

Vindforskprojekt v-210 (Drift)



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Optimal maintenance management
for wind power systems
- using condition based monitoring
systems with aspect to reliability
and cost

Lina Bertling, Andrea Lang, Francois Besnard
KTH Skolan för Elektro- och Systemteknik/RCAM

RCAM/Wind Research group

Supervisors, KTH:

- Roland Eriksson, professor
- Lina Bertling, assistant professor, research leader



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Ph.D. student: Andrea Lang

M.Sc. students: Francois Besnard, Michele Lucente

Senior guest researchers and co-operation partners:

- Mikael Patriksson, Professor applied mathematics, Chalmers
- Erik Dotzauer, Ph.D., Fortum Värme
- Arnt Ove Eggen, SINTEF, Norway
- Jörn Vatn, NTNU, Norway

Financial support: Vindforsk, EKC

Industry Collaboration: SvK, Vattenfall, Fortum, EON

Content



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- Introduction: background and goal
- Theory: basic concepts of maintenance
- History: research within the RCAM group
- Project outlay: activities for 2007
- Closure and contact

Introduction: background and goal

Background:

- Maintenance planning of wind power plants is today not optimized.
- The development towards offshore farms requires a more efficient maintenance planning.
- With Condition Monitoring Systems, CMS, maintenance can be scheduled prior to the occurrence of the failure.



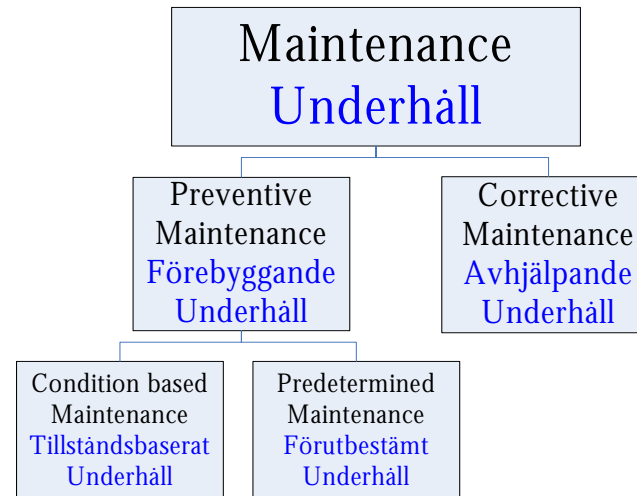
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Goal:

- The final goal is an algorithm for an optimal maintenance strategy, using **achievable** data as input.

Theory: basic concepts of maintenance

- Different kinds of maintenance



Swedish Standard SS-EN 13306
Maintenance terminology

- Reliability indices

- Mean time to failure (MTTF)
- Number of failures per time unit
- $P(\text{item is working at time } t)$ (availability)



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History: research within RCAM/Wind

RCAM: Reliability Centered Asset Management

Quantitative approach of RCM (Reliability Centered Maintenance): a systematic method to balance between preventive and corrective maintenance.



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The RCAM research group at KTH:

School of Electrical Engineering,
Division of Electrotechnical Design, (Prof. Roland Eriksson)

7 Ph.D. students, research leader Lina Bertling

History: research within RCAM/Wind

Pre-study 2005-2006



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- Aim: investigate the effect of CMS for the maintenance process
- Participants: Lina Bertling, (project leader, examiner and supervisor), Thomas Ackerman (supervisor), Julia Nilsson and Johan Ribrant (master thesis students)
- Publications:
 - 2 IEEE Transactions of Energy Conversion, March 2007
 - 2 Master theses, April 2006
 - Elforskrapport 06:39 "Förstudie om tillförlitlighetsbaserat underhåll för vindkraftsystem", May 2006

History: research within RCAM/Wind

Ribrant, J., Bertling, L., "Reliability performance and maintenance – A survey of failures in wind power systems"

- Failure statistics from Sweden, Finland and Germany
- Gear box identified as critical component – almost 20% of down time due to gear box failures



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Nilsson, J., Bertling, L., "Maintenance management of wind power systems – Cost effect analysis of condition monitoring systems"

- Data from Olsvenne2, at Näsudden (Gotland, Sweden), and Kentish Flats, in the UK
- LCC analysis with/without CMS
- CMS interesting for wind farms

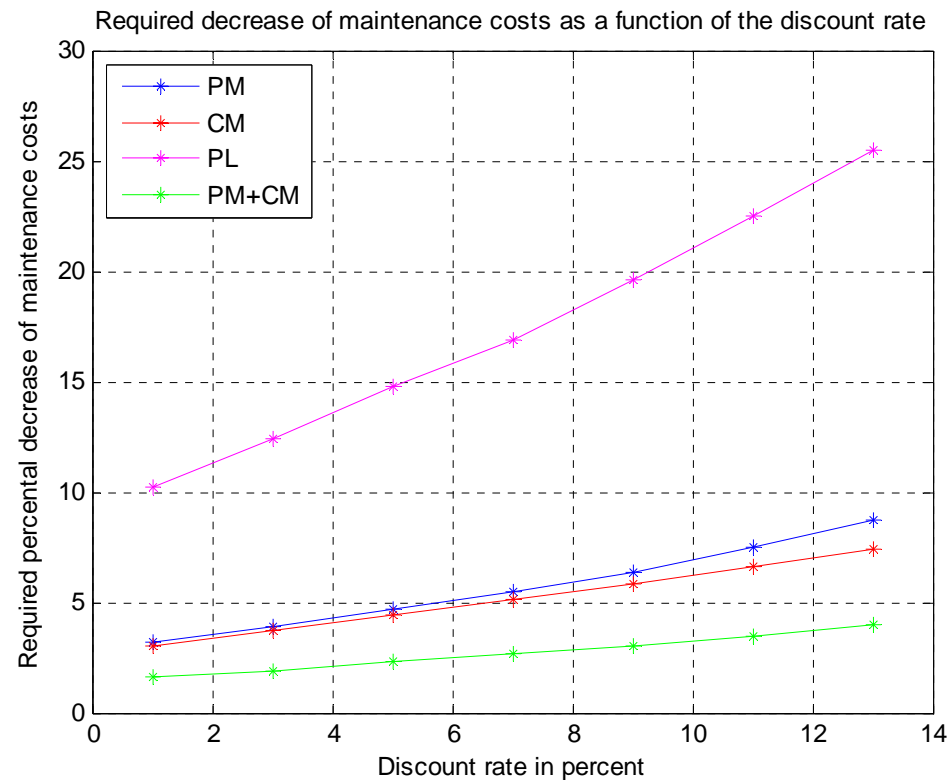
History: research within RCAM/Wind

Required decrease of maintenance costs as a function of the discount rate



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PM: Preventive Maintenance
CM: Corrective Maintenance
PL: Production Loss



History: research within RCAM/Wind

Ongoing master theses:



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- **Maintenance optimization for the gear box**
 - Lina Bertling, supervisor and examiner
 - Jorn Vatn, NTNU Norway, supervisor
 - Michele Lucente, master thesis student
(Performed at NTNU, Norway)
- **Stochastic dynamic programming**
 - Lina Bertling, supervisor and examiner
 - Michael Patriksson, supervisor
 - Francois Besnard, master thesis student

Project outlay: activities for 2007

“Optimal maintenance management for wind power systems using condition based monitoring systems with aspect to reliability and cost”

Ph.D Project started in December 2006. Main activities:



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- Conferences, written reports:
 - SINTEF wind energy conference, Trondheim 25-26 Jan.
 - Vinforsk “Vindkraftforskning i fokus”, KTH 8 February
 - VGB conference on maintenance of wind power systems, Hamburg 26-27 March
- Sensitivity analysis of results in the thesis work of J. Nilsson (figure above)
- Literature study; “state of art”
- Visit at Smöla wind farm, May 2007

Project outlay: activities for 2007

State of art study: content

- 1 Description of the maintenance process
- 2 Overview of research within the area
- 3 Comparison between theory and reality
- 4 Description of mathematical methods
- 5 Suggestion to problem formulation



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State of art study: working plan

- Telephone interviews (Göran Olsson, Vattenfall) and visits (Smöla, Norge), as well as written reports and notes from conferences.
- Literature study
- Time plan: finished summer 2007

Project outlay: activities for 2007

Main questions to be answered

What parts of the maintenance process are optimized?

What optimization methods could be used?



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Result

Exact definition of the project

Thank you for the attention!

- Welcome to take contact for further information and questions!
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