Blades & Rotors

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- DAMPBLADE – CRES (GR) M€ 1.1
- KNOW-BLADE – RISØ (DK) M€ 1.0
- MEXICO – ECN (NL) M€ 1.5
- OPTIMAT BLADES – WMC (NL) M€ 2.4
- SIROCCO – ECN (NL) M€ 1.7
- STABCON – RISØ (DK) M€ 1.9
- COMHUB – UN. GIRONA (ES) M€ 0.8

Total EC contribution: M€ 10.4
(>1/3 of FP5 WIND budget)
Introduction

- The rotor is the most visible aspect of a wind turbine
  - Big
  - External
  - Moving
- Very noticeable in case of failure!
- First step in conversion from wind to electricity
  - External influences
Challenges

- **€/kWh:**
  - Beating the square-cube law:
    - The energy output $\sim D^2$ $\Leftrightarrow$ The blade mass $\sim D^3$
    - Worse for gravity component

- **Public acceptance**
  - Decrease generated aerodynamic noise
    - **SIROCCO**
  - Increase aerodynamic efficiency
    - lower loads on blades, same energy yield
    - **MEXICO**
Challenges: continued

- Increasing average diameter
  - Less reserves: more detailed structural analysis necessary
    - **OPTIMAT BLADES**
  - Optimised rotor parts
    - Weight, corrosion, casting problems
    - **COMHUB**
  - Improved damping qualities
    - **DAMPBLADE**

- Increased risk of aeroelastic instabilities
  - Less reserves: more detailed aeroelastic analysis necessary
    - **KNOW-BLADE**
    - **MEXICO**
    - **STABCON**
  - Improve structural damping qualities
    - **DAMPBLADE**
Achievements, materials & structures

◆ Materials & Structures

- First full database on a material **OPTIMAT BLADES**
  - More Bi-axial material data, comparison between FE and digital imaging techniques
- Improved knowledge on damping 80% improvement damping capacity achieved **DAMPBLADE**
- Composite Hub designed and produced **CONHUB**
Achievements, Aeroelastic

- First Detached Eddy Simulation of a full wind turbine **KNOW-BLADE**
- Full 3D NS model
- Fully instrumented model in Wind tunnel **MEXICO**
- Aeroelastic stability limit tools **STABCON**
**Achievements, result**

- **Square-cube law: mitigated by improved designs**

![Blade Weight vs Diameter graph]

- $y \sim x^{3}$
- $y \sim x^{2.63}$
- $y \sim x^{2.42}$
Future R&D

◆ Unified material qualification procedure
  ➔ Fatigue progressive damage model
    ● Failure prediction under static/fatigue loads
◆ Probabilistic approach to blade design
◆ Improved aerodynamic understanding
  ➔ Higher energy yield, lower static/fatigue loads
◆ Integrated design tools
  ➔ Overall optimisation possible
  ➔ Include LCA (Life Cycle Analysis)
◆ Small turbines
  ➔ R.I.P. (-off)
    ● Hybrid systems possible for remote locations
Future R&D, continued

◆ Extended aeroelastic model
  - In between full N.S. and blade moment
    - For instance “2.5 D” instead of full 3D
  - Unsteady Aerodynamics on rotating blades, incl. massively separated flows
  - relation between wake and rotor-inflow
  - yawed flow

◆ Norms and standards
  - Unified material qualification procedure
  - Aerodynamic/Aeroelastic: still limited to consultants.
    - Blade loads: some 20% difference
Wind Energy R&D support from the European Commission

EWEC 2004, London 23rd November 2004