 99 (2) 8. A total re-instrumentation of off-shore masts (Omø, Gedser Rev and Rødsand), end 99 (2) 9. Development of a 2D IBL model, with stability change, to determine changes of the wind speed profile with regard to fetch (2) Commercial 10. Start and the first prognoses within short-term projects in the United States, mid 99 (1) 11. Sale of the first copies of WAsP, version 6.0, start 99 (1) 12. Release of WAsP Utilities for Windows, version 1.0, mid 99 (1)		<u>Follow-up</u> 1. OK 2. OK 3. OK 4. OK 5. OK 6. OK 7. OK 8. OK 9. OK 10. Started 11. OK 12. Published in part 13. OK 14. OK 15. Replaced by internet information
<u>Initiatives towards industry with milestones for 1999</u> The wind energy industry, i.e. the wind turbine manufacturers and the electric utilities are briefed continuously about WAsP, short-term prediction, offshore wind resources and the internet database. The information exchange is mainly through industry involvement in projects, but also through information days and visits. 13. WasP course 14. WasP visits to industry 15. Publication of two-page "Info sheets", tailor-made to manufacturers and describing new research results, summary of reports and new ideas.		

Total programme effort	Commercial	Programme research	Own research	Risø-funded objectives	Overhead	Total
Man months, result for 1998	12	104	6		3	125
Man months, planned for 1999	15	83	10	6	6	120
Man months, result for 1999	37	89	5	6	13	150

Know-how/research field	Result 1998	Planned 1999	Result 1999	Commercial exploitation of results	Result 1998	Planned 1999	Result 1999
Programme income (KDKK)	6.528	4.700	9.703	Commercial turnover (KDKK)	1.452	1.800	2.869
Articles in international journals and books (number)	15	12	8	Core customers (number)			
International books and reports (number)	1	2	1	New licenses (number))			
Danish books and reports (number)	(10)	2	3	Co-operation with industry (man months)	18	20	36
Conference contributions with proceedings (number)	10	20	33	Industry Post.Docs (man months)			
Patent applications (number)				Educational activities			
Co-operation with research institutions (man months)	55	55	56	Total number of PhD students	3	3	3
				Industry researchers incl. total number of "industry PhD's"			
Assistance to authorities				Master students (number)			1
Co-operation with authorities (man months)	6	6	1	Courses (weeks)		2	3

Objectives, resources and results 1999

Research programme

<u>Programme</u> Aeroelastic Design (AED)	<u>Head</u> Flemming Rasmussen	<u>Department</u> VEA
<u>Objective</u> To develop new knowledge on design wind conditions as well as aerodynamic and structural dynamic characteristics with regard to new wind turbine concepts and models for analysis, design basis and optimisation of wind turbines		
<u>Mid-term goals</u> Through a long-term strategic and applied research and development in the fields of numerical aerodynamics and aero-acoustics (CFD and CAA), experimental aerodynamics, structural dynamics and design basis to develop: 1. an analytical and numerical tool, "the numerical wind tunnel", for aeroelastic design and optimisation of wind turbines to supplement and replace empirical methods, 2. a new generation of the traditional concept for three-bladed wind turbines, 3. a basis for a two-bladed, flexible wind turbine concept in the MW class		
<u>Milestones for 1999 with regard to mid-term goals</u> Own research • CFD-model with sliding grids for simulation of blade-tower interaction (1). Programme research: • Design modifications to prevent double-stall of existing blades (1), • Development of an airfoil family for active stall regulation (2), • Aeroelastic model for flexible blades with large deflection (3), • Loads and dynamic stability for MW-turbines with regulation (2), • Clarification of the aerodynamics for rotors at stand-still in connection with calculations of extreme loads (2)		<u>Follow-up</u> OK OK OK OK OK
<u>Initiatives towards industry with milestones for 1999</u> Frequent visits to manufacturers for discussion of research topics and joint activities. Implementation of the first case from the patent pool. Determined for Danish industry		OK OK

Total programme effort	Commercial	Programme research	Own research	Risø-funded objectives	Overhead	Total
Man months, result for 1998	3	145	18		4	170
Man months, planned for 1999	5	134	24		12	175
Man months, result for 1999	2	137	12		8	159

Know-how/research field	Result 1998	Planned 1999	Result 1999	Commercial exploitation of results	Result 1998	Planned 1999	Result 1999
Programme income (KDKK)	7.489	8.200	7.623	Commercial turnover (KDKK)	341	250	196
Articles in international journals, and books (number)	4	6	8	Core customers (number)			
International books and reports (number)	2		6	New licenses (number)			
Danish books and reports (number)	(39)		4	Co-operation with industry (man months)	48	70	70
Conference contributions with proceedings (number)	15	9	14	Industry Post.Docs (man months)			
Patent applications (number)	1	1	1	Educational activities			
Co-operation with research institutions (man months)	98	60	69	Total number of PhD students	1	1	1
				Industry researchers incl. total number of "industry PhD's"			
Assistance to authorities				Master students (number)	2		
Co-operation with authorities (man months)		2		Courses (weeks)			

Objectives, resources and results 1999

Research programme

<u>Programme</u> Wind Turbines (VIM)	<u>Head</u> Peter Hjuler Jensen	<u>Department</u> VEA
<u>Objective</u> The objective is to achieve a more reliable basis for development and utilisation of wind turbine technology and to support the energy political objectives for an increased international application of Danish wind turbine technology. Among the initiatives are development of new knowledge and methods to verify loads and safety for wind turbines, experimental verification of the strength of wind turbine components, new components for wind turbines, methods to assess the technical and economic consequences of investing in different wind turbine applications and new opportunities with regard to electric grids and hybrid energy systems.		
<u>Mid-term goals</u> Through a long-term strategic and applied research and development effort within the scientific fields of loads and safety, structural design and verification as well as application and integration of wind turbines in the energy systems, to:		
<ol style="list-style-type: none"> develop new and more realistic assumptions for load and safety design of wind turbines, technical requirements for design of wind turbines, site studies and evaluation, certification and standardisation develop new methods to establish the background for decisions to increase the use of centralised and decentralised energy systems (large-scale integration and hybrid energy systems) develop and establish methods for technical/economic modeling/estimation/assessment of the development in the wind-turbine field develop new methods for experimental determination of wind turbine characteristics and their components, including testing methods for industrial application conduct test-station tasks for the Danish Energy Council 		
<u>Milestones for 1999 with reference to the mid-term goals</u>		<u>Follow-up</u>
Own research		
1. Guest scientist and post doc within probabilistic methods to design offshore wind farms (1)		1. ÷
Programme research		
2. Establishment of an offshore wind farm research project in co-operation with the electric utilities to establish the design basis for offshore wind farms (1)		2. OK
3. Development of calibration methods for partial coefficients to design offshore wind farms (1)		3. OK
4. Testing of prototype laser instrument (1)		4. OK
5. Development of methods for structural modeling of wind-turbine blades (1)		5. OK
6. Development of a model to calculate the technical/economic lifetime of a wind turbine (3)		6. OK
7. Start of project to verify the site-calibration method in connection with "performance measurements" (4)		7. OK
8. Formulation of a proposal for standard measurements of the energy production in wind farms (4)		8. OK
9. Start development of a method to determine modal shapes for MW wind turbines (4)		9. OK
10. Start of project to evaluate the Doppler SODAR in preparation for performance and load measurements of wind turbines on land and at sea (4)		10. OK
11. Start of project to optimise cup anemometers for wind energy application (4)		11. OK
12. Issue of a revised recommendation of the technical basis for the Danish Approval System for Wind Turbines (5)		12. OK
<u>Initiatives towards industry with milestones for 1999</u>		
13. User guide for design of isolated systems (2)		13. Delayed
14. Publication of "Fact sheets" with results from the programme research projects to manufacturers and other interested parties		14. Replaced by web information

Total programme effort	Commercial	Programme research	Own research	Risø-funded objectives	Overhead	Total
Man months, result for 1998		267			52	319
Man months, planned for 1999	20	251	12		50	333
Man months result for 1999	5	268	0		79	352

Know-how/research field	Result 1998	Planned 1999	Result 1999	Industrial exploitation of results	Result 1998	Planned 1999	Result 1999
Programme income (KDKK)	17.015	19.500	18.751	Commercial turnover (KDKK)	606	500	1.158
Articles in international journals and books (number)	2	6	9	Core customers (number)			
International books and reports (number)	8	2	7	New licenses (number)			
Danish books and reports (number)	(13)	2	8	Co-operation with Industry (man months)	48	60	70
Conference contributions with proceedings (number)	10	12	23	Industry Post Docs (man months)			
Patent application (number)		1	1	Educational activities			
Co-operation with research institutions (man months)	164	11	110	Total number of PdD students		1	1
				Industry researchers including "industry PdD's" (number)			
Assistance to authorities				Master students (number)		2	
Co-operation with authorities (man months)	105	50	98	Courses (weeks)			

Objectives, resources and results 1999

Research programme

<u>Programme</u> Electric Design and Control (EDS)	<u>Head</u> Peter Hjuler Jensen	<u>Department</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 in order to increase their value with respect to energy production and capacity value		
<u>Mid-term goals</u> 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 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 1999 with reference to mid-term goals</u> <ul style="list-style-type: none"> Design of control criteria for the application of fast responding dynamic VAR compensation unit to improve the power quality for wind turbines with direct-coupled induction generators (1 + 2) Study of wind farm influence on the power quality in weak grids (1) Design of a basis for development of wind-turbine control with automatic adjustment of the operation to an actual site in relation to optimisation of loads, production and power quality (1) 		<u>Follow-up</u> + OK +
<u>Initiatives towards industry with milestones for 1999</u> <ul style="list-style-type: none"> Implementation and test of the dynamic VAR compensation unit in co-operation with a wind turbine manufacturer (1+2) Publication of "Info sheets" with results from programme research projects 		+ +

Total programme effort	Commercial	Programme research	Own research	Risø-funded objectives	Overhead	Total
Man months, result for 1998		41			3	44
Man months, planned for 1999		66	1		7	74
Man months, result for 1999		32	1		8	41

Know-how/research field	Result 1998	Planned 1999	Result 1999	Commercial exploitation of results	Result 1998	Planned 1999	Result 1999
Programme income (KDKK)	1.842	2.800	2.489	Commercial turnover (KDKK)		50	
Articles in international journals and books (number)		3		Core customers (number)			
International books and reports (number)				New licenses (number)			
Danish books and reports (number)	(5)			Co-operation with Industry (man months)	30	15	25
Conference contributions with proceedings (number)	4	4	9	Industry Post Docs (man months)			
Patent applications (number)				Educational activities			
Co-operation with research institutions (man months)	6	5	5	Total number of PhD's	1		1
				Industry researchers including "industry PhD's" (number)			
Assistance to authorities				Master students (number)			
Co-operation with authorities (man months)		15	2	Courses (weeks)			

Objectives, resources and results 1999

Special task

<u>Task</u> Type Approval and Certification (GDK)	Head Carsten Skamris	Department VEA
<u>Objective</u> International, accredited research based type approval of wind turbines and wind turbine components as well as project certification of international wind turbine projects on commercial terms. The approvals are performed in co-operation with Det Norske Veritas.		
<u>Public funding of services, users and service goals</u> None		
<u>Services paid by users</u> The following customers make use of services (certification, Gutachten, technical investigations, verification of measurements) carried out by the Secretariat for Type Approval on commercial terms: NEG Micon A/S Bonus Energy A/S Wind World af 1997 A/S A/S Wincon West Wind Vestas Wind Systems A/S Genvind Production Aps Hanstholm Møllen Dan Service/Norwin Windgineering Folkecenter LM Glasfiber Svendborg Brakes SEAS A/S Nordvestsjælland's Energiforsyning AmbA I/S Midtkraft Københavns Belysningsvæsen Danmarks Vindmølleforening DTI/DTO Ingenieurburo für Windenergie, Dieter Frey Nordex Balcke-Dürr GmbH Windflower I/S		
<u>Milestones for 1999</u> <ul style="list-style-type: none"> • International, accredited certification of products according to IEC standards • Implementation of certification according to IEC standard • Prolongation of agreement on co-operation with Det Norske Veritas (DNV) International marketing of product certification of wind turbines at the EWEA Nice conference and Husumer Wind Energie Tage	<u>Follow-up</u> ÷ ÷ OK OK	

Total programme effort	Commercial	Programme research	Own research	Risø-funded objectives	Overhead	Total
Man months, result for 1998	29				14	43
Man months, planned for 1999	29				8	37
Man months, result for 1999	27				9	36

Production	Result 1998	Planned 1999	Result 1999	Operation and service	Result 1998	Planned 1999	Result 1999
Approvals A, B and C	12	16	8				
Approvals, conversions	5	5					
HC/HB	1	0	2				
Re-certification A and B	21	20	8				
Project approval		2	0				
Gutachten	2	5	3				
Know-how/research field				Commercial exploitation of results			
Programme income (KDKK)			15	Commercial turnover (KDKK)	2.293	3.000	2.397

Objectives, resources and results 1999

Special task

<u>Task</u> Experimental Meteorology (EME)	<u>Head</u> Søren Larsen	<u>Department</u> VEA
<u>Objective</u> Implementation of meteorological measurements and application of data-management systems used in the department's experiments and monitoring tasks. The activity is performed mainly in connection with the department's programme research but also directly for external customers. The tasks are performed on programme research or commercial terms, dependent on the specific task. Also included in this special task is service, maintenance and development of instruments as well as data sampling and management systems.		
<u>Public funding of services, users and service goals</u> The primary services based on public funding are: a) service and calibration of EME's instrument pool; b) operation of a number of meteorological measuring stations, from which continued data series are considered to be important (eg the Risø mast). Primary users are the programmes of the department, especially VKM and ATU, Risø's Safety Secretariat and the Department of Electronics and Mechanics (ELM)		
<u>Services paid by users</u> EME participates in a substantial part of the experimental activities in the department as well as tasks on commercial terms EME performs meteorological measuring tasks on commercial terms Meteorological instruments are developed and sold on commercial terms by EME in co-operation with the Electronics Department		
<u>Milestones for 1999</u> <ul style="list-style-type: none"> • Use of satellite data transmissions for online control and data display • Implementation of a comprehensive semi-automatic data reduction and display system • Continuation of a internet database within the framework of IEA, mid 1999 		<u>Follow-up</u> OK ÷ Transferred to AED

Total programme effort	Commercial	Programme research	Own research	Risø-funded objectives	Overhead	Total
Man months, result for 1998		6	2	36	1	45
Man months, planned for 1999				36	2	38
Man months, result for 1999	6			50	3	59

Production	Result 1998	Planned 1999	Result 1999	Operation and service	Result 1998	Planned 1999	Result 1999
Campaigns	11	8	12				
Monitoring tasks	9	7	11				
Risø mast measurements	1	1	1				
Know-how/research field				Commercial exploitation of results			
Programme income (KDKK)	11		585	Commercial turnover(KDKK)		100	569

5 The 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.

5.1 Aeroelastic Design (AED)

Title: Various Commercial Tasks

Programme and psp: AED, psp 1110001-00, start date: continuous

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 three-fold: they represent a dedicated investigation, they act as an efficient way of transferring new knowledge, and gives a direct and valuable feedback and inspiration for the research.

Partners: Risø together with Industry.

Sponsor: Danish Industry.

Contact person: Flemming Rasmussen, flemming.rasmussen@risoe.dk

+45 46775048

Title: Design and Experimental Verification of the Risø-A1 Airfoil

Programme and psp: AED, psp 1110003-00, start date: 1998.07.01

Description: This project involved design and experimental verification of the Risø-A1 airfoil family. This airfoil family was tailored to wind turbines by use of an airfoil design tool using numerical optimisation together with a flow solver. Good off-design characteristics, insensitivity to leading edge roughness and geometric and aerodynamic compatibility were design drivers. Two-dimensional wind tunnel experiments were carried out for three airfoils and the theoretical airfoil characteristics were verified.

Partners: Risø, DTU, LM Glasfiber A/S, Vestas Wind Systems A/S

Sponsor: The Danish Energy Agency, ENS 1363/98-0038

Contact person: Peter Fuglsang, peter.fuglsang@risoe.dk +45 46775071

Title: Aero-acoustic Optimisation

Programme and psp: AED, psp 1110014-00, start date: 1997.07.01

Description: The two main objectives of the project are 1) two improve noise measurement techniques and 2) design and test a new blade tip for minimum aerodynamic noise. The Risø contribution to the project has mainly been to design the new blade tip. The design goal has been to develop a tip shape so that the separation of the tip vortex is minimised. A 3D CFD model of the blade tip has been developed and the design has been adjusted to a minimum separation of the tip vortex. In the last part of the project the tip will be tested on a full scale turbine.

Partners: dk-TEKNIK, DELTA Akustik & Vibration, Vestas and Risø.

Sponsor: The Danish Ministry of Energy.

Contact person: Helge Aagaard Madsen, helge.aagaard.madsen@risoe.dk

+45 46775047

Title: Programme for Aeroelasticity Research 1999-2000

Programme and psp: AED, psp 1110015-00, start date: 1999.07.01

Description: The project is part of five-year research programme on aeroelasticity and carried out in close collaboration with Danish wind turbine industry. The research work has been centred within the following five areas. 1) Detailed verification of 3D CFD on the NREL rotor; 2) development of a

model for airfoil roughness (CFD); 3) aeroelastic modelling of a rotor with flexible blades; 4) loads in combination with regulation – active stall – pitch regulation – variable speed; 5) aero-acoustic modelling of propagation of airfoil noise from an airfoil.

Partners: Danish Technical University (DTU) and Risø.

Sponsor: The Danish Ministry of Energy.

Contact person: Helge Aagaard Madsen, helge.aagaard.madsen@risoe.dk
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Title: Determination of Damping for Edgewise Blade vibrations.

Programme and psp: AED, psp 1110016-00

Description: A new method to determine damping of edgewise blade vibrations has been developed. The method consists of an excitation method and a whirl analysis of the blade movements. The method has been verified with measurements on a Bonus 600 kW turbine and for this particular turbine, the damping has been identified at several different operational conditions.

Partners: Bonus Energy A/S, LM Glasfiber, DTU and Risø.

Sponsor: The Danish Ministry of Energy and Technology.

Contact person: Kenneth Thomsen, kenneth.thomsen@risoe.dk +45 46775052

Title: Investigation of the Aerodynamic Interaction between Wind Turbine Rotor Blades and the Tower and its Impact on Wind Turbine Design (ROTOW).

Programme and psp: AED, psp 1110017-00, start date: 1998.10.01

Description: The work is concentrated on measurements and predictions of the aerodynamic forces and moments, the associated blade response and methods to characterise and reduce unsteady loads, resulting from interaction. The methods used to investigate the interaction are: 1) wind tunnel tests of model scale blades; 2) field rotor blade pressure data analysis; 3) computational fluid dynamics (CFD) with a blade passing a tower, 4) blade element theory (BEM) with investigation and tuning of dynamic stall models and 5) monitoring and analysis of operating machine data.

Partners: Imperial College (GB), Garrad Hassan & Partners Ltd (GB), T.G. Teknikgruppen AB (S), FFA (S), Bonus Energy A/S (DK), ECN (NL), National Technical University of Athens (GR), National Observatory of Athens (GR), Aristotle University of Thessaloniki (GR) and Risø National Laboratory (DK)

Sponsor: EC, Non-Nuclear Energy Programme: JOULE III.

Contact person: Christian Bak, christian.bak@risoe.dk +45 46775091

Title: Viscous and Aeroelastic Effects on Wind Turbine Blades (VISCEL)

Programme and psp: AED, psp 1110018-00, start date: 01-07-1998

Description: The objectives of the VISCEL project are: 1) To employ systematic 3-D Navier-Stokes calculations for rotor blades of different shape in order to clarify the aerodynamic mechanisms associated to three-dimensional and rotational effects and their dependence on the geometrical and inflow parameters. 2) To revisit the dynamic stall problem from the aeroelastic point of view using simple modelling of dynamics and advanced solvers for the aerodynamics. 3) To devise a comprehensive aerodynamic database including both the 3-D and the aeroelastic results. This database will be valuable for tuning and assessing the performance of simpler, engineering-type, models. 4) To provide a detailed step by step account of the progress, significant achievements and breakthroughs which have been built up so far on the aerodynamic and aeroelastic codes through JOU2-CT93-0345, JOR3-CT95-0007 and the current project.

Partners: CRES, DLR, DTU, FFA, LM Glasfiber, NTUA, Risø

Sponsor: European Commission

Contact person: Niels Nørmark Sørensen, nns@risoe.dk +45 46775053

Title: Verification of European Wind Turbine Design Codes.

Programme and psp: AED, psp 1110019-00

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 aeroelastic 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 is not known. The aim of the present project is to answer this question. The main objectives of the project are: to assess the accuracy and reliability of the most widely used European wind turbine design codes for improved support of wind turbine design and certification and to define 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, Risø, DK, partner; Centre for Renewable Energy Sources, CRES (GR), partner; Garrad Hassan and Partners, GH, UK, partner; Stork Product Engineering, SPE, NL, partner; Technical University of Denmark, (DTU), DK, partner; Teknikgruppen AB, TG, SE, partner; National Technical University of Athens, NTUA, partner; Lagerwey, The WindMaster B.V. NL, partner

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

Contact person: Kenneth Thomsen, kenneth.thomsen@risoe.dk +45 46775052

Title: NewGust

Programme and psp: AED, psp 1110020-00 Start date: 1998.07.01

Description: Up to now simple deterministic gusts have been used to determine extreme wind turbine response from aeroelastic calculations. However, amplitude and time period specified for these discrete events remain rather arbitrary and largely invalidated. The main objective of NewGust is to develop a realistic and verified description of extreme gusts based on the stochastic properties of the wind. The analysis comprises the following. 1) development of a theoretical gust description; 2) experimental verification of the (mean) shape of extreme gusts; 3) development of an advanced method to determine the dynamic response of a wind turbine on extreme gusts and 4) experimental verification of the loading and response of a wind turbine on extreme gusts.

Partners: Delft University, Risø, Vestas

Sponsor: EU

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

Title: Site Specific Design of Wind Turbines based on Numerical Optimisation, SITEOPT

Programme and psp: AED, psp 1110021-00, start date: 1998.08.01

Description: This project involves incorporation of site characteristics into the design process to enable site specific design of wind turbines. Two wind turbines of different concept are optimised at six different sites. Recommendable design guidelines are established for adoption of existing wind turbines to specific sites and for new design of site-specific wind turbines. Existing design tools based on numerical optimisation and aeroelastic calculations are improved with a detailed cost model and detailed wind climate input.

Partners: Risø, ECN, University of Sunderland, Bonus Energy A/S, Lagerwey B.W.

Sponsor: The European Commission, JOR3-CT98-0273, The Danish Energy Agency, UVE51171/98-0014

Contact person: Peter Fuglsang, peter.fuglsang@risoe.dk +45 46775071

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

Programme and psp: AED, psp 1110023-00, start date: 1998.08.01

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 and optimum active stall regulation. A blade was designed with the Risø-A1 airfoil family and the rotor was manufactured and installed on a 600 kW rotor. To evaluate the performance of the rotor, measurements are on going.

Partners: Risø, VEA Engineering, LM Glasfiber A/S, Nordvind

Sponsor: The Danish Energy Agency, UVE 51171/97-0051 51171/99-0028

Contact person: Peter Fuglsang, peter.fuglsang@risoe.dk +45 46775071

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

Programme and psp: AED, psp 1110024-00 Start date: 1999.01.01

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 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 of 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) Dissemination of the knowledge of the database and the possibilities of making use of the data material.

Partners: USA, Japan, Norway, Sweden, The Netherlands, Denmark

Sponsor: IEA Annex

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

Title: Programme for Aeroelasticity Research 1999-2000

Programme and psp: AED, psp 1110025-00, start date: 1999.07.01

Description: The project is part of a five-year research programme on aeroelasticity and carried out in close collaboration with Danish wind turbine industry. The research work has been centred within the following five areas. 1) wind tunnel test of a NACA 63-415 airfoil with a modified leading edge; 2) detailed verification of 3D CFD on the NREL rotor; 3) development of a model for airfoil roughness (CFD); 4) aeroelastic modelling of a rotor with flexible blades; 5) loads in combination with regulation – active stall – pitch regulation – variable speed; 6) aero-acoustic modelling of propagation of airfoil noise from an airfoil.

Partners: DTU and Risø.

Sponsor: The Danish Ministry of Energy.

Contact person: Helge Aagaard Madsen, helge.aagaard.madsen@risoe.dk
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5.2 Atmospheric Transport and Exchange (ATU)

Title: Great Belt Climatology.

Programme and psp: ATU, psp 1100001-02, start date: 1977.01.01.

Description: Climatological wind monitoring with mean values and turbulence structure studies. Conducted in connection with the construction of the Great Belt Bridge and tunnel connection. After construction of the bridge, different consultancy projects are being conducted.

Partners: COWI Consult.

Sponsor: Sund & Bælt Inc.

Contact person: Niels Otto Jensen, n.o.jensen@risoe.dk 45 46775007

Title: Aujeszky's Virus

Programme and psp: ATU, psp 1100006-00, start date: 1990.01.01.

Description:

On-line real-time Aujeszky Pig disease airborne virus attack warning system based on an on-line met tower (Kegnes, southwest Denmark)

Partners: Danish Slaughterhouses, Veterinarian, Ph.D., Sten Mortensen Axelborg, København

Sponsor: Danish Slaughterhouse Association

Contact person: Torben Mikkelsen, torben.mikkelsen@risoe.dk 45 46775009

Title: Ulborg

Programme and psp: ATU, psp 1100007-00, start date: 1990.09.01.

Description: A study of forest productivity correlated to water balance (i.e. precipitation and evapotranspiration), 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, Copenhagen University; DMU (Danish Environmental Research Institute); FSL (Danish Forest and Landscape Research Institute) and similar research institutes from 32 other European countries.

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

Contact person: Niels Otto Jensen, n.o.jensen@risoe.dk +45 46775007

Title: NATO/CCMS ITM Conference

Programme and psp: ATU, psp 1100010, start date: 1992

Description: The series of regular NATO/CCMS International Technical meetings on Air Pollution Modelling and its Application (ITM) was started in 1974. Since 1992 Denmark has been pilot country with Risø acting as host organisation. The most recent, the 23rd ITM, was held near Varna, Bulgaria September 28 - October 2, 1998. 120 participants representing 30 countries from North and South America, Europe, Asia and Australia attended the conference. The proceedings of the conferences are published by Kluwer Academic/-PLENUM Press (Air pollution modelling and its application).

Partners: National Institute of Meteorology and Hydrology, Bulgarian Academy of Sciences (latest conference).

Sponsor: NATO/CCMS

Contact person: Sven-Erik Gryning, sven-erik.gryning@risoe.dk
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Title: Air-Sea Exchange

Programme and psp: ATU, psp1100015-00, start date: 1999.02.01

Description: The overall goal is to develop and improve numerical models for the simulations of the marine environment and for assessment purposes. The Baltic is chosen as the case for this study. To study the behaviour, variability and response of the Baltic ecosystem to the atmospheric input at the sea-surface a marine model and an atmospheric model are constructed and linked. Furthermore a database containing chemical and meteorological parameters is established for use in model validation.

Partners: Finnish Institute of Marine Research; Finnish Meteorological Institute; Uppsala University and National Environmental Research Institute

Sponsor: Nordic Council of Ministers, The air- and sea group.

Contact person: Lise Lotte Sørensen, lotte.geern@risoe.dk +45 46775015

Title: BNFL Peer Review

Programme and psp: ATU, psp 1100017-61, start date: 1996-08-01

Description: Peer review of the environmental dose assessment models to be used by Westlake Research Institute (WRI) on behalf of BNFL for the assessment of radiation doses to individuals in Ireland from releases from Sellafield (in connection with Short and Others v BNFL and Others). Risø has followed WRI's implementation and testing of the selected sub-models on a test-sample basis.

Partners: Department of Nuclear Safety Research

Sponsors: British Nuclear Fuels

Contact person: Søren Thykier-Nielsen, soeren.thykier@risoe.dk
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Title: EUROFLUX

Programme and psp: ATU, psp 1100018-00, start date: 1996.01.01.

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: 1) to provide useful parameters to 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 factors governing the gains and losses. This includes different vegetation composition

in different climate regions. A specific Risø interest is to develop an improved Soil Vegetation Atmosphere Transfer (SVAT) model.

Partners: Dept. of Forest Science and Environment, University of Tuscia, Viterbo, Italy (project leader) and 10 other research institutes from EU countries.

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

Contact person: Niels Otto Jensen, n.o.jensen@risoe.dk +45 46775007.

Title: LUMINY.

Programme and psp: ATU, psp 1100020-00, start date: 1996.08.01.

Description: The LUMINY project aims to develop and test models for air-sea exchange of gases for conditions with and without breaking waves. The measurements were conducted in the large air-sea exchange tunnel in Marseilles. The gases considered are CO₂, SF₆, He₂, CH₃Br, N₂O and air. The air-sea fluxes are determined from the time change of concentration in the air and the water of the tunnel.

Partners: TNO, IRPHE-IOA, SUDO, University of Galway, PML, Max-Planck I. Chem.

Sponsor: EC RTD ENVIRONMENT & CLIMATE Programme ENV4-CT95-0080.

Contact person: Søren E. Larsen, soeren.larsen@risoe.dk +45 46775012

Title: RODOS2000

Programme and psp: ATU, psp 1100021-00, start date: 1996.01.01.

Description: Implementation of a comprehensive meteorological and atmospheric dispersion model chain for all distance ranges and its coupling to local synoptic stations and weather forecasts of the national weather services in the joint European decision support system for nuclear emergencies RODOS.

Partners: FZK, GSF, UOM, NRPB, Risø, DMI, SMHI, NCSR, NNC, JRC, ICET

Sponsor: EU Community Research - Nuclear sciences and technologies.

Contact person: Torben Mikkelsen, torben.mikkelsen@risoe.dk +45 46775009

Title: RS-Model

Programme and psp: ATU, psp 1100030-00, start date: 1997.01.01.

Description: The long title of the project is "Remote Sensing Based Crop Simulation and Soil-Vegetation-Atmosphere-Transport Modelling". The primary objective is the integration of remotely sensed information and vegetation (crop) modelling at landscape scales. The main emphasis is on the hydrological aspects. The tasks of Risø were to contribute with one experimental station measuring fluxes on the field scale (observation height about 2m). Other groups participated with five similar stations situated in various crops. The aim was to contribute with one experimental station measuring fluxes on the landscape scale (observation height 48m). Finally to compare the measured fluxes on field and landscape scale with simulated fluxes by means of an aggregation model based on remotely sensed surface parameters, that is being developed.

Partners: Danish Institute of Plant and Soil Science, Research Centre Foulum (project leader); Danish Hydraulic Institute; Department of Agricultural Sciences, the Royal Veterinary and Agricultural University; Institute of Geography, University of Copenhagen.

Sponsor: The Research Programme on Earth Observation under the Danish Research Councils.

Contact person: Niels Otto Jensen, n.o.jensen@risoe.dk +45 46775007

Title: WINTEX (WINTer EXperiment)

Programme and psp: ATU, psp 1100031-00

Description: The objective was to perform a pilot experiment to test measurement equipment in order to earn practical experience in the special problems to be encountered during winter conditions. The experiment was performed in Finnish Lapland in March 1997. A very extensive data set was achieved on the components of the energy balance within and above a boreal forest. A simple model for the surface energy balance of a sparse forest is developed. The model introduces a factor that accounts for the shading of the ground at low solar elevation angles, and a parameter that deals with the partial transparency of the forest.

Partners: Uppsala University and the Defence Research Establishment (Sweden), FMI (Finland), and the Wageningen Agricultural University (The Netherlands).

Sponsor: EC RTD ENVIRONMENT & CLIMATE Programme (ENV4-CT96-0324)

Contact person: Sven-Erik Gryning, sven-erik.gryning@risoe.dk

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Title: Research & Development.

Programme and psp: ATU, psp 1100032-00, start date: .

Description: The project number is used for these research and development activities within the ATU programme that are not directly related to the research and development activities of any individual project.

Partners: -

Sponsor: Internal

Contact person: Søren E. Larsen, soeren.larsen@risoe.dk +45 46775012

Title: Particle Tracking.

Programme and psp: ATU, psp 1100034-00, start date: 1997.01.14.

Description: The tracking project studies relative turbulent diffusion under controlled, reproducible conditions in the laboratory in order to determine fundamental properties of dispersion. These include the Richardson-Obukhov constant and the distance-neighbour function. The results are obtained by the particle tracking technique in which small illuminated particles are follow in space by use of four video cameras.

Partners:

Sponsor: Danish Technical Research Council, contract no 9601244.

Contact person: Jakob Mann, jakob.mann@risoe.dk +45 46775019

Title: Atmospheric Measurements on Mars.

Programme and psp: ATU, psp 1100035-00, start date: 1997.04.01.

Description: Participation in Mars missions involving surface landers. Participation in atmospheric science teams for the NASA Pathfinder Lander, and in the multinational NetLander project aiming to place four surface stations simultaneously on the surface of Mars. Work with the planing, instrument development, surface atmospheric measurements and data interpretation

Partners: ATMIS team in Pathfinder and Netlander. Primary: JPL, Pasadena, FMI, Helsinki, CNES, Paris, UW, Seattle, USA

Sponsor: Danish Research Agency, Grant No. 9602457 & 9802921.

Contact person: Søren E. Larsen, soeren.larsen@risoe.dk +45 46775012

Title: RODOS Eastern Europe

Programme and psp: ATU, psp 1100036-00, start date: 1997.01.01.

Description: As RODOS 2000- but for Eastern Europe.

Partners: FZK, Risø, UOM, CRCM, IPEP, NRPI, UITA, NRIRR, KFKI, IAE, IFA, IFIN, TYPHOON, NSI, NPPRI, RIARAE, IMMS CC

Sponsor: EU Community Research - Nuclear sciences and technologies.

Contact person: Torben Mikkelsen, torben.mikkelsen@risoe.dk +45 46775009

Title: NOPEX (Northern Hemisphere Climate-Processes Land-surface Experiment)

Programme and psp: ATU, psp 1100037-00

Description: The objective of the NOPEX project is to study land-surface processes at a regional scale for a mixed land cover dominated by boreal forest. Risø participated in two Concentrated Fields Efforts, and in the overall co-ordination of the project. A method to determine the regional flux from measurements on the evolution of the mixed-layer was developed. Scientific results are published in a special issue on Boreal Forest and Climate (Agricultural and Forest Meteorology 98-99,1999), with Sven-Erik Gryning as one of the guest editors.

Partners: Several including Uppsala University, University of Copenhagen, Research Centre Foulum.

Sponsor: Several including the Nordic Environmental Research Programme.

Contact person: Sven-Erik Gryning, sven-erik.gryning@risoe.dk

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Title: OMEXII-2.

Programme and psp: ATU, psp 1100040-00, start date: 1998.08.01.

Description: The objective of the OMEXII-2 project is to determine the carbon balance at the ocean shelf outside North Western Portugal to evaluate whether the margin is a sink or source of atmospheric Carbon. OMEXII-2 descends from a number of earlier OMEX projects, all focused on the carbon cycle and the marginal seas west of Europe. The project involves 29 partners. Risø's participation focuses on estimation of air sea exchange of CO₂.

Partners: Université Libre, Bruxelles; Université Liege; GEOMAR, Kiel; University of Tromsø; PML, Plymouth; POL, Merseyside, UK.

Sponsor: EC RTD ENVIRONMENT & CLIMATE Programme MAS3-CT97-0076.

Contact person: Søren E. Larsen, soeren.larsen@risoe.dk +45 46775012

Title: RTMOD

Programme and psp: ATU, psp 1100041-00, start date: 1998.01.01.

Description: RTMOD is an automated statistical evaluation package for the inter-comparison of the predictions of mathematical models simulating the dispersion of air pollutants. The background of RTMOD is the ETEX project that involved about 50 models run in several Institutes around the world to simulate two real tracer releases involving a large part of the European territory. The project continues with ENSEMBLE, starting on Oct 1, 2000 .

Partners: German Weather Service, Royal Netherlands Meteorological Institute, National Inst. of Public Health and Environ. Protection; Royal Meteorological Institute, Belgium; Meteo France; British Met. Office; Finnish Meteorological Institute; Swedish Meteorological and Hydrological Institute; Danish Meteorological Institute; Austrian Meteorological and Geophysical Office; ENVIROWARE-SRL; Polish Atomic Energy Institute; Norwegian Meteorological Office; Greece National Research Centre "Demokritos"; JRC-Ispra - Environment Institute - European Commission; University of Manchester; Savannah River National Laboratory; Danish Emergency Management Agency.

Sponsor: EU Community Research - Nuclear sciences and technologies

Contact person: Torben Mikkelsen, torben.mikkelsen@risoe.dk +45 46775009

Title: COFIN

Programme and psp: ATU, psp 1100042-00, start date: March 1, 1998

Description: Random concentration fluctuations caused by atmospheric turbulence tend to intensify the hazards of toxic and flammable gas releases. Practical risk analysis of industrial hazards often involves dispersion modelling of the gas field. This does usually not include concentration fluctuations, since existing theory is considered difficult in application or to rely on too idealised situations. The aim of the COFIN project is to develop a model framework applicable also for practical risk assessment. The approach is semi-empirical; i.e. we examine the statistical properties of experimental data and include stochastic information in the models.

Partners: Sheffield University.

Sponsor: EU-ENVIRONMENT Programme, contract no. ENV4-CT97-0629

Contact person: Morten Nielsen, n.m.nielsen@risoe.dk +45 46775022

Title: SMP-2, C and N Exchange

Programme and psp: ATU, psp 1100043-00, start date: 1997.07.01.

Description: The objectives of this subproject (9.1.1 Atmosphere/canopy exchange of C and N compounds) are to quantify through experimental field measurements the fluxes of gaseous C and N compounds over forest and over a nearby agricultural field and to compare the fluxes over these two different ecosystems. The set-up relies to a fairly large degree on the infrastructure established in connection with the EUROFLUX project.

Partners: Partners in Centre for Sustainable Land Use and Management of Contaminants, Carbon and Nitrogen, and University of Kiel, Chalmers University of Technology, Göteborg.

Sponsor: The Danish Environmental Research Programme.
Contact person: Niels Otto Jensen, n.o.jensen@risoe.dk +45 46775007

Title: PEP (Pilot Study on Evaporation and Precipitation in the Baltic Sea)

Programme and psp: ATU, psp 1100044-00, start date: 1 Nov. 1997

Description: The main objective of PEP is to estimate precipitation (P) and evaporation (E) over the Baltic Sea. Risø has performed continuous measurements of evaporation with an eddy correlation technique at Christiansø during the 18-month period (May 1998 to December 1999). During a two week concentrated field effort in October/November 1998, Risø performed extensive radio soundings at Christiansø. Based on the radio soundings the height of the boundary layer was determined, having typical values in the range of 500 metres, and successfully simulated.

Partners: Uppsala Univ. and SMHI (Sweden); Max-Planck-Inst. Hamburg, and Univ. of Kiel (Germany) and FMI (Finland).

Sponsor: EC RTD ENVIRONMENT AND CLIMATE Programme (ENV4-CT97-0484)

Contact person: Sven-Erik Gryning, sven-erik.gryning@risoe.dk
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Title: SNF-Atlantic CO₂ and Particulates.

Programme and psp: ATU, psp 1100045-00, start date: 1997.12.01

Description: The objective of the project is to study the origin, variability and air/sea fluxes of CO₂ and atmospheric particulates over the North East Atlantic Region (NEAR). The study is carried out by measuring the CO₂-concentration in water and air, and the amount of particulate matter in the near surface air; deriving local area average surface fluxes of CO₂ and particulates at selected locations within NEAR.

Partners: Copenhagen University, National Environmental Research Institute.

Sponsor: The Danish National Science Research Council,

Contact person: Lise Lotte Sørensen, lotte.geern@risoe.dk +45 46775015

Title: SFINCS.

Programme and psp: ATU, psp 1100046-00, start date: 1997.04.01.

Description: The SFINCS project aims to improve the parameterisation of the atmospheric boundary layer in climate and weather forecast 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: Uni. Uppsala, SMHI, Sweden, Max Planck Inst., Hamburg, NOAA, Athens, Inst. Atmos. Phys., Moscow

Sponsor: EC RTD ENVIRONMENT & CLIMATE ENV4-CT97-0573

Contact person: Søren E. Larsen, soeren.larsen@risoe.dk +45 46775012

Title: URAHFREP.

Programme and psp: ATU 1100049-1 start: 1998.01.01.

Description: The aim of the HF project is to test whether an instantaneous accidental release of HF acts as a passive trace gas cloud or a buoyant cloud with a lift-off. If HF acts as a buoyant cloud, safety distances around factories using or producing HF can be reduced. Experimental campaigns have been designed, and Risø's mini lidar system will be used to measure a passive and a HF cloud respectively to test the theory. At Risø the project involves both experimental and modelling work and is made in co-operation with the System Analysis Department, Risø National Laboratory. The System Analysis Department is project co-ordinator at Risø and the main task for Risø is to conduct the experimental campaign, to interpret the measurements and to develop a new HF thermodynamic module to be included in the Risø heavy gas model developed in the System Analysis Department.

Partners: HSE England, CEA France, SUAS/FOA Sweden, BRE England, AEA Technology England.

Sponsor: European Commission

Contact person: Hans E. Jørgensen hans.e.joergensen@risoe.dk
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Title: AutoFlux.

Programme and psp: ATU, psp 1100051-1, start date: 1998.08.01.

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 determined mainly from turbulence measurements by the dissipation method.

Partners: Uppsala Univ., Southampton Ocean. Centre, Gill Instruments, Royal Dutch Met, Inst. CETP/CNRS France.

Sponsor: EC RTD ENVIRONMENT & CLIMATE Programme MAS3-CT97-0108.

Contact person: Morten Nielsen, n.m.nielsen@risoe.dk +45 46775022

Title: Understanding the Role of Vehicle Emissions in the Formation of Secondary Organic Aerosols

Programme and psp: ATU, psp 1100053-1, start date: 1999.01.01.

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:

Sponsor: Ford Research Centre, Aachen

Contact person: Rebecca Barthelmie, r.barthelmie@risoe.dk +45 46775020

Title: SAT-MAP-CLIMATE

Programme and psp: ATU, psp 1100054-1, start date: 1999.04.01.

Description: Satellite based maps of land surface roughness, albedo and vegetation state will be area-averaged and input to the HIRLAM model. Validation from wind and temperature data at synoptic weather stations, 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. This work is basic to improvements in global climate change predictions.

Partners: Danish Meteorological Institute, University of Copenhagen

Sponsor: Danish Research Agency, ESA/ Danish Natural Science Research Council, Journal no. 9802916

Contact person: Charlotte Bay Hasager, charlotte.hasager@risoe.dk
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Title: LSMC 2000

Programme and psp: ATU, psp 1100 055-1/2/3, start date: 1999-10-01

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 re-structuring of Rimpuff.

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

Sponsors: Danish Emergency Management Agency

Contact person: Søren Thykier-Nielsen, soeren.thykier@risoe.dk
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Title: Pigs in Space

Programme and psp: ATU, psp 1100059-1, start date: 1999.01.01.

Description: In today's large-scale pig farming units, malodour in the near by environment is a concern, and in some cases a problem for the nearby neighbours. Mitigation in form of odour reduction is costly and requires decision support based on a scientific basis. Together with the Danish environmental Institute (NERI), full scale odour concentration dispersion tests on second time

scale are being conducted from a 1600 pig fattening unit farm house in Roager, Jutland. Combined smoke tracer (LIDAR) and gas tracer (SF₆) experiments are conducted to determine the best strategy for venting and mitigating the effects of malodour.

Partners: National Environmental Research Institute (NERI) + Danish Slaughterhouse Association - Axelborg (Peter Kai)

Sponsor: Danish Agricultural Structure Fond + Danish Slaughterhouse Association - Axelborg

Contact person: Torben Mikkelsen, torben.mikkelsen@risoe.dk +45 46775009

Title: BASYS

Programme and psp: ATU, psp 1100302-00, start date 1996.08.01.

Description: The goal of the BASYS project is to extend the understanding of air-sea exchange processes through field studies, upgraded parameterisations and high resolution modelling. In particular the objectives are to improve the parameterisation of deposition processes, to develop model tools for extrapolation of coastal deposition measurements to the open Baltic Sea and to construct high-resolution deposition fields by the development of nested atmospheric transport models.

Partners: National Environ. Res. Inst., TNO Physics and Electronics Lab., Hamburg Uni., Inst. For Baltic Research

Sponsor: EC MAST Programme MAS3-CT96-0058.

Contact person: Lise Lotte Sørensen, lotte.geern@risoe.dk +45 46775015

Title: ANICE

Programme and psp: ATU, psp 1100303-00, start date: 1998.02.01

Description: The overall goal of the ANICE project is to develop a coupled Lagrangian-Eulerian model of atmospheric nitrogen deposition, which includes extended performance of air-sea flux parameterisations and inclusion of heterogeneous processes. There are three tasks in the project: transport and chemistry modelling, instrument development, and field experiments, where fluxes and parameters for model validation are measured.

Partners: National Environmental Res. Inst., TNO Physics and Electronics Lab., Hamburg Uni., East Anglia Uni.

Sponsor: EC RTD ENVIRONMENT AND CLIMATE Programme ENV4-CT97-0594.

Contact person: Lise Lotte Sørensen, lotte.geern@risoe.dk +45 46775015

5.3 Electrical Design and Control (EDS)

Title: Solar Energy Centre Denmark, Hybrid Systems Part

Programme and psp: EDS, 1115003-00, 1998.01.01

Description: Participation in the work of the Solar Energy Centre Denmark performing 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 person: Henrik Bindner, henrik.bindner@risoe.dk +45 46775050

Title: Design and Development of a Gear-less Wind Turbine with a Multi-pole Generator.

Programme and psp: EDS, psp 1115009-00, start date: 1996.01.01; end date: 2000.02.01

Description: Main goal of the project was design and development of a gear-less stall regulated wind turbine with a multi-pole generator, power electronics and variable speed operation. This was due to the following main features: reduced requirements to grid strength, improved power quality, controllable power output, increased yearly power production, smaller loads and reduced acoustic noise. During the project, it turned out that the multi-pole generator solution would become too expensive. Therefore, the main goal was changed to design and implementation of 1) a control strategy for variable speed and 2) a blade pitch system.

Partners: NEG Micon (Nordtank Energy Group), Siemens and Elkraft.

Sponsors: Danish Energy Agency, case no. 1363/96-0003 (EFP).

Contact person: Lars Henrik Hansen, lars.henrik.hansen@risoe.dk
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Title: Donegal wind farm, Thermie

Programme and psp: EDS, 1115011, 1996.09.01

Description: The objective of the project was to develop, implement and test a control scheme for a complete wind farm that ensures that the voltage level at the point of common connection never exceeds the level prescribed by the utility. A voltage controller was installed at a 6*600kW wind farm that based on the actual voltage level controlled the active power output of the wind farm.

Partners: Vestas A/S, Gineadoiri Gaoithe Tearanta, EuroScan

Sponsor: EU Thermie

Contact person: Henrik Bindner, henrik.bindner@risoe.dk+45 46775050

Title: Power Quality and Integration of Wind Farms in Weak Grids

Programme and psp: EDS, psp 1115015-00, start date 1998.04.01

Description: The objective of this project has been to study wind farms connected to weak grids and to provide recommendations for the grid connection. The conditions in India have been studied as an example of very large wind farm regions connected to very weak grids in rural areas. Both the influence of the grid on the wind turbines and the influence of the wind farms on the power quality have been assessed.

Partners: DEFU (Danish Utilities Research Institute) and ER&DCI(T) (Electronic Research and Development Institute of India)

Sponsor: Danish Energy Agency 1363/98-0024 and the Indian Ministry of Non-Conventional Energy Sources (MNES) Reference: 52/164/97/WE/PG dated 7/10/98

Contact person: Poul Sørensen, poul.e.soerensen@risoe.dk +45 46775075

Title: Monitoring of Wind Turbines

Programme and psp: EDS, 1115016, 1999.01.01

Description: Advanced condition monitoring of wind turbines primarily of the gearbox, the main bearings and parts of the wind turbine structure in order to be able to perform preventive maintenance and avoid operation in situations with extremely high loads.

Partners: Dan-Service, CC Electronics, Leif Hansen Rådg. Ing., Flender, WEA Engineering, Inge-mannsson Technology

Sponsor: EU CRAFT

Contact person: Henrik Bindner, henrik.bindner@risoe.dk +45 46775050

Title: IRENE2010

Programme and psp: EDS, 1115017, 1999.05.01

Description: The focus is on the implications of the targets of the EU white paper on renewable energy of the European power system. Through a 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 needs change when large amounts of renewable energy are being included in the power production. The issues of spatial and temporal distribution of renewable energy have also been addressed in order to have a foundation for the identification of possible bottlenecks in the transmission system.

Partners: Tractebel, EDF, PPC, Iberdrola, Elsamprojekt, Eurec Agency

Sponsor: EU ALTERNER

Partners: Tractebel, EDF, PPC, Iberdrola, Elsamprojekt, Eurec Agency

Sponsor: EU ALTERNER

Contact person: Henrik Bindner, henrik.bindner@risoe.dk +4546775050

Title: Simulation of Wind Power Plants

Programme and psp: EDS, psp 1115018-00, start date 2000.04.01

Description: The objective of this project is to develop a model for the 6x2 MW wind farm in Hageholm and its interaction with the power systems. The 2000 models are developed in the commercial tool for power system simulation DIgSILENT. The available models for power system components in DIgSILENT are used, whereas the wind turbine models are built from standard dynamic blocks.

Partners: Aalborg University, Dancontrol Engineering A/S

Sponsor: Danish Energy Agency 1363/00-0003

Contact person: Poul Sørensen, poul.e.soerensen@risoe.dk +45 46775075

5.4 Wind Power Meteorology (VKM)

Title: European Wind Atlas

Programme and psp: VKM, psp 1105001-00, start date: 01/01/1989

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

Partners: None

Sponsor: Various

Contact person: Niels G. Mortensen, niels.g.mortensen@risoe.dk

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Title: Wind Atlas Analysis and Application Programme (WAsP)

Programme and psp: VKM, psp 1105 002-01/02, start date: 01/07/1987

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, training, consultancy work and second opinion studies.

Partners: None

Sponsor: Various

Contact person: Niels G. Mortensen, niels.g.mortensen@risoe.dk

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Title: Wind Atlas for Egypt

Programme and psp: VKM, psp 1105005-00, start date: 01/01/1995

Description: Distribution of the wind atlas and the associated database for the Gulf of Suez 1991-95.

Partners: None

Sponsor: Various

Contact person: Niels G. Mortensen, niels.g.mortensen@risoe.dk

+45 46775027

Title: Wind Atlas for Russia

Programme and psp: VKM, psp 1105007-00, start date: 1997.

Description: The project aims at developing a wind atlas for Russia. The method used is that of the European Wind Atlas (Risø Wind Atlas Methodology). The project will analyse data from more than 300 stations distributed all over the Russian territory will be analysed. 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 person: Lars Landberg, lars.landberg@risoe.dk +45 46775024

Title: Instrumentation of Offshore Masts

Programme and psp: VKM, psp 1105011-00, start date: 1997.08.01.

Description: This project involves instrumentation of a number of offshore masts (Gedser Land, Gedser Rev, Rødsand and Omø Stålgrunde) and running of the meteorological instruments necessary to provide a database for wind resource assessment.

Partners:

Sponsor: SEAS/ELKRAFT

Contact person: Rebecca Barthelmie, r.barthelmie@risoe.dk +45 46775020

Title: Wind Wave Interaction in Fetch Restricted Coastal and Shallow Water Environment.

Programme and psp: VKM, psp 1105013-00, start date: 1994.03.01.

Description: The wave growth and wave roughness are theoretically investigated by use of numerical wave models and compared with data from a number of experimental sites with both meteorological and wave measurements.

Partners: Danish Hydraulic Institute, Danish Meteorological Institute.

Sponsor: Danish Energy Agency, Grant No. 97-8125.

Contact person: Søren E. Larsen, soeren.larsen@risoe.dk +45 46775012

Title: WAsP Engineering Version 1.0 DK

Programme and psp: VKM, psp 1105021-07, start date: 1997.01.01.

Description: WAsP Engineering is a series of experimental and theoretical activities concerning properties of the winds in moderately complex terrain with relevance for loads on wind turbines and other large structures. These properties include extreme winds, wind shear and turbulence. Most of the models have been integrated in a windows programme prototype, also called WAsP Engineering.

Partners: Svend Ole Hansen ApS.

Sponsor: Danish Energy Agency, Contract ENS-1363/97-0004.

Contact person: Jakob Mann, jakob.mann@risoe.dk +45 46775019

Title: Instrumentation of mast at Middelgrunden

Programme and psp: VKM, psp 1105024-00, start date: 1997.08.01.

Description: This project involves instrumentation of the offshore mast at Middelgrunden and running of the meteorological instrumentation necessary to provide a database for wind resource assessment.

Partners:

Sponsor: SEAS/ELKRAFT

Contact person: Rebecca Barthelmie, r.barthelmie@risoe.dk +45 46775020

Title: WAsP Consulting

Programme and psp: VKM, psp 1105026-01, start date: N/A continuous.

Description: This project covers all consulting done in connection with the WAsP program. This includes second opinion studies, due diligence, offshore wind farm production estimation, measuring programmes and so on.

Partners: various commercial and international institutions

Sponsor: various

Contact person: Lars Landberg, lars.landberg@risoe.dk +45 46775024

Title: Wind Energy Feasibility Studies in Estonia

Programme and psp: VKM, psp1105026-4, start date: 1999.04.01

Description: The project aimed to: (1) clarify legal and institutional aspects of wind energy in Estonia; (2) select possible wind turbine sites near Tallinn; (3) estimate the wind potential; (4) evaluate wind energy economy for these sites and (5) evaluate the need for and activities at a wind energy know-how centre near Tallinn. VEA/Risø has contributed especially to (3) and (5).

Status: Finished. Concluding seminar held in Tallinn, April 2000, reporting finished July 2000.

Partners: SEAS Wind Energy Centre (project leader), Elkraft Consult, Tripod Wind Energy ApS (all DK)

Sponsor: Danish Environment Related Energy Sector Programme (Danish Energy Agency)

Contact persons: Risø: Ole Rathmann, ole.rathmann@risoe.dk +45 46775003; SEAS WEC: Frank Olsen, frank.a.olsen@seas.dk +45 56372391

Title: WASP for Windows

Programme and psp: VKM, psp 1105027-01, start date: 1999.01.01.

Description: This project aims at developing the Windows version of the WASP program.

Partners: World in a Box, Finland; Lambda Soft, Denmark

Sponsor: Risø/VKM's own funds

Contact person: Lars Landberg, lars.landberg@risoe.dk +45 46775024

Title: The Numerical Wind Atlas - the KAMM/WASP method

Programme and psp: VKM, 1105028-00, start date: 01/04/1998

Description: Deriving wind atlases from numerical simulations with the Karlsruhe Atmospheric Mesoscale Model KAMM using climatologies of the large-scale geostrophic wind from the NCEP/NCAR reanalysis. Simulations are performed for different regions in Europe and compared with wind atlas data derived from observations in these regions. The effect of different grid resolutions on the results is investigated. Also, the size of maps to clean the observations is varied to investigate its effect on the observed wind atlas data.

Partners: None

Sponsor: Danish Energy Agency, EFP 1998

Contact person: Helmut P. Frank, helmut.frank@risoe.dk +45 46775013

Title: Short-term Prediction DE

Programme and psp: VKM, psp 1105029-00, start date: 1998.06.01.

Description: The project aims at implementing a version of Risø's Prediktor Programme for a number of sites in Germany alongside a new prediction model developed by University of Oldenburg. Furthermore the effects of wind farms distributed over a large area will be investigated.

Partners: University of Oldenburg, Germany; Fachhochschule Magdeburg, Germany.

Sponsor: European Commission, JOULE contract no JOR3-CT98-0272.

Contact person: Lars Landberg, lars.landberg@risoe.dk +45 46775024

Title: Analysis of Wind Resource at Middelgrunden

Programme and psp: VKM, psp 1105031-1, start date: 1998.01.01.

Description: The focus of the project was to analyse existing measurements from the mast at Middelgrunden together with long-term data sets in order to provide an estimate of the long-term wind resource for Middelgrunden wind farm. Additional analysis was undertaken to provide details regarding the turbulence and stability characteristics of the site.

Partners: SEAS/ELKRAFT

Sponsor: EFP

Contact person: Rebecca Barthelmie, r.barthelmie@risoe.dk +45 46775020

Title: MOWIE

Programme and psp: VKM, psp 1105033-1, start date: 1998.06.01

Description: Improving tools to predict wind energy production in mountainous regions.

Partners: FMI, COORD(FI), CRES(GR), UU(SE), DEWI(DE), Bonus(DK), + three associated contractors

Sponsor: EU, DG XII, Contract No JOR3-CT98-0254 (DG 12 - WSMN)

Contact person: Erik Lundtang Petersen, erik.lundtang@risoe.dk
+45 46775001

Title: EU-Measure Correlate Predict

Programme and psp: VKM, psp 1105034-1, start date: 1998.05.01.

Description: The project aims at developing new measure-correlate-predict methods. A neural network will be developed alongside a mathematical/statistical model developed by Risø and one by Ecotecnica. The three developed methods will be compared.

Partners: Renewable Energy Systems, UK; Ecotecnica, Spain.

Sponsor: European Commission, JOULE contract: JOR-CT98-0295

Contact person: Lars Landberg, lars.landberg@risoe.dk +45 46775024

Title: EU-Offshore Wind/Wave

Program and psp: VKM, psp 1105035-1, start date: 1998.

Description: This project is linked to the Marie Curie research grant for Bernhard Lange's PhD thesis.

Partners: University of Oldenburg, Germany

Sponsor: European Commission

Contact: Lars Landberg, lars.landberg@risoe.dk +45 46775024

Title: Predicting Offshore Wind Energy Resources (POWER):

Programme and psp: VKM psp 1105036-1, start date: 1998.08.01

Description: POWER is funded by the European Commission JOULE programme. To date the focus of the project is mapping of thirteen years' 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) which 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 The Netherlands (NL), University of East Anglia (UK)

Sponsor: European Commission

Contact person: Rebecca Barthelmie, r.barthelmie@risoe.dk +45 46775020

Title: IRESMED

Programme and psp: VKM, psp 1105037-1, start date 1998.11.01.

Description: Integration of renewable energies in the Southern Mediterranean Region.

Partners: OME, COORD.(FR) + 13 EU + 8 Southern Med. countries.

Sponsor: EU, DGXII, Contract No JOR3-CT98-0209 (DG 12 - WSMN)

Contact person: Erik Lundtang Petersen, erik.lundtang@risoe.dk
+45 46775001

Title: EFP99 - Zephyr

Programme and psp: VKM, psp 1105039-1, start date: 1999.04.01.

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 Danish Technical University. The model is to be developed and installed at all the Danish utilities with wind energy. The HIRLAM model from the Danish Meteorological Institute drives the predictions.

Partners: IMM, DMI, SEAS, Elkraft, Elsam, Eltra, Denmark

Sponsor: Danish Energy Agency, EFP99 contract: 1363/99-0017

Contact person: Lars Landberg, lars.landberg@risoe.dk +45 46775024

Title: UVE99 - Site Assessment

Programme and psp: VKM, psp 1105040-1, start date: 1999.

Description: The project aims at assessing a number of sites in different climatological and orographic settings. The assessment will be done with respect to the wind resource and wind engineering aspects. After the sites have been visited, a report generalising the findings of the individual studies will be written. This report can be used as a guideline to assess a site.

Partners: Bonus, NEG Micon, Vestas, Denmark

Sponsor: Danish Energy Agency, UVE99 contract: 51171/98-0035

Contact person: Lars Landberg, lars.landberg@risoe.dk +45 46775024

Title: Wind resources at Rødsand and Omø Stålgunde

Programme and psp: VKM, psp 1105041-1, start date: 1999.05.01.

Description: The focus of the project was to analyse existing measurements from the Rødsand and Omø Stålgunde masts together with long-term data sets in order to provide an estimate of the long-term wind resource at these prospective wind farm sites. Additional analysis was undertaken to pro-

vide details regarding the turbulence and stability characteristics of the sites. Wind speed profiles and distributions at Rødsand are impacted by stability even after fetches of over 20 kilometres. Statistical analysis of the data sets indicates that wind speeds offshore are not more highly correlated than those at land sites but that wind speeds above turbine cut-in speeds are more persistent while those below cut-in wind speeds are less persistent.

Partners:

Sponsor: SEAS/ELKRAFT

Contact person: Rebecca Barthelmie, r.barthelmie@risoe.dk +45 46775020

Title: Transfer of Wind-resource Know-how to Czech Republic.

Programme and psp: VKM, psp1105042-1, start date: 1999.11.01

Description: The project aims at increasing the Czech capacity to estimate domestic wind resources by performing a training workshop for about 10 target persons; performing in general terms - a survey of the wind resources in the C.R. and at clarifying and possibly seeking to propose a solution for an existing less successful wind farm project.

Status: Training workshop for 13 persons held, survey of wind resources and wind energy related electricity tariffs in C.R. in progress, the status of the less successful wind farm project clarified.

Partners: None.

Sponsor: DANCEE, case no 124/043-0056

Contact person: Ole Rathmann, ole.rathmann@risoe.dk +45 46775003

Title: UNEP-SWERA Global Wind Atlas

Programme and psp: VKM, psp 1105048-1, start date: 1999.

Description: This is a project which is developing a full-scale UNEP/GEF funded 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's own funds.

Contact person: Lars Landberg, lars.landberg@risoe.dk +45 46775024

Title: UVE-2000, Energy production calculation

Programme and psp: VKM, psp 1105054-1, start date: 01/01/2000

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: Energi- og Miljødata, Elsamprojekt, WEA Engineering, Bonus, NEG Micon A/S, Nordex, Vestas, Wincon

Sponsor: Danish Energy Council (UVE), WEA Engineering, Bonus, NEG Micon A/S, Nordex, Vestas, Wincon

Contact person: Niels G. Mortensen, niels.g.mortensen@risoe.dk

+45 46775027

Title: Wind Atlas for Egypt

Programme and psp: VKM, psp 1105104-00, start date: 19/12/1997

Description: The objective is to improve the conditions for large-scale wind power development in Egypt. This is done through establishing of a Wind Atlas for Egypt with emphasis on those parts where the wind regimes are attractive. Also to establish an extended and updated wind atlas for the Gulf of Suez and provision of a decision tool for environmental impacts (especially on bird migration). Finally, provision of recommendations for a common framework for wind farm planning in the Gulf of Suez and transfer of knowledge and experience about the methodology applied in establishing a wind atlas.

Partners: Ornis Consult, DMU

Sponsor: DANIDA

Contact person: Jens Carsten Hansen, carsten.hansen@risoe.dk +45 46775074

Title: Validity of the Assumption of Gaussian Turbulence

Programme and PSP: VKM, PSP 1105300-00, start date: 1/1 1998

Description: Wind turbines are designed to withstand the impact of turbulent winds, which fluctuations usually are assumed by Gaussian probability distribution. Based on a large number of measurements from many sites, this seems a reasonable assumption in flat homogeneous terrain whereas it may fail in complex terrain. At these sites the wind speed often has a skew distribution with more frequent lulls than gusts. In order to simulate aerodynamic loads, a numerical turbulence simulation method was developed and implemented. This method may simulate multiple time series of variable not necessarily Gaussian distribution without distortion of the spectral distribution or spatial coherence. The simulated time series were used as input to the dynamic-response simulation Programme Vestas Turbine Simulator (VTS). In this way we simulated the dynamic response of systems exposed to turbulence of either Gaussian or extreme, yet realistic, non-Gaussian probability distribution.

Partners: Vestas Wind Systems, The Technical University of Denmark

Sponsor: The Danish Energy Agency

Contact person: Morten Nielsen, n.m.nielsen@risoe.dk +45 46775022

5.5 Wind Turbines (VIM)

Title: Consulting

Programme and psp: VIM, psp 1120006

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 person: Sten Frandsen, sten.frandsen@risoe.dk +45 6775072

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

Programme and psp: INR - 1120076-02, Start date: September 1996

Description: Calibration of terrain descriptions of the 60-MW wind farm site at Zafarana, Egypt, is provided for wind flow modelling using an adaptation of the IEC site calibration methodology. The project will transfer knowledge and experience about the methodology and the on-site wind conditions for accurate wind turbine micro-siting and information about wind conditions before and after wind farm installation, including turbulence characteristics.

Partners: -

Sponsor: DANIDA

Contact person: Jens Carsten Hansen, carsten.hansen@risoe.dk +45 46775074

Title: Isolated Systems with Wind Power

Programme and psp: VIM, psp 1120084, start date 1998.02.01

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 person: Per Lundsager, per.lundsager@risoe.dk +45 46775045

Title: Calibration of Partial Safety Factors for Design of Wind Turbine Rotor Blades against Fatigue Failure.

Programme and psp: VIM, psp 1120092, start date: 01.01.1998.

Description: The project has performed a calibration of partial safety factors for wind turbine rotor blades subjected to fatigue loading in flap-wise and edgewise bending. While earlier models - developed by the authors - dealt with such calibrations for site-specific individual turbines only, the calibration model applied herein covers an integrated analysis with different turbines on different sites and with different blade materials. The result is an optimised set of partial safety factors, i.e. a set of safety factors that lead to minimum deviation from the target reliability of the achieved reliabilities over the selected scope of turbines, sites and materials. The turbines included in the study cover rated powers of 450-600 kW.

Partners: Det Norske Veritas (DNV)

Sponsor: Danish Energy Agency - Development programme for renewable energy, Case no. 51171/96-0038

Contact person: Morten Lybech Thøgersen, morten.thoegersen@risoe.dk
+45 46775968

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

Programme and psp: VIM, psp 1120098-00

Description: This project includes investigations in better determination of blade properties using modal analysis, investigations in use of thermographic 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.

Sponsor: Danish Energy Agency 51171/97-0043.

Contact person: Erik R. Jørgensen, erik.r.jorgensen@risoe.dk +45 46775064

Title: European Wind Turbine Certification

Programme and psp: VIM, psp 1120099, start date: 01.05.1999

Description: Comparison of wind turbine certification carried out by 4 different certifying bodies. The objective is to establish a basis for harmonisation of certification procedures for wind turbines in EU.

Partners: CRES, Greece; DNV, Denmark; ECN, The Netherlands; GL, Germany

Sponsor: EC, contract JOR3CT980265

Contact person: Peter Hjuler Jensen, peter.hjuler@risoe.dk +45 46775037

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

Programme and psp: VIM, psp 1120100-00

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, ECN, CRES.

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

Contact person: Erik R. Jørgensen, erik.r.jorgensen@risoe.dk +45 46775064

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

Programme and psp: VIM, psp 1120101-00, start date 1998.08.01

Description: The Sitepariden project aims to contribute to a better understanding of the parameters which 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: Risoe, Cres, Dewi, Windtest, ECN, NEG Micon A/S, Bonus

Sponsor: EU

Contact person: Ioannis Antoniou, ioannis.antoniou@risoe.dk +45 46775082

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

Program and psp: VIM, 1120102

Description: The current project is focused on designing a cost effective laser anemometer to provide information about the wind speed approaching the wind turbine and to implement this information into the turbine control system for regulating the blade pitch and the speed of the rotor. The anemometer is planned to be mounted on the nacelle of the turbine and 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 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 are in progress. Also, strategies for controlling the turbine using this new information are discussed and implemented. The main benefits from implementing the laser anemometer together with the control system are foreseen to be reduced mechanical stresses due to wind gusts in strong winds and an increased energy yield at low wind speeds.

Partners: Risø, NEG Micon A/S Howden Laser Division, Wind Engineering Aps

Sponsor: EU

Contact person: Sten Frandsen, sten.frandsen@risoe.dk +45 46775072

Title: CLASSCUP

Programme and psp: VIM, psp 1120103-00, start date: 1998.09.01.

Description: The primary objective is to produce a cup anemometer design has 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 required applications. 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 Sweden, DEWI, Germany.

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

Contact person: Troels Friis Pedersen, troels.friis.pedersen@risoe.dk +45 6775042

Title: Operation and Maintenance Economics of Wind Turbines

Programme and psp: VIM, psp 1120105-00, start date: 1998.01.01.

Description: The purpose of the project is as follows. To update data and statistics on establishment, operation and maintenance costs with specific weight on the 500-750 kW generation; to highlight questions regarding technically and economically lifetime of wind turbines using the data on operation and maintenance costs; to disseminate the results in Denmark and also internationally.

Partners: Wind Turbine Industry, Elsam, Elkraft, and Danmarks Vindmølleforening.

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

Contact person: Lars Henrik Hansen, lars.henrik.hansen@risoe.dk
+45 46775076

Title: Guidelines for Design of Wind Turbines.

Programme and psp: VIM, psp 1120110, start date: 01.01.1999.

Description: The knowledge in wind turbine design gained within the last decades is immense and often only available 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 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; parties that are both involved in wind turbine certification. Thus, an important part of the guidelines is to outline current design requirements, which a new turbine must satisfy in order to achieve a type approval.

Partners: Det Norske Veritas (DNV)

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

Contact person: Jesper H. Schaarup, jesper.schaarup@risoe.dk +45 46775065

Title: National Wind Turbine Test Station, India

Programme and PSP: VIM, PSP 1120111, start date 1999.01.01 (PSP 1170-111 from 2000.10.01)

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, Denmark; NIRAS A/S, Denmark.

Sponsor: Danida - Danish International Development Agency, Contract number 1363/503, File number 104.Indien.179

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

Title: Type approval of Domestic Wind Turbines 1999.

Programme and psp: VIM, psp 1120112, start date: 99.01.01

Description: Commercial type approval (HC- and HB-Approval) according to "Teknisk grundlag for godkendelse af vindmøller med rotordiameter mellem 2 meter og 13 meter". 1) Revision of type approval HC-104 for Calorius Type 37.

Partners: None

Sponsor: The private sector

Contact person: Poul Højholdt, poul.hoejholdt@risoe.dk +45 46775063

Title: Demonstration Wind Farm Project Design, South Africa

Programme and psp: INR - 1120113-00, Start date: 22 January 1999

Description: The objective of the assignment is as Core-Consultant to produce an agreed project document (design stage) in the standard DANCED format. This should fully describe possible DANCED support to bulk wind energy generation in South Africa through support to the establishment of the Slangkop demonstration wind farm in Darling, Western Cape, generated through the participatory project development methodology outlined in the DANCED Project Management Manual, project.

Partners: Rambøll and ADventures in Sustainable NRG (NL)

Sponsor: DANCED

Contact person: Jens Carsten Hansen, carsten.hansen@risoe.dk +45 46775074

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

Programme and psp: VIM, psp 1120114-00, start date 1999

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 met. masts to measure the wind characteristics. In this phase of the project a SODAR was situated close to the Risoe 123m met. mast and 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: Risoe

Sponsor: Danish Energy Agency

Contact person: Ioannis Antoniou, ioannis.antoniou@risoe.dk +45 46775082

Title: Design Basis for Offshore Wind Turbines

Programme and psp: VIM, psp 1120115, start date:

Description: For the immediate future, 700 MW of offshore wind farms are planned for the relatively shallow waters around Denmark. In preparation of the first demonstration projects of approx. 100 units each it was proposed to conduct an investigation of the needs as to revision of the design basis for wind turbines and subsequently prepare such revision.

Partners: SEAS, Elsamprojekt, Rambøll, Niras, DNV
Sponsor: Danish Energy Agency, EFP-1999
Contact person: Sten Frandsen, sten.frandsen@risoe.dk +45 46775072

Title: Energy Management in Lesotho – Wind Energy Advisor
Programme and psp: INR - 1120116-00, Start date: February 1999
Description: Objectives are to assist selection of areas with potential wind energy resources in Lesotho; to make wind resource assessment for selected areas of Lesotho and to present results in a wind atlas format; to apply wind resource assessment results in selected wind power project feasibility study; to recommend inputs to a wind energy programme as part of the Lesotho Energy Master Plan. The project supplies and installs three sets of measurement equipment, and it measures at selected sites for 1 year after which data analyses and feasibility study are performed.

Partners: Rambøll
Sponsor: DANCED
Contact person: Jens Carsten Hansen, carsten.hansen@risoe.dk
+45 46775074

Title: Wind Turbine Round Robin Test Programme, IEA Annex 16
Programme and psp: VMD, psp 1120300-3-2, start date: 1999.01.01.
Description: An extensive field measuring campaign has been conducted for the performance and load assessment of a round robin wind turbine at different test stations within the Annex XVI “Wind Turbine Round Robin Test Programme” to the IEA Wind Energy R&D Implementing Agreement. The objective of the work is to compare, to identify and to quantify the measured differences in the actual performance and loads on the wind turbine, and to stipulate error sources in the total uncertainty budget of the measurements.
Partners: NREL , AWTS, CRES **Sponsor:** ENS.
Contact person: Uwe S. Paulsen, uwe.schmidt.paulsen@risoe.dk
+45 46775055

Title: Mechanical Power Measurements on Wind Turbine Rotor Shaft
Programme and psp: VMD, psp 1120300-3-2, start date: 1999.01.01.
Description: To improve and verify a new measurement concept for measuring mechanical power on a wind turbine. Analysis of the performance, accuracy and application possibilities are made.
Partners: FKS, Bergen Norway **Sponsor:** ENS.
Contact person: Uwe S. Paulsen, uwe.schmidt.paulsen@risoe.dk
+45 46775055

5.6 Experimental Meteorology (EME)

Title: Management and Administration
Programme and psp: EME, psp 1160000, start date: - .
Description: This project includes the EME activities that are associated with management, administration, internal meetings and other activities not related to any specific projects or to the general research and development project.
Partners: None
Sponsor: Internal
Contact person: Søren E. Larsen, soeren.larsen@risoe.dk +45 46775012

Title: Small Measuring Stations.
Programme and psp: EME, psp 1160001-00, start date: - .
Description: The project includes 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: - .
Sponsor: Internal, and many different external sponsors.

Contact person: Søren E. Larsen, soeren.larsen@risoe.dk +45 46775012.

Title: General Technological Development and Maintenance.

Programme and psp: EME, psp 1160003-00, start date:

Description: The project includes the technological development and maintenance of the technical facilities and activities charged to EME.

Partners: None

Sponsor: Internal

Contact person: Søren E. Larsen, soeren.larsen@risoe.dk +45 46775012

Title: The Risø Mast

Programme and psp: EME, psp 1160003-01, start date: 06/06/1957

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 measurements of direction variance, relative humidity, barometric pressure, precipitation, duration of sunshine, and solar insolation are performed. Occasional testing of other meteorological sensors.

Partners: None

Sponsor: None

Contact person: Niels G. Mortensen, niels.g.mortensen@risoe.dk
+45 46775027

Title: Offshore Data Logging.

Programme and PSP: EME, PSP 1160004, start date: 1999-01-01.

Description: The project focuses on installing, servicing and storing data from a number of off-shore measuring stations in inner Danish Waters for SEAS Wind Energy Centre.

Partners: None.

Sponsor: SEAS Wind Energy Centre.

Contact person: Ole Frost Hansen, ole.frost@risoe.dk +45 46775525.

Title: Gedser Rev Instrumentation.

Programme and PSP: EME, PSP 1160005, start date: 1999-01-01.

Description: The project comprises installing, servicing and storing data from an off-shore measuring station at Gedser Rev in Inner Danish Waters for SEAS Wind Energy Centre.

Partners: None.

Sponsor: SEAS Wind Energy Centre.

Contact person: Ole Frost Hansen, ole.frost@risoe.dk +45 46775525

Title: Field Equipment for NWTTS, India.

Programme and PSP: EME, PSP 1160006, start date: 1999-01-01.

Description: The project comprises installing and servicing of field instrumentation for the National Wind Turbine Test Station at Kayathat in India

Partners: None

Sponsor: Danida

Contact person: Ole Frost Hansen, ole.frost@risoe.dk +45 46775525

Title: Small Contracts.

Programme and psp: EME, psp 1160 007, 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. Examples are technical support for the Environmental Authorities of Copenhagen and operation of offshore meteorology masts for SEAS Wind Energy Centre.

Partners: None.

Sponsor: København Kommunes Miljøkontrol, SEAS Wind Energy Centre, Faroe Island Harbour Authorities, etc.

Contact person: Ole Frost Hansen, ole.frost@risoe.dk +45 46775525

Title: Lesotho Met. Stations.

Programme and psp: EME, psp 1160008, start date: 1999-12-01.

Description: The project comprises supply of three state-of-the-art automatic battery-powered wind-measuring stations for 30 m masts recording wind speed statistics, wind direction, air pressure and temperature. The stations include sensors, signal conditioning units, data logger, data storage and data reading equipment. The stations are suppliers to psp 1170116-00, Energy Management in Lesotho, which in turn supplies the stations to Danced.

Partners: None.

Sponsor: Danced.

Contact person: Ole Frost Hansen, ole.frost@risoe.dk +45 46775525

Title: Tanzania Meteorological Stations.

Programme and psp: EME, psp 1160009, start date: 2000-02-01.

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, wind direction, air pressure, solar radiation and temperature. The stations include sensors, signal conditioning units, data logger, data storage and data reading equipment. The stations are suppliers to psp 1170118-00, Tanzania wind measurements, which in turn supplies the stations to Danida.

Partners: None.

Sponsor: Danida.

Contact person: Ole Frost Hansen, ole.frost@risoe.dk +45 46775525

Title: Equipment for NWTTS, India.

Programme and psp: EME, psp 1160010, start date: 1999-12-01.

Description: The project comprises supply of two complete sets of sensors and data acquisition equipment for testing of two wind turbines at the National Wind Turbine Test Station at Kayathat in India. Each set constitutes a self-contained measurement system capable of performing power curve measurement according to IEC TC88 1400-12, as well as type testing according to the Indian provisional type test system.

Partners: None.

Sponsor: Danida.

Contact person: Ole Frost Hansen, ole.frost@risoe.dk +45 46775525

5.7 Wind Turbine and Blade Testing (PRV)

Title: NEG Micon A/S

Programme and psp: PRV, psp 1155008-07, start date: 01-02-97

Description: Power curve and rotor load measurements.

Partners: NEG Micon A/S

Sponsor: NEG Micon A/S

Contact person: Søren M Petersen, soeren.m.petersen@risoe.dk +45 46775043

Title: NEG Micon A/S

Programme and psp: PRV, psp 1155008-08, start date:

Description: Measurement of rotor loads

Partners: NEG Micon A/S

Sponsor: NEG Micon A/S

Contact person: Søren M Petersen, soeren.m.petersen@risoe.dk +45 46775043

Title: NEG Micon A/S

Programme and psp: PRV, psp 1155016-01, start date 1999

Description: Power curve and structural load measurements

Partners: NEG Micon A/S

Sponsor: NEG Micon A/S

Contact person: Ioannis Antoniou, Ioannis.Antoniou@risoe.dk +45 46775082

Title: NEG Micon A/S. **Confidential**

Programme and psp: PRV, psp 1155016-02, start date:

Description: Load and power curve measurements.

Partners: NEG Micon A/S

Sponsor: NEG Micon A/S

Contact person: Allan Vesth, allan.vesth@risoe.dk +45 46775049

Søren M Petersen, soeren.m.petersen@risoe.dk +45 46775043

Title: NEG Micon A/S

Programme and psp: PRV, psp 1155016-03, start date 1999

Description: Power curve and structural loads measurements

Partners: NEG Micon A/S

Sponsor: NEG Micon A/S

Contact person: Ioannis Antoniou, Ioannis.Antoniou@risoe.dk +45 46775082

Title: NEG Micon A/S

Programme and psp: PRV, psp 1155016-04, start date: 1999.06.01.

Description: To provide load documentation

Partners: **Sponsor:** NEG Micon A/S, Randers Denmark

Contact person: Uwe S. Paulsen, uwe.schmidt.paulsen +45 46775055

Title: NEG Micon A/S, USA

Programme and psp: PRV, psp 1155016-06

Description: Confidential

Partners: NEG Micon A/S.

Sponsor: NEG Micon A/S.

Contact person: Troels Nielsen, troels.eske.nielsen@risoe.dk+45 46775081

Title: NEG Micon A/S

Programme and psp: PRV, psp 1155016-08, start date October 2000

Description: Power curve and structural loads measurements

Partners: Risø and NEG- Micon

Sponsor: NEG Micon A/S

Contact person: Ioannis Antoniou, Ioannis.Antoniou@risoe.dk +45 46775082

Title: NEG Micon A/S, DK

Programme and psp: PRV, psp 1155016-09

Description: Measurement of the power performance

Partners: NEG Micon A/S.

Sponsor: NEG Micon A/S.

Contact person: Troels Nielsen, troels.eske.nielsen@risoe.dk +45 46775081

Title: Vestas Spain, **Confidential**

Programme and psp: PRV, psp 1155017-01, start date: 01-03-99

Description: Measurement project

Partners: Vestas

Sponsor: Vestas

Contact person: Søren M Petersen, soeren.m.petersen@risoe.dk +45 46775043

Title: Wincon. **Confidential**

Programme and psp: PRV, psp 1155018-01, start date:

Description: Measurement system

Partners: Wincon

Sponsor: Wincon

Contact person: Søren M Petersen, soeren.m.petersen@risoe.dk +45 46775043

Title: Mechanical Rotor Shaft Measurements on Wind Turbine with New Soft Brake Option

Programme and psp: PRV, psp 1155019-01, start date: 1999.01.01.

Description: To improve and verify a new soft braking concept for stopping a wind turbine. Analyses of the performance and safety are made.

Partners: Svendborg Brakes **Sponsor:** Svendborg Brakes.

Contact person: Uwe S. Paulsen, uwe.schmidt.paulsen +45 46775055.

Title: Secretariat for Type Approval

Programme and psp: GDK, psp 1150000

Description: The Secretariat for Type Approval have carried out accredited certification and type approval of wind turbine design for several manufacturers in compliance with national requirements in Denmark and The Netherlands. Furthermore design evaluation has been carried out in compliance with regulations in Germany.

Partners: Various manufacturers

Sponsor: Wind turbine manufacturers

Contact person: Erik Jørgensen, erik.r.joergensen@risoe.dk +45 46775064

Title: Blade testing, LM Glasfiber A/S

Programme and psp: SPK, psp 1155007-31

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 are measured. The tests are carried out at the facilities in Sparkær and as field measurements.

Partners: LM Glasfiber A/S

Sponsor: LM

Contact person: Carsten Skamris, c.skamris@risoe.dk +45 46775066

Title: Blade testing, Vestas Wind Systems A/S

Programme and psp: SPK, psp 1155007-32

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 are measured. The tests are carried out on the facilities in Sparkær.

Partners: Vestas Wind Systems A/S

Sponsor: Vestas

Contact person: Carsten Skamris, c.skamris@risoe.dk +45 46775066

6 Committee and Expert 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 (OWEMES) 2000

Barthelmie, R. American Association of Aerosol Research, Atmospheric Aerosols Working Group

Barthelmie, R. Air and Waste Management Association, Visibility Working Group

Bjerregaard, E. Danish Energy Agency, Task Group for Wind Energy R&D

Bjerregaard, E. *Secretary*, Danish Energy Agency, Approval Scheme for Wind Turbines

Christensen, C.J., *Chairman*, International Electrotechnical Committee, Technical Committee 88, Wind Turbine Systems

Christensen, C.J. Dansk Elektroteknisk Komite, DEK. Teknisk Udvalg 88 (S-588) Sikkerhed af Elproducerende Vindmøller (Danish Electrotechnical Committee, Technical Committee S-588, Safety on Wind Turbine Generator Systems)

Christensen, C.J., *Chairman*, European Standards for Wind Turbines, CENELEC BTTF 83-2

Frandsen, S. International Electrotechnical Committee (IEC), Technical Committee TC88, Working Group 6, Test Procedures for Wind Turbine Testing

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

Friis Pedersen, T. Dansk Elektroteknisk Komite, DEK. Teknisk Udvalg 88 (TU88), Sikkerhed af Elproducerende Vindmøller (Danish Electrotechnical Committee, Technical Committee TU88, Safety on Wind Turbine Generator Systems)

Friis Pedersen, T. *Chairman*, International Electrotechnical Committee (IEC), Technical Committee TC88, Working Group 6: Test Procedures for Wind Turbine Testing

Friis Pedersen, T. Danish Energy Agency, Technical Committee (IEC), Technical Committee on Certification and Type Approval

Friis Pedersen, T. *Convenor*, International Electrotechnical Committee (IEC), Technical Committee 88 (TC88) Power Performance Measurement Procedures

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. *Chairman*, Scientific Steering Committee on NATO/CCMS International Technical Meetings on Air Pollution Modelling and Its Application, Conference Series

Gryning, S.E. Science Panel on Atmospheric Chemistry Research (DG XII, EU)

Gryning, S.E. *Guest Editor*, Journal of Agriculture and Forest Meteorology. Special issue of the NOPEX experiment

Gryning, S.E. *Guest Editor*, Theoretical and Applied Climatology. Special issue on “Land-surface/atmosphere exchange in high-latitude landscapes”

Hasager, C.B. Corps of External Examiners, University of Copenhagen

Hasager, C.B. *Convenor*, European Geophysical Society, Symposium on Land Surface Parameterisation in Global Hydrological and Atmospheric Models

Hasager, C.B. *Convenor*, European Geophysical Society, Symposium on Internal Variability in Biosphere-atmosphere Exchange

Hasager, C.B. *National EC-representative*, DG VI, Working Group on Remote Sensing Applications on Forest Health Assessment

Hasager, C.B. Steering Committee, MEAD

Hasager, C.B. *Treasurer*, Erdas Imagine, Danish User Group

Højholdt, P., Danish Energy Agency, Promoter Committee on Small Wind Turbines

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 Electrotechnical 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 Electrotechnical Committee (IEC). Technical Committee 88 (TC88), Safety of Wind Turbine Generator Systems, Working Group 9: Certification Procedures of Wind Turbines

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

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

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

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

Hjuler Jensen, P. Steering Committee, Approval Secretariat, Risø National Laboratory

Hjuler Jensen, P. International Electrotechnical 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 El-producerende Vindmøler (Danish Electrotechnical 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 Electrotechnical 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. Research Advisory Committee for Wind Energy (DK), Danish Energy Agency

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

Hjuler Jensen, P. *Programme Chairman*, 1999 European Union Wind Energy Conference and Exhibition, 1 - 5 March 1999, Nice, France

Hummelshøj, P. *Secretary*, Nordic Society for Aerosol Research (NOSA)

Hummelshøj, P. International Advisory Organisation Committee, The Aerosol Society

Højholdt, P. Danish Energy Agency, Promoter Committee for Small Wind Turbines

Højholdt, P. Technical Committee for Domestic Wind Turbines

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

Jensen, N.O. *Secretary*, Steering Committee, Danish Society for Atmospheric Research (DSAR)

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 Physics

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

Jensen, N.O. Expert Group Geoscience, Swedish Natural Science Research Council

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. *Board Member*, 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. *Editorial Board*, JWB Study on Hydro Power

Landberg, L. Steering Committee of Off-shore 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

Larsen, S.E. Steering Committee, EUROTRAC2-CAPP Project

Larsen, S.E. Steering Committee DSAR (Danish Society of Atmospheric Research)

Lundtang Petersen, E. EUREC-Agency EEIG

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

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

Lundtang Petersen, E. *Chairman*, 1999 European Union Wind Energy Conference and Exhibition, 1 - 5 March 1999, Nice, France

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, EU, DG-XI/XII

Mikkelsen, T., International Scientific Committee on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes

Mikkelsen, T., *Administrative Co-ordinator*, EU Concerted Action Program on Real-time Models for Intercomparison (RTMOD)

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.

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

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.

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

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

Skamris, C. International Electrotechnical 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

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 Electrotechnical Committee (IEC), Technical Committee TC88, Working Group 10

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

Vignati, E. Association for Aerosol Research (GaeF)

Winther-Jensen, M. Advisory Committee on Insurance, The Danish Wind Power Utilities

Winther-Jensen, M. International Electrotechnical Committee (IEC). Technical Committee 88 (TC88), Working Group 8, Testing of Rotor Blades

Winther-Jensen, M. European Standards for Wind Turbines, CENELEC BTTF 83-2, Technical Committee on Labour Safety

7 Publications

7.1 International publications

- Andersen, H.V.; Hovmand, M.F.; Hummelshøj, P.; Jensen, N.O. (1999) Measurements of ammonia concentrations, fluxes and dry deposition velocities to a spruce forest 1991-1995. *Atmos. Environ.*, **33**, 1367-1383
- Barthelmie, R.J. (1998) A brief review of offshore wind energy activity in the 1990's. *Wind Eng.*, **22**, 265-273
- Barthelmie, R.J. (1999) The effects of atmospheric stability on coastal wind climates. *Meteorol. Appl.*, **6**, 39-47

- Barthelmie, R.J.; Pryor, S.C. (1999) A model mechanism to describe oxidation of monoterpenes leading to secondary organic aerosol: 1 α -pinene and β -pinene. *J. Geophys. Res.*, **104(19)**, 23657-23669
- Batchvarova, E.; Cai, X.; Gryning, S.E.; Steyn, D. (1999) Modelling internal boundary-layer development in a region with a complex coastline. *Boundary-Layer Meteorol.*, **90**, 1-20
- Bertagnolio, F (1999) Solution of the incompressible Navier-Stokes equations on domains with one or several open boundaries. *Int. J. Num. Methods Fluids*, **31**, 1061-1085
- Braam, H.; Ronold, K.O.; Christensen, C.J. (1998) PRODETO – Computer Program. Theory and program structure, ECN Report no ECN-C-97-093, Petten, The Netherlands, 56 pp.
- Braam, H.; Dam, J.J.D. Van; Christensen, C.J.; Larsen, G.C.; Thøgersen, M.L.; Ronold, K.O.; Argyriadis, K.; Boer, J. de; Fabian, O. (1999) Probabilistic design tool PRODETO. Final report. ECN-C-99-023, 18 pp.
- Braam, H.; Christensen, C.J.; Dam, J.J.D. van; Larsen, G.C.; Ronold, K.O.; Thøgersen, M.L.; Argyriadis, K.; Boer, J. de; Fabian, O. (1999) Probabilistic design tool PRODETO. Final report. ECN-CX-99-046, 128 pp.
- Braam, H.; (ed.); Seebregts, A.J.; Winther-Jensen, M.; Christensen, P.; Christensen, C.J.C.; Hinrichsen, E. (1999) European wind turbine standards 2. Part 2. Quantification of failure probabilities. In: European wind turbine standards 2. Project results. ECN-C-99-073, 69 pp.
- Bulder, B.H. (ed.); Vionis, P.; Vega, F.A.; Sanz-Martín, J.C.; Winther-Jensen, M.; Brokopf, C. (1999) European wind turbine standards 2. Part 3. Integration of blade test in design. In: European wind turbine standards 2. Project results. ECN-C-99-073, 50 pp.
- Chaviaropoulos, P.; Glinou, G.; Mouzakis, F. (eds.); Winkelaar, D.; Hendriks, B.; Heijdra, B.; Markkilde Petersen, S.; Vølund, P.; Larsen, G.C.; Carlén, I.; Ganander, H.; Morfiadakis, E.; Papadopoulos, K.; Douvikas, D.; Vionis, P.; Fragoulis, A. (1999) European wind turbine standards 2. Part 1. Load spectra and extreme wind conditions. Sub B: Complex terrain and fatigue loading. In: European wind turbine standards 2. Project results. ECN-C-99-073, 86 pp.
- Cionco, R.M.; aufm Kampe, W.; Bilotto, C.; Byers, J.H.; Collins, C.G.; Higgs, T.J.; Hin, A.R.T.; Johansson, P.-E.; Jones, C.D.; Jørgensen, H.E.; Kimber, J.F.; Mikkelsen, T.; Nyrén, K.; Ride, D.J.; Robson, R.; Santabarbara, J.M.; Streicher, J.; Thykier-Nielsen, S., van Raden, H.; Weber, H. (1999) An overview of MADONNA: a multinational field study of high-resolution meteorology and diffusion over complex terrain. *Bulletin, Am. Meteorol. Soc.*, **80**, 5-19
- Claiden, P.; Cockerill, T.T.; Fuglsang, P.; Bak, C.; Schepers, J.G.; Builder, B.; Rossum, R. van; Pedersen, K.Ø. (1999) Site specific design optimisation of wind turbines (SITEOPT). Task 2 report. European Commission, 60 pp.
- Crespo, A.; Hernandez, J.; Frandsen, S. (1999) Survey of modelling methods for wakes and wind farms, *Wind Energy*, **2**, Issue 1, 1-24
- Derrick, A. (ed.); Antoniou, I.; Brand, A.; Frandsen, S.; Glinou, G.; Pahlke, T.; Pérez, I.M.; Ravey, I.; Schwenk, B. (1999) European wind turbine standards 2. Part 5. Site evaluation. In: European wind turbine standards 2. Project results. ECN-C-99-073, 77 pp
- Ekaterinaris, J.A. (1999) New formulation of Hardin-Pope equations for aero-acoustics. *AIAA J*, **37**, 1033-1039
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- Frandsen, S.; Lading, L.; Hansen, R.S.; Kristensen, L.; Miller, G.; Kjær Hansen, J.; Sangill, O.; Lading, P. (1999) Laser anemometry for control and performance testing of wind turbines. Progress report for the period 1 July 1998 to 1 July 1999. European Commission, 73 pp.
- Frank, H.P.; Petersen, E.L.; Hyvönen, R.; Tammelin, B. (1999) Calculations on the wind climate in northern Finland: The importance of inversions and roughness variations during the seasons. *Wind Energy*, **2**, 113-123
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- Fuglsang, P. (1999) Site specific design optimisation of wind turbines. Mid-term assessment report 1 August 1998 to 31 October 1999. European Commission, 28 pp.
- Fuglsang, P.; Bak, C.; Schepers, J.G.; Builder, B.; Cockerill, T.; Claiden, P. (1999) Site specific design optimisation of wind turbines (SITEOPT). Task 3 report. European Commission, 50 pp.
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- Vignati, E.; Kulmala, M.; Raes, F.; Hansson, H.C. (1999) In-cloud processing and subsequent transport in the free troposphere of H₂SO₄-H₂O and soot particles. EGS XXIV General Assembly, The Hague, The Netherlands, 19-23 April 1999. Geophysical Research Abstracts, volume 1, no 2 (Hydrology, Oceans and Atmosphere), p. 504
- Vignati, E.; Leeuw, G. de; Berkowicz, R. (1999) Transport of aerosols and their interaction with gases in the coastal environment. EGS XXIV General Assembly, The Hague, The Netherlands, 19-23 April 1999. Geophys. Res. Abstr., vol 1, no 2 (Hydrology, Oceans and Atmosphere), p. 510
- Wilson, J.; Vignati, E. (1999) Modelling aerosol mixing and ageing. In: ALPS 99. International conference and workshops, Méribel (FR), 18-22 Jan 1999. (Centre National d'Etudes Spatiales, Méribel, 1999) 4 pp.
- Zilitinkevich, S.; Gryanik, V.M.; Lykossov, V.N.; Mironov, D.V. (1998) A new concept of the third order transport and non-local turbulence closures for convective boundary layers (solicited paper). Proceedings of XXIII General Assembly, Nice, France, 20-24 April 1998, *Annales Geophysicae*, part II, supplement II, **16**, C609
- Zilitinkevich, S.; Johansson, P.-E.; Baklanov, A.; Moronov, D.V. (1998) A prognostic equation for the depth of evolving stable stratified atmospheric planetary boundary layers. Proceedings of XXIII General Assembly, Nice, France, 20-24 April 1998, *Annales Geophysicae*, part II, supplement II, **16**, C609

7.7 Educational activities

- Dellwik, E. (1999) Associate teacher on "Multiphase flow in soil", Danish Technical University, autumn term
- Giebel, G. (1999) Teacher, two-day WASP course, Risø National Laboratory (DK)
- Hasager, C.B. (1999) Introduction to satellite imagery, Wind Atlas for Egypt – Component B, Training T2.2 "Wind Resource Assessment, Wind Atlas Analysis and Application" 6-17 September 1999, Risø National Laboratory, Denmark . Notes available, 27 pp
- Landberg, L. WASP course. One-day upgrade course, Risø National Laboratory
- Landberg, L. WASP course. Two-day course, Risø National Laboratory
- Larsen, S.E. Lectures in micro-scale meteorology at Niels Bohr Institute for Astronomy, Physics and Geophysics, University of Copenhagen, spring term
- Mann, J. (1998) Lecture notes for the PhD course on experimental fluid dynamics and data interpretation, Danish Technical University (DK), 19-28 August 1998. Notes available, 20 pp.
- Rathmann, O. (1999) Teacher, one-day upgrade WASP course, Risø National Laboratory (DK)
- Rathmann, O. (1999) Teacher, two-day upgrade WASP course, Risø National Laboratory (DK)
- Rathmann, O. (1999) Teacher, two-day WASP seminar, Yerevan, Armenia, 9-10 August 1999

7.8 Patent applications

- Bak, C.; Fuglsang, P. (1999) Modification and design of an airfoil. patent application (DK) PA 1999 01180
- Lading, L.; Frandsen, S.; Hansen, J.K.; Sangill, O. (1999) Laser anemometry for wind turbines. PCT patent application WO/DK/98/00125

7.9 Seminars held in the department

- Bergmann, Juan, "Implications of the stability-caused vertical decrease of density on constant-flux layers and idealised stable ABL", June
- Dellwik, Ebba, "Fetch considerations for flux measurements over forest", March
- Gillies, Rob "SVAT model simulations of canopy transpiration under doubled CO² atmospheric conditions
- Lenschow, Donald H. "The buffer layer - adding complexity to the lower troposphere", March
- Löfdahl, Lennart "Use of MEMS in turbulence measurements", March
- Marchuk, G.I., "Future of science in the next millennium", June
- Stevens, Bjorn, "Simple model for convective PBLs" (May)

7.10 Assignments and Awards

- Søren E. Larsen, Assigned professor in Geophysics, University of Copenhagen (1 September 1999 - 1 September 2004)
- Peter Hauge Madsen, Award for best wind energy conference paper for the 1999 ASME Wind Energy Symposium "Predicting ultimate loads for wind turbine design"

8 Staff and Guests

8.1 Staff

Administration

Clausen, Gitte, *Project Administrator*

Madsen, Peter Hauge, *Deputy Department Head*

Petersen, Erik Lundtang, *Department Head*

Secretary

Christiansen, Ulla Riis

Programme: Wind Turbines

Scientific staff

Bjerregaard, Egon, *Senior Consultant* (from 1 July)

Christensen, Carl Jørgen

Frandsen, Sten Tronæs

Hansen, Jens Carsten

Højholdt, Poul

Jensen, Peter Hjuler, *Programme Head*

Jørgensen, Erik Rosenfeldt

Lemming, Jørgen (till 30 September)

Lundsager, Per

Nørgaard, Per

Thøgersen, Morten Lybech (from 1 December)

Winther-Jensen, Martin

PhD students, graduates and post doctoral researchers

None

Technical staff

Hagensen, Flemming

Lange, Rolf

Secretaries

Henriksen, Mette Porsdal

Westermann, Kirsten

Programme: Aeroelastic Design

Scientific staff

Bak, Christian

Fuglsang, Peter

Hansen, Morten, Hartvig (from 1 September)

Johansen, Jeppe

Larsen, Gunner

Larsen, Torben Juul

Madsen, Helge Aagaard

Petersen, Jørgen Thirstrup

Flemming Rasmussen, *Programme Head*

Sørensen, Niels Nørmark

Thomsen, Kenneth

PhD students, graduates and post doctoral researchers

Baumgart, Andreas

Bertagnolio, Franck

Dahl, Kristian Skriver

PhD theses

Johansen, Jeppe

Secretary

Westermann, Kirsten

Programme: Electric Design and Control**Scientific staff:**

Bindner, Henrik W.

Hansen, Lars Henrik

Hjuler Jensen, Peter, *Programme Head*

Sørensen, Poul

PhD students, graduates and post doctoral researchers

Hansen, Anca Daniela

Pereira, Alexandre

Secretary

Madsen, Jytte

Special Task: Tests and Measurements**Scientific staff**

Antoniou, Ioannis

Krogsgaard, Jørgen

Lind, Søren Ømann (till 1 October)

Nielsen, Troels Eske (from 1 October)

Paulsen, Uwe Schmidt

Pedersen, Troels Friis, *Programme Head*

Petersen, Søren Markkilde

Vesth, Allan (from 1 October)

PhD students, graduates and post doctoral

de Barros, Eliza Medeiros (from 15 November)

Rosas, Pedro André (from 15 November)

Technical staff

Borchsenius, Jens (from 1 September)

Christensen, Kurt

Clemmensen, Kaspar (from 1 September)

Hansen, Per

Høst, Oluf

Larsen, Gert

Nielsen, Finn Linke

Rasmussen, Michael

Secretary

Hansen, Anne-Marie

Special Task: Type Approval**Scientific staff**

Krogh, Thomas

Schaarup, Jesper

Skamris, Carsten, *Head*

Secretary

Madsen, Tina Precht (from 1 April)

Sparkær Centre (Wind Turbine Blade Testing)**Scientific staff**

Grove-Nielsen, Erik

Kristiansen, Kristian Quist, *Head* (from 12 April)

Aarhus, Karl

Technical staff

Bruun, Peter, substitute (1 December 1999 - 31 May 2000)

Lind, Per

Lund-Thomsen, Hans (till 30 April)

Pedersen, Jimmy (from 3 May)

Thinggaard, Jesper (from 1 March)

Secretary

Kristensen, Bente Hangaard (from 1 December)

Programme: Wind Power Meteorology**Scientific staff**

Frank, Helmut

Højstrup, Jørgen (on leave)

Kristensen, Leif

Landberg, Lars, *Programme Head*

Mann, Jakob

Mortensen, Niels Gylling

Rathmann, Ole

Sempreviva, Anna Maria

PhD students, graduates and post doctoral researchers

Bergmann, Juan (till 15 April)

Giebel, Gregor

Joensen, Alfred

Lange, Bernhard

PhD theses

Sempreviva Anna Maria

Secretary

Nielsen, Rikke

Programme: Wind Energy and Atmospheric Processes**Scientific staff**

Astrup, Poul

Gryning, Sven Erik

Hasager, Charlotte Bay

Hummelshøj, Poul (on leave from 1 April)

Jensen, Niels Otto

Jørgensen, Hans

Mikkelsen, Torben

Larsen, Søren, *Programme Head*

Nielsen, Morten

Sørensen, Lise Lotte

Thykier-Nielsen, Søren

PhD students, graduates and post doctoral researchers

Dellwik, Ebba (from 16 April)

Frohn Lise (from 1 May; in a collaboration with NERI)

Moltesen, Asta (till 30 June)

Vignati, Elisabetta (till 31 March)

PhD theses

Friis Kjeld, Jørgen

Moltesen, Asta

Santabàrbara, Josep Moreno

Vignati, Elisabetta

Secretary

Skrumtsager, Birthe

Special Task: Experimental Meteorology

Scientific staff

Courtney, Mike (on leave from 1 March)

Hansen, Ole Frost

Larsen, Søren, *Head*

Møller, René

Sanderhoff, Peter

Technical staff

Andersen, Anker Bruun

Christensen, Lars (on leave from 1 April)

Hansen, Arent

Hansen, Finn

Hansen, John (on leave from 1 April)

Jensen, Gunnar

Lund, Søren

Nielsen, Jan

Secretary

Skrumsager, Birthe

8.2 Guest scientists

Barker, Richard	15.06 - 20.09	Loughborough Univ., UK
Barthelmie, Beki	18.05 - 28.09	University of Indiana, USA
Bergmann, Juan	01.01 - 15.04	Hamburg, Germany
Dunkerley, Fay	03.05 - 30.06	UMIST, Manchester, Great Britain
	01.08 - 30.09	
Garg, B.M.L.	24.10 - 06.11	India
Lumby, Ben	15.06 - 20.09	Loughborough Univ., UK
Moltesen, Asta	01.01 - 30.06	
Prasad, N.S.	24.10 - 06.11	India
Sastry, J.P.L.N.	24.10 - 06.11	India

Title and authors

Annual Progress Report
Wind Energy and Atmospheric Physics Department

Søren E. Larsen and Birthe Skrumsager (eds.)

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Wind Energy and Atmospheric Physics Department	June 2000

Groups own reg. number(s)	Project/contract No(s)

Pages	Tables	Illustrations	References
78	10		

Abstract (max. 2000 characters)

The report describes the work of the Wind Energy and Atmospheric Physics Department at Risø National Laboratory in 1999. 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 1999 is presented, including lists of publications, lectures, committees and staff members

Descriptors INIS/EDB

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Wind Energy & Atmospheric Physics Dept. Risø National Laboratory - 1999 In Brief



Objective:

The purpose of the department is - by research and development and by providing technical services in areas where the department has a special research-based expertise - to establish:

- the scientific background and technological opportunities for the global exploitation of wind energy, the international competitiveness of the wind energy industry and the implementation of the Danish energy policies, and
- the atmospheric physics basis for the assessment and prediction of wind effects, transport, transformation and exchange of air pollution and other airborne sub-stances as well as for the consequences in case of emergencies

Organisation:

The department management consists of:

- Erik Lundtang Petersen, Head (ext.. 5001)
- Peter Hauge Madsen, Deputy head (ext. 5011)

The research is organised in the research programs:

- Atmospheric Transport & Exchange
Søren Larsen, Head (ext. 5012)
- Wind Power Meteorology
Lars Landberg, Head (ext. 5024)
- Aeroelastic Design
Flemming Rasmussen, Head (ext.5048)
- Electric Design & Control
Peter Hjuler Jensen, Head (ext. 5037)
- Wind Turbines
Peter Hjuler Jensen, Head (ext. 5037)

The special tasks are:

- Wind Turbine & Blade Testing
Troels Friis Petersen, Head (ext. 5042)
- Type-Approvals & Certification
Carsten Skamris, Head (ext. 5066)
- Experimental Meteorology
Søren Larsen, Head (ext. 5012)

Publications:

International Publications	63
Danish Publications:	18
Conference Papers with Proc.	108
Popular Scientific Publications	
Unpublished Lectures	

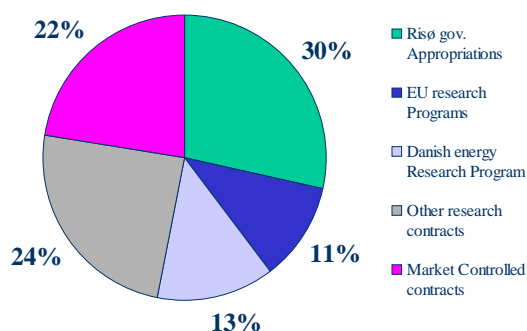
Staff :

Academic staff:	58
Technical/administrative staff:	26
Ph.D. and Post Docs	7

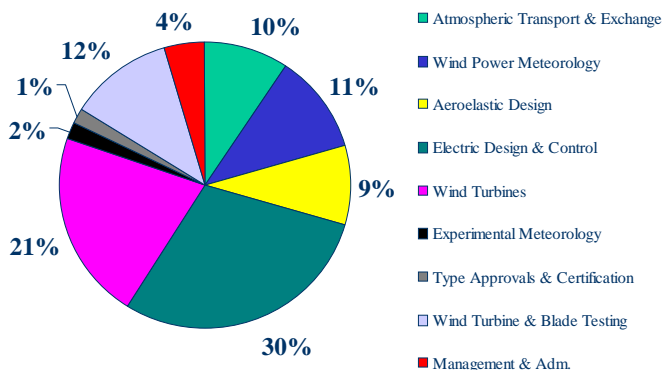
Finances:

Turnover:	DKK 97.9 million
Contracts market controlled :	DKK 27.2 million
Contracts grant controlled:	DKK 46.3 million

Funding Sources 1999



Activity turnover



Expenses

