RISØ National Laboratory

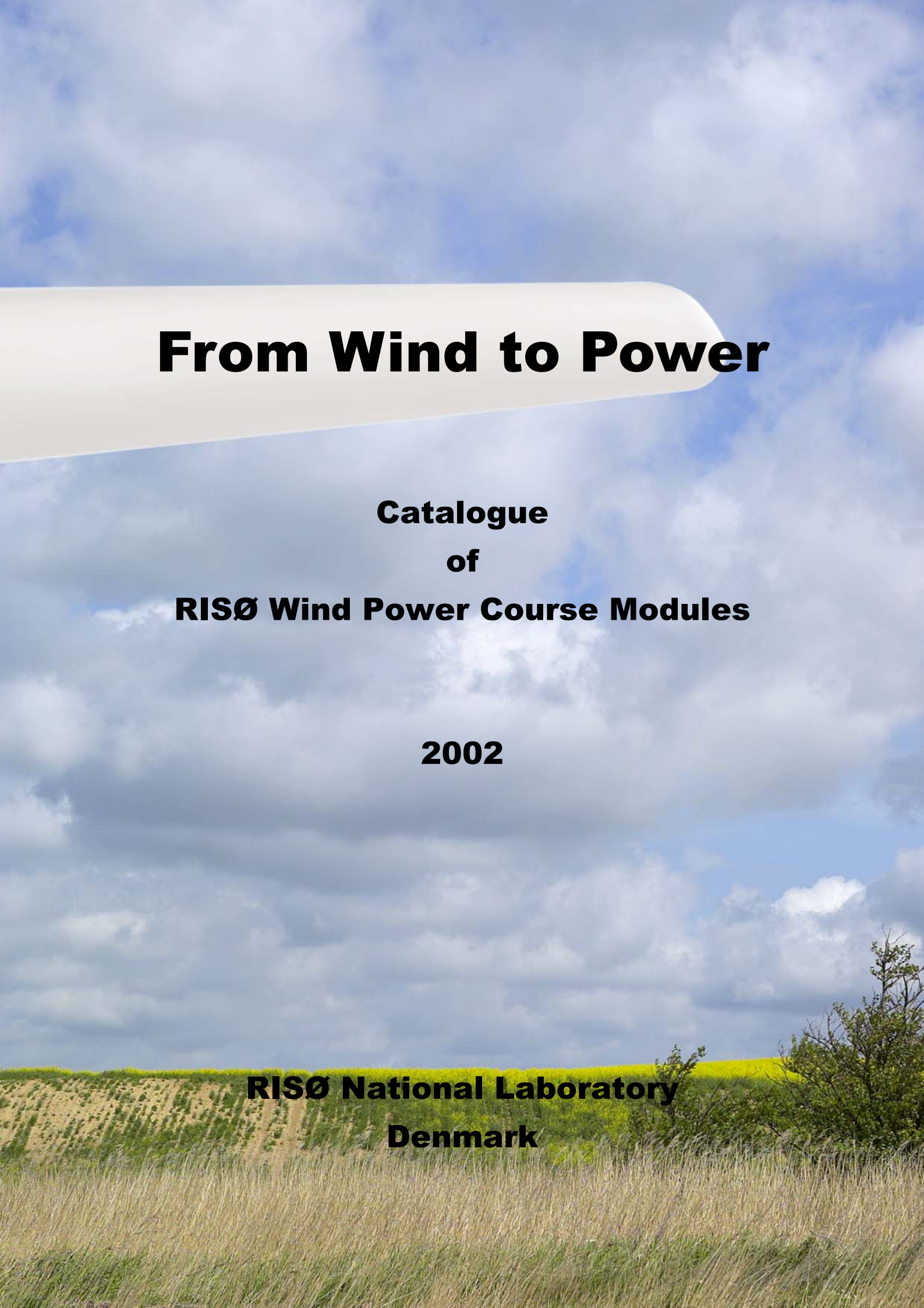
RISØ is a national, state owned research & development institution with 1000 employees. The main research areas are

- Energy
- Materials
- Bio technology

RISØ Wind Energy

The Wind Energy Department with a staff of over 100 covers most of the research & development subjects from wind to power, including

- Wind meteorology
- Wind resources
- Aerodynamics
- Structural dynamics
- Aero-elasticity
- Materials
- Determination of load basis
- Wind turbine design
- Certification of wind turbines and projects
- Electrical design and control
- Wind power integration
- Electrical system analysis and design
- Feasibility analysis
- Project development and implementation
- Institutional and human resource development



From Wind to Power

Catalogue
of
RISØ Wind Power Course Modules

2002

RISØ National Laboratory
Denmark

Wind Power Course Modules

This catalogue presents examples of wind energy courses offered by RISØ.

Based on RISØ's many years of experience in research, development, consultancy and education within the utilisation of wind energy, we offer courses in most of the subjects related to the development, design, utilisation and evaluation of the wind power technology. Standard courses within general demanded common subjects are offered on regular basis. Dedicated courses are designed for specific purposes. The courses may either be carried out at RISØ providing the possibility to make use of the various RISØ specialists and the RISØ workshop facilities, or locally giving more people easier access to participate.

RISØ WindConsult

RISØ offers consultancy work on ordinary commercial basis.

The RISØ WindConsult unit coordinates RISØ's international wind energy consultancy and compose dedicated offers on request – including course packages. RISØ experts and specialists carry out the work, based on their experience and on the state-of-the-art knowledge and methods.

RISØ has established alliances with organisations, supplementing RISØ's own expertise.

In addition, RISØ participate in international networks and collaborate with institutions worldwide.

Please contact RISØ WindConsult for more information

- by phone: +45 4677 5070
- by e-mail: windconsult@risoe.dk
- or visit our web-site: www.risoe.dk/windconsult

Alliances

DNV – Det Norske Veritas

Danish Research Consortium for Wind Energy

Collaboration

Denmark

- DTU
- AUC
- HIH
- DHI

International

- ISET
- ECN
- CRES

List of Modules

Course Module	*Contact person*
Boundary Layer Meteorology	Niels Gylling Mortensen
Wind Atlas Methodology	Lars Landberg
WAsP	Ole Rathmann
WAsP Engineering	Jakob Mann
Wind Turbine Design Basis	Sten Frandsen
Loads and Lifetime	Kenneth Thomsen
Aero-elastic design	Kenneth Thomsen
Blade design	Peter Fuglsang
Wind Turbine Testing	Søren Markilde Petersen
Wind Turbine Certification	Erik Jørgensen
Wind Turbine Standards	Peter Hauge Madsen
Wind Power Integration	Henrik Bindner
Hybrid Power Systems	Per Lundsager
Wind Power Feasibility Analysis	Jens Carsten Hansen
Wind Resource Assessment	Lars Landberg
Power Performance Testing	Troels Friis Petersen
Offshore Wind Power	Rebecca Barthelmie

Education coordinator: Søren Larsen

Course coordinator: Per Nørgaard

Module: **Boundary Layer Meteorology**

Topics:

- Global wind meteorology
- Local wind climatological effects
- Boundary layer meteorology
- The Wind Atlas method
- Wind characteristics
- Wind statistics

Contents: The course introduce the basics for understanding and using the Wind Atlas Metodology for wind resource assessments.

The Wind Atlas Metodology forms the basis for the WAsP tool, developed at RISØ.

Pre-qualifications:

Contact: Niels Gylling Mortensen

Module: **Wind Atlas Methodology**

Topics:

-

Contents:

Pre-qualifications:

Contact: Lars Landberg

Module: **WAsP**

Topics:

- The Wind Atlas Metodology
- The flow modelling
- The local wind climate
- The local wind obstackles
- Characterisation of the surface roughness
- Characterisation of the orography
- Wind measurements
- Estimated energy production
- The wind park effects

Contents: WAsP, developed by RISØ, has become the World industry standard tool and reference for wind resource assessments.

WAsP - Wind Atlas, Analysis and Application Program - is a numerical model, tool and code for PC based on the Wind Atlas Metodology - the metodology applied to PC.

Pre-qualifications:

Contact: Ole Rathmann

Module: **WAsP Engineering**

Topics:

- The models applied in WAsP Engineering
- WAsP Engineering input
- WAsP Engineering applications
- The WAsP Engineering user interface
- WAsP Engineering hands-on

Contents: WAsP Engineering is a numerical tool for detailed estimation of the wind design parameters relevant for engineering construction and design, in specific for design of wind power applications.

The course present the tool, the background theory, the models applied, the assumptions, the input, the output, the typical applications and the limitations.

Pre-qualifications:

Contact: Jakob Mann

Module: **Wind Turbine Design Basis**

Topics:

- Wind turbine designs
- Airfoil characteristics - lift and drag coefficients, 3-dimensional effects, tip effects, hysteresis effects
- Blade and rotor design
- Wind turbine structural design
- Aeroelastic design
- Design tool - HAWC

Contents: The course present and discuss the important elements in the structural design of a horisontal axis wind turbine.

The overall optimisation parameter in the design is $/kWh - the cost of produced energy over the wind turbines lifetime. The design aims to optimise the cost over the lifetime (including material quantity and the maintenance necessary), the energy production and the reliability (including the components lifetime).

Various models and tools for disign purposes are presented and demonstrated.

Pre-qualifications:

Contact: Sten Frandsen

Module: **Loads and Lifetime**

Topics:

- Dynamic and extreem loads
- Material characteristics
- Fatigue analysis
- Rainflow counting
- Lifetime estimation

Contents: One of the critical parameters in the design of wind turbines is the estimated lifetime of the components - in specific the critical and expensive components.

The course presents methods, standards and tools for estimation of characteristic design loads for the design of wind turbine constructions and the estimation of the components lifetime.

The course characterise the load basis, describe the accepted design load cases and present the basis and metods for estimation of the materials and the components lifetime.

Pre-qualifications:

Contact: Kenneth Thomsen

Module: **Aero-elastic design**

Topics:
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Contents: Aero-elastic design - the interaction between structural and aerodynamic design - is especially relevant in the optimisation of the modern wind turbine disign with large, light and elestic structures.

Pre-qualifications:

Contact: Kenneth Thomsen

Module: **Blade design**

Topics:

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Contents: As the size of the blades for modern and cost efficient wind turbines becomes larger, the design of the blades become more critical.

The course present various methods and tools for the optimisation of the blade design, combining a number of optimisation parameters.

Pre-qualifications:

Contact: Peter Fuglsang

Module: **Wind Turbine Testing**

Topics:

- Power performance testing
- Testing of structural loads
- Identification of eigenfrequencies
- Power quality testing

Contents:

Pre-qualifications:

Contact: Søren Markilde Petersen

Module: **Wind Turbine Certification**

Topics:

- Loads and safety
- Load cases
- Calculations vs measurements
- National and international standards
- Legal framework and organisational setup

Contents: The course present and discuss the aims, the conditions, the framework and the necessary technical basis for establishing a certification scheme for wind turbines.

Pre-qualifications:

Contact: Erik Jørgensen

Module: **Wind Turbine Standards**

Topics:

- The international standard series 61400-xx
- Part 1: Safety requirements
- Part 2: Safety of small wind turbines
- Part 11: Acoustic noise measurement techniques
- Part 12: Wind turbines power performance testing
- Part 13: Measurement of mechanical loads
- Part 23: Full-scale structural testing of rotor blades

Contents: The course present and discuss the objectives, contents and use of the international standards for wind turbine and their applications - the ISO 61400 serie.

Pre-qualifications:

Contact: Peter Hauge Madsen

Module: **Wind Power Integration**

Topics:

- Wind turbine controller and power regulation
- Power fluctuations
- Wind turbine cut-in
- Wind turbine grid connection
- Power quality characteristics and requirements
- System integration of large-scale wind power

Contents: The course present and discuss the specific problems related to the integration of wind power into the power supply system, and how the wind farm(s) and the power system can be designed and optimised to maximise the value of the wind power.

Pre-qualifications:

Contact: Henrik Bindner

Module: **Hybrid Power Systems**

Topics:

- Isolated power supply systems with wind power
- Wind / diesel power supply systems
- Battery storage systems (and PV)
- Weak coupled local power generating systems

Contents: The course presents the specific problems related to utilise wind power in isolated hybrid power supply systems, like the combined wind + diesel system with a battery storage as an option.

The various configurations and their characteristics are presented and discussed.

Various analysis and tools for the design and evaluation are presented and demonstrated.

Pre-qualifications:

Contact: Per Lundsager

Module: **Wind Power Feasibility Analysis**

Topics:

- Wind farm siting
- Wind farm layout and micro-siting
- Estimated annual production
- Estimated project costs
- Financial and economic analysis
- Environmental impacts
- Organisational requirements

Contents: The various elements in a feasibility study of wind power as an option for a given system or application are presented and discussed.

The presentations are based on RISØ extended experience in the field and based on real case studies performed by RISØ.

Pre-qualifications:

Contact: Jens Carsten Hansen

Module: **Wind Resource Assessment**

Topics:

- The Wind Atlas method - WAsP
- The meso-scale method - KAMM
- Wind measurements and wind statistics
- Local effects - orography, surface roughness, obstacles
- Wind resource mapping
- The Local Wind Climate

Contents: The course present and discuss the various elements and metodologies in a wind resource assessment.

The characteristics, quality and limitation of the various metodologies are discussed.

Pre-qualifications:

Contact: Lars Landberg

Module: **Power Performance Testing**

Topics:

- The Power Curve
- International standards
- Uncertainties

Contents: The power curve is one of the essential characterisation and specification of a wind turbine.

The course present and discuss the various problems in determining a reliable power curve for a wind turbine.

The course present the international standard for obtaining the power curve.

The course discuss how the power performance of a wind turbine can be defined in contractural applications, and how the gauranteed performance can be tested on site.

Pre-qualifications:

Contact: Troels Friis Petersen

Module: **Offshore Wind Power**

Topics:

- Offshore wind characteristics
- Combined loads - wind, waves, ice
- Offshore wind turbine foundations
- Grid connection of offshore wind farms
- Operation and maintenance of offshore wind farms

Contents: Offshore wind power is attractive due to the high wind energy potential and the less visual impact, but the installation, operation and maintenance is more expensive and complicated than onshore. The design criteria are different.

The course present and discuss the specific problems related to offshore wind power applications.

The course discuss the specific environmental operation conditions, the specific maintenance problems and the specific grid connection characteristics.

Pre-qualifications:

Contact: Rebecca Barthelmie