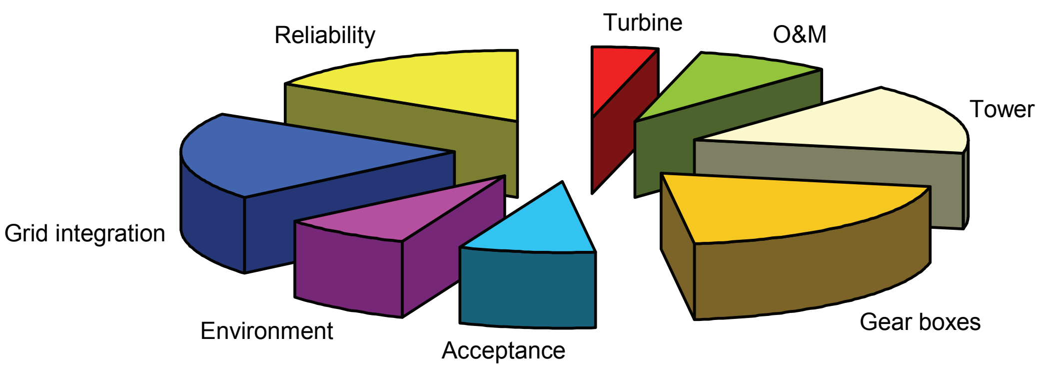
INTERNATIONAL ENERGY AGENCY

Implementing Agreement for Co-operation in the Research, Development and Deployment of Wind Turbine Systems
Task 11

55th IEA Topical Expert Meeting

Long Term Research Needs In the Frame of the IEA Wind Co-operative Agreement

Berlin, Germany, December 2007
Organised by: German Ministry for Environment



Scientific Co-ordination:
Sven-Erik Thor
Vattenfall AB, 162 87 Stockholm, Sweden

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After one year the proceedings can be distributed to all countries, that is December 2008.

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For more information about IEA Wind see www.ieawind.org

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IEA RD&D Wind Task 11

Topical Expert Meeting #55

Long Term Research Needs
In the Frame of the IEA Wind Co-operative Agreement

TASK 11
BASE TECHNOLOGY INFORMATION EXCHANGE

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E-mail: sven-erik.thor@vattenfall.com

The objective of this Task is to promote wind turbine technology through cooperative activities and information exchange on R&D topics of common interest. These cooperative activities have been part of the Agreement since 1978.

The task includes two subtasks. The objective of the first subtask is to develop recommended practices for wind turbine testing and evaluation by assembling an Experts Group for each topic needing recommended practices. For example, the Experts Group on wind speed measurements published the document titled “Wind Speed Measurement and Use of Cup Anemometry”.

The objective of the second subtask is to conduct joint actions in research areas identified by the IEA R&D Wind Executive Committee. The Executive Committee designates Joint Actions in research areas of current interest, which requires an exchange of information. So far, Joint Actions have been initiated in *Aerodynamics of Wind Turbines, Wind Turbine Fatigue, Wind Characteristics, Offshore Wind Systems and Wind Forecasting Techniques.* Symposia and conferences have been held on designated topics in each of these areas.

In addition to Joint Action symposia, Topical Expert Meetings are arranged once or twice a year on topics decided by the IEA RD&D Wind Executive Committee. One such Expert Meeting gave background information for preparing the following strategy paper “Long-Term Research and Development Needs for Wind Energy for the Time Frame 2000 to 2020”. This document can be downloaded from source 1 below.

Since these activities were initiated in 1978, more than 60 volumes of proceedings have been published. In the series of Recommended Practices 11 documents were published and five of these have revised editions.

All documents produced under Task XI and published by the Operating Agent are available to citizens of member countries from the Operating Agent, and from representatives of countries participating in Task XI.

More information can be obtained from:

1. www.ieawind.org
2. http://www.ieawind.org/summary_page_xi.html

September, 2007

INTRODUCTORY NOTE

IEA TOPICAL EXPERT MEETING # 55

ON

LONG TERM RESEARCH NEEDS – IN THE FRAME OF THE IEA WIND ENERGY CO-OPERATIVE AGREEMENT

Dr. Joachim Kutscher and Sven-Erik Thor

BACKGROUND

The International Energy Agency (IEA) Wind agreement is a vehicle for member countries to exchange information on the planning and execution of national large-scale wind system projects and to undertake co-operative research and development (R&D) projects called Tasks.

At the close of 2006, 83% of the more than 74 GW of worldwide wind generating capacity was operating in the IEA Wind member countries. Hence also the needs of strategic research on wind energy deployment is concentrated to these countries. Common research tasks which are in progress at present under IEA Wind are:

- Power System Operation with Large Amounts of Wind Power
- Integration of Wind and Hydropower
- Offshore Wind Energy Technology Development
- Dynamic models of wind farms for power system studies
- Horizontal axis wind turbine aerodynamics (HAWT) and models from wind tunnel measurements
- Base technology information exchange

A similar meeting on this subject was arranged in 2001. It is now due time to arrange a new meeting on the same subject in order to sum up progress and identify future research needs.

The Present and Future Status of Wind Energy

Total electrical generation from wind in the IEA Wind member countries has increased from less than 10 TWh in 1995 to nearly 118 TWh in 2006. The contribution from wind energy to the combined electricity demand of the member countries varied from under 1% to 16.8% in Denmark. In five countries wind energy exceeded 5% contribution to the national electrical demand.

Wind energy can be a significant source of electrical generation. For example, Spain supplies a full 9% of its electricity demand with wind. In Denmark, the highest average coverage of wind power yearly was nearly 17%; between 27% and 29% of the total electricity consumption was covered by wind power in November and December alone.

In the coming years an even larger introduction of wind energy will be seen. In order to make this deployment come true, it has to be supported by extensive R&D and Development actions. Future R&D will support incremental improvements in e.g. understanding extreme

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wind situations, aerodynamics and electrical machines. But, the challenge is to try to find those evolutionary steps that can be taken to further improve wind turbine technology, for example in large scale integration incorporating wind forecasting and grid interaction with other energy sources.

AIM AND OBJECTIVES

The aim of the Topical Expert Meeting (TEM) is to discuss long-term research needs for the timeframe 2020. The objective the meeting is to try to identify needed future results from R&D both in the 5 to 10 and the 10 to 20 year time frames. The strategic goal of the TEM is to give recommendations to the IEA Wind Executive Committee and to the governments involved which are based at the latest international wind technological stage. The outcome of the meeting will be used to develop a new strategic R&D plan for IEA Wind.

The objectives are to review the latest wind energy technology and to draw conclusions for a further successful development to expand the place of wind energy in the worlds energy mix by means of R&D.

The participants are encouraged to prepare presentations relevant to these objectives.

EXPECTED PARTICIPANTS

Participants are expected to represent, but not limited to, government research players, active researchers and manufacturers.

EXPECTED OUTCOMES

One of the goals of the meeting will be to gather the existing knowledge on the subject and come up with suggestions / recommendations on how to proceed. This will involve definition of necessary research activities for "Recommendations" to the IEA Wind Agreement and the governments involved on the following topics

- Future turbine and drive train technologies,
- Rotor blade design and new materials,
- Offshore aspects as foundations, logistics, grid connection, condition monitoring and maintenance, prevention of environmental impact etc.
- Grid integration and intermediate storage of large energy amounts,
- Environmental Impact and Acceptance,
- Improvement of wind turbine production technologies.

Based on the above a document will be compiled containing:

- Presentations by participants
- Compilation of the most recent information on the topic
- Input to define IEA Wind RD&D’s future role in this topic

TENTATIVE AGENDA

The tentative agenda covers the following items:

DAY 1

1. Introduction by host
2. Introduction by Operating Agent, Recognition of Participants
3. Collecting proposals for presentations.
   The participants are encouraged to prepare a presentation 15-20 minutes in length including a short discussion
4. Presentation of Introductory Note
5. Individual presentations

DAY 2

6. Individual presentations
7. Discussion
8. Collection of main topics for long term research needs and summary of meeting

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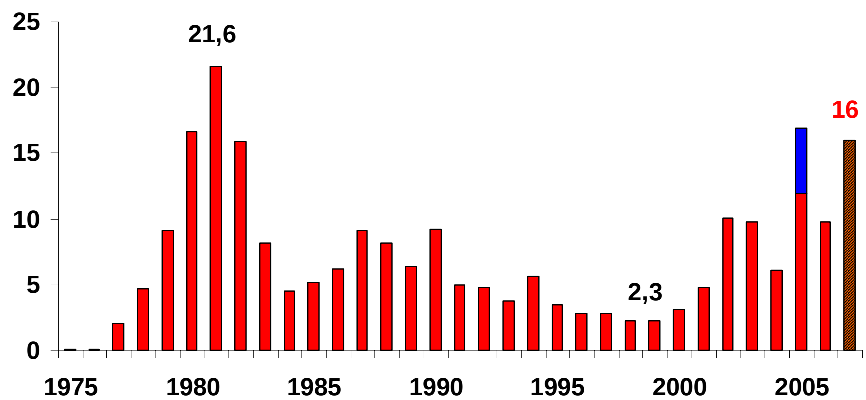
Long Term R&D Needs for Wind Energy

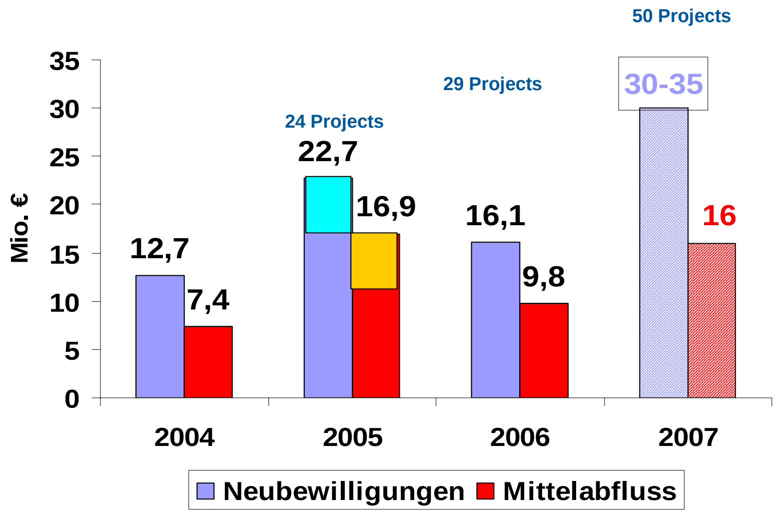
Dr. Joachim Kutscher, PtJ

1. Status of Wind Energy Research in Germany
2. Some Assumptions on R&D Needs

Funds of the Federal Government for Wind R&D / Mill. Euro

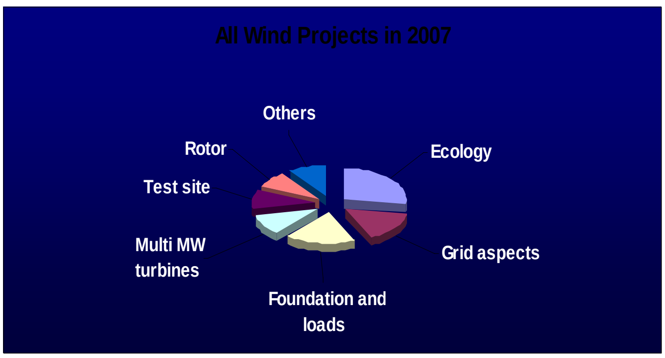


Yearly New Funded Projects – Consumption per Year



IEA Long Term R&D Needs, December 2007 Berlin

All Wind Projects 2007 / Snap Shot as of 30.11.07



Nr. of projects

Ecology	25
Grid aspects	15
Foundation and loads	17
Multi MW turbines	10
Test site	9
Rotor	8
Others	9
∑	93

Research Status and Road Map of Wind Energy

Evaluation report of the research since 2001

presented by Gerhart J. Gerdes

Road Map on wind energy development

presented by Prof. Jürgen Schmid

IEA Long Term R&D Needs, December 2007 Berlin

Assumptions on R&D Needs (1)

Turbine Component / Process	R&D – Topics / Objectives
Turbine horizontal axis, up to 8-10 MW	offshore maintenance and repair friendly, new drive principles (hydrodyn.), reduction of mass, condition monitoring, adaptation to arid and cold climates
Rotor 3-bladed	aerodynamic improvement, new materials, condition monitoring, on site final component combination, radar compatible,

Assumptions on R&D Needs (2)

Turbine Component / Process	R&D – Topics / Objectives
Offshore Foundation	optimisation of the traditional structures, new structures (bionics), new materials and combinations of materials, optimisation of ramming depth, deep water solutions, new landing systems
Production turbine, rotor, foundation	transition from manufacturing to automated serial production, tools for operating the production

Assumptions on R&D Needs (3)

Turbine Component / Process	R&D – Topics / Objectives
Offshore logistics	optimisation of transport and installation processes, new transport and installation equipment,
Grid	improvement of prognosis tools, remote and satellite based wind measuring systems, improvement of communication and regulation between the components of the grids, intermediate storage, cable technologies, high voltage electronics

IEA Long Term R&D Needs, December 2007 Berlin

Assumptions on R&D Needs (4)

Turbine Component / Process	R&D – Topics / Objectives
Acceptance	offshore to be reached, onshore always to be adapted to the social and economic situation, technologies for minimization of environmental impact
Research and Development	improvement of research and education structures, basic research under wind aspects, test sites for R&D

Thank you

Joachim Kutscher, PtJ

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Fraunhofer Institut Solare Energiesysteme
Evaluation of the German Renewable Energies Research Programme (EFP)
Results from the evaluation: Wind Energy
Deutsche WindGuard
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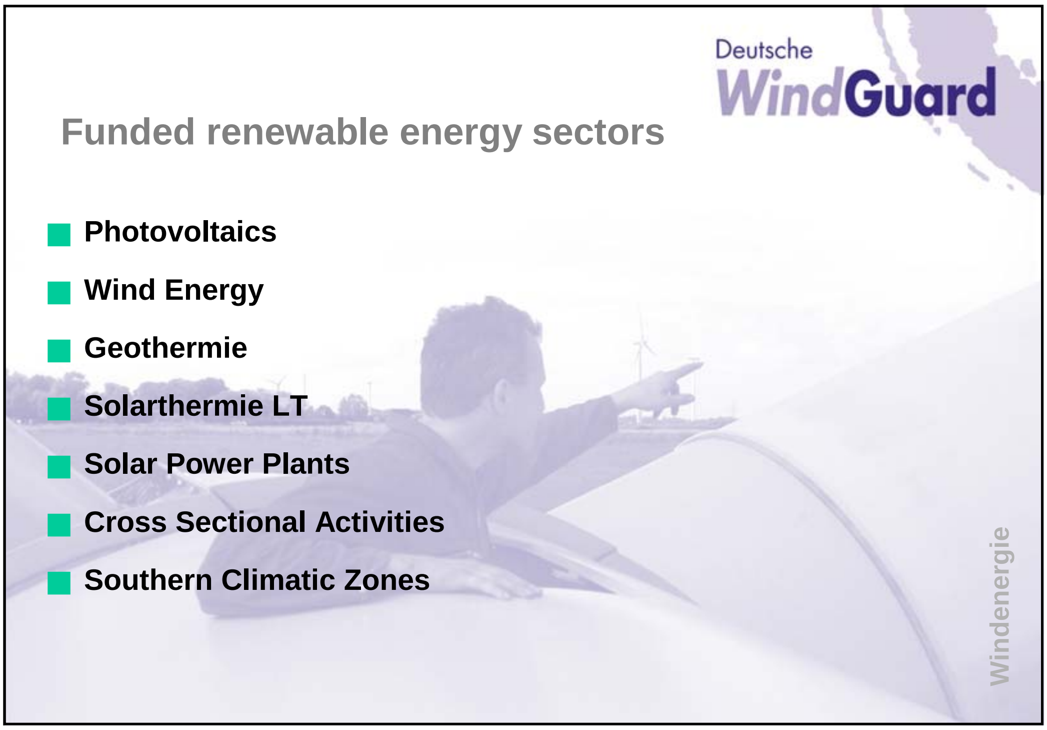
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Funded renewable energy sectors
Photovoltaics
Wind Energy
Geothermie
Solarthermie LT
Solar Power Plants
Cross Sectional Activities
Southern Climatic Zones
Windenergie

Deutsche WindGuard

Results of the specific evaluation Wind Energy

- Method
- Chronological development of research funding: subjects and volume
- Analysis of the technological effects
- Analysis of the market effects
- Summary of the evaluation research funding wind energy
- Recommendation for future actions regarding wind energy

Windenergie

Deutsche WindGuard

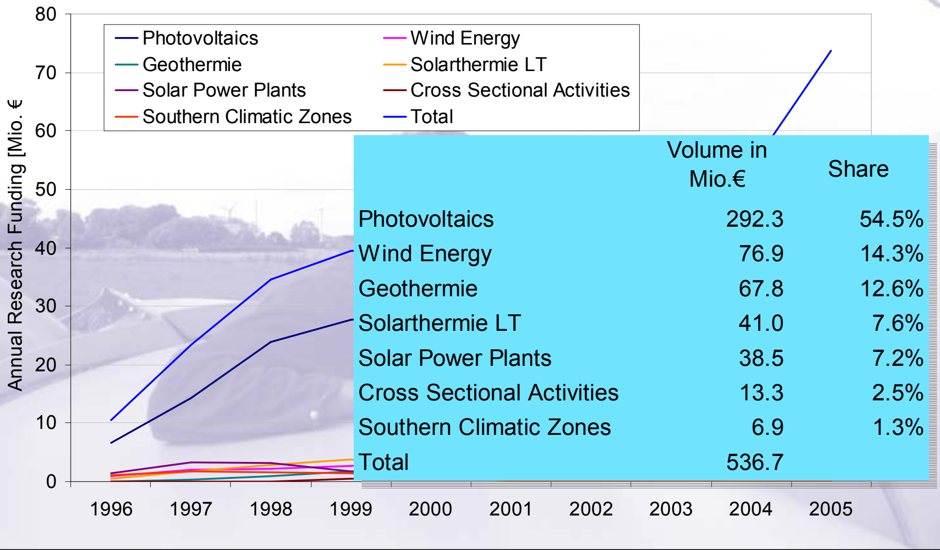
Method of the specific evaluation – all Technologies

Document analysis	Survey	Case studies	Patent review	Peer review	Sector analysis
Technology Company Market&sectors Administration	Technology **Company** **Market&sectors** **Administration**	Technology **Company** **Market&sectors** **Administration**	**Technology** Company Market&sectors Administration	**Technology** Company **Market&sectors** **Administration**	Technology **Company** **Market&sectors** Administration

625 projects
429 project participants
207 returned questionaires

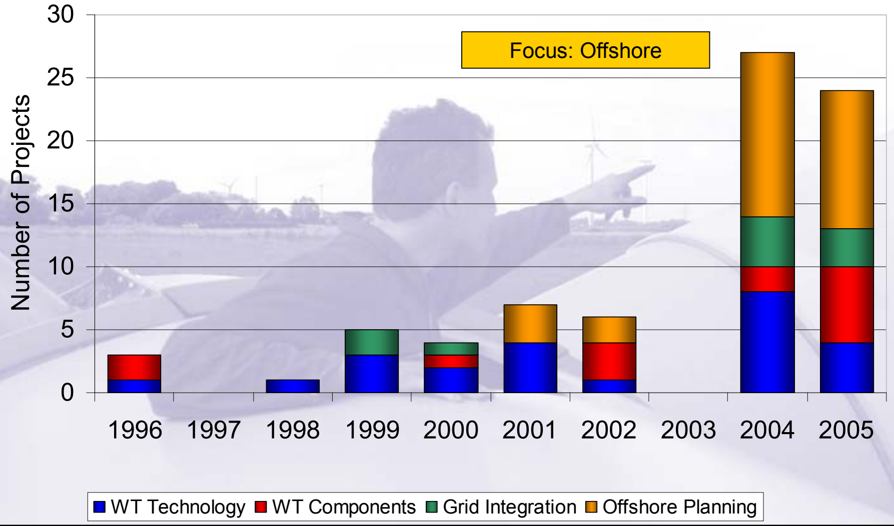
Windenergie

Project statistics – Chronological development of research volumina



	Volume in Mio.€	Share
Photovoltaics	292.3	54.5%
Wind Energy	76.9	14.3%
Geothermie	67.8	12.6%
Solarthermie LT	41.0	7.6%
Solar Power Plants	38.5	7.2%
Cross Sectional Activities	13.3	2.5%
Southern Climatic Zones	6.9	1.3%
Total	536.7	

Project statistics (Wind Energy) - Chronological development of research subjects



Analysis of the technological effects **(Wind Energy)**
Accentuation on four areas

Deutsche WindGuard

Turbine Up-scaling	Turbine Availability	Electrical Grid	Offshore-Wind Energy
WT Technology - *Large WT* - *gearless WT* - ... **WT Components** - Drive train large WT - *Rotor blades (Manufacturing, aerod./akust. Optimisation ...)* - *Lightning protection* - ...	**WT Technology** - *Large WT* - *gearless WT* - *design methods* - *Life time prolongation* **WT components** - *design methods* - *Life time prolongation* - ...	**Grid integration** - *Integration of onshore and offshore WF* - *energy storing* - ... **Power quality** - *Harmonics, flicker ...* - .... **Short time prognosis** - *Forecast model wind power* - ... **Site assessment** - *Energy yield assessment* - ...	**WT Technology** - *Large turbines* - *Offshore foundations* - ... **Manufacturing and installation** - *Installation method* - ... **Platforms / Test site** - *Fino 1, Fino 2, ...* - *Offshore test site* **Approval / Ecology** - *sea mammals, Avifauna, ...* - *strategic environmental assessment* - ...

Analysis on the impact on market effects

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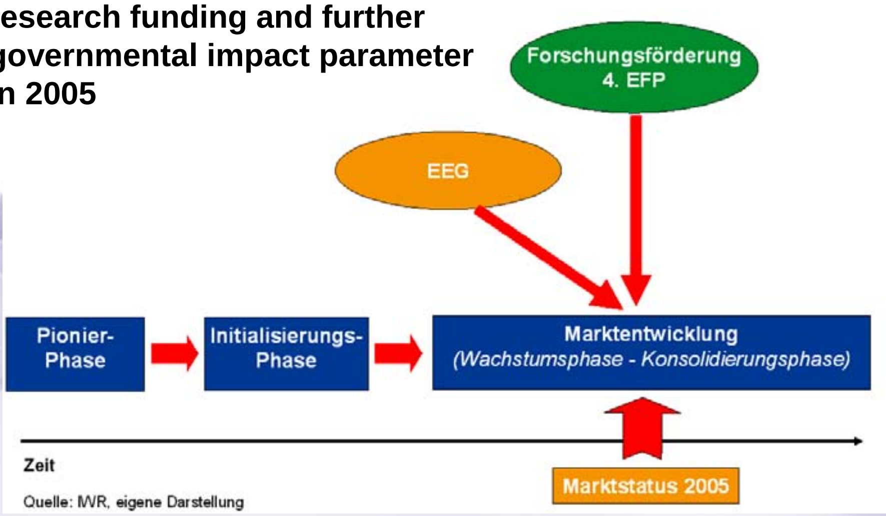
Status-Quo and Effects of research funding and further governmental impact parameter in 2005



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Analysis of the market effects (Wind Energy)

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1. Effects for enterprises

- Companies did profit / Overlap with other market relevant parameters
  - a. Market position could be held / improved on national und international level
  - b. Creation of development process for large WT on international level

2. Effects for technological projects

- Market relevance is given
  - a. Large WTs: prototypes are installed
  - b. Drive train: components are introduced / will be shortly introduced to the market

3. Effects on accompanying / supporting research

- No direct merket relevance / essential for new application areas
  - a. Offshore supporting research
  - b. grid integration research

Windenergie

Evaluation summary of research funding (Wind Energy)

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Alignment of funding 4. EF-Programme
- Pragmatic
- Proposals by industry
- Focus on offshore

Technological contribution
- Support of up-scaling
- WT optimisation, reduction of loads and weights
- Support of new application areas

Effects in the market
- Market position: strengthening / extension
- Know-how improvement
- Companies have a good reputation on international level
- Products are introduced to the market
- Supporting research: new areas of application

Atmosphere protection / energy supply
- Remarkable contribution to energy supply
- High contribution to protection of the atmosphere

Programme architecture / administration
- Processing: okay
- Adminstrative efforts: acceptable (in comp. To EU-projects)
- Minor effort / major economic effects
- Supply chain to be optimised
- More transparency of the entire objectives

Recommendations for future Research Funding **(Wind Energy)**

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Main target: Development of power plant like wind farms

Subtargets:

1. Technical targets

- Development of components / WT systems in complete supply chain
- System oriented services
- Grid integration
- Reliability of WTs and costs

2. Master plan research funding wind energy

- Committee to develop am master plan with annual contiuation

3. Networking of researchers / central research institution

4. Coordination of research funding on international level

- Use of synergetic effects on international level / increase of transparency

Research needs from a Swedish perspective

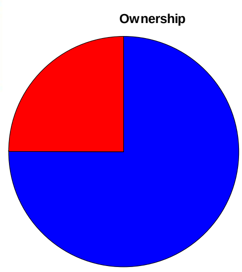
- About Elforsk
- Wind energy R&D today in Sweden
- R&D needs 2010 - 2020

Sara Hallert, Elforsk, programme manager for the wind energy R&D programme ”Vindforsk”

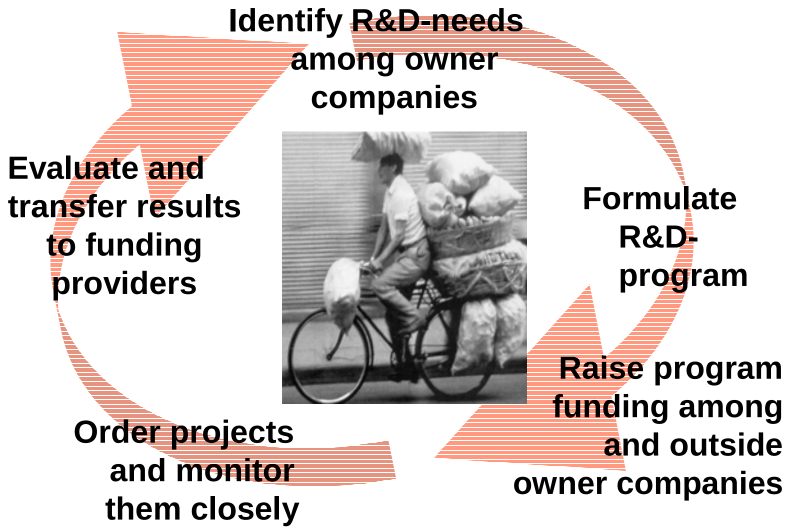
Sara.hallert@elforsk.se

R&D Resource for Power Industry

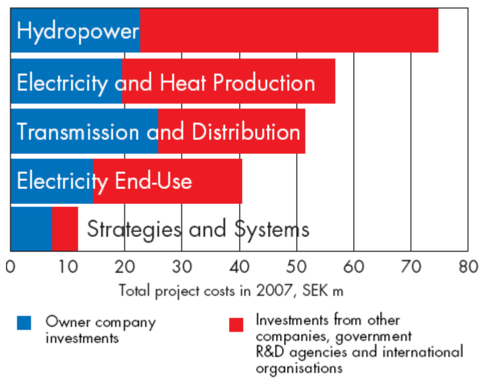
- Established 1993
- 12 employees
- Stabile average sales 100 MSEK/year past five years.
  - ~70 % from ownership companies
- Owned by Swedenergy and the Swedish TSO



Coordinate the industry's joint research and development



Gearing up owners' funding



Owner companies invest ~ MSEK 70
Total portfolio ~ MSEK 235

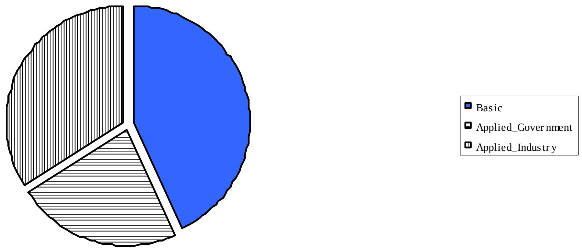
Swedish Wind Energy R&D today

- R&D programme ”Vindforsk”
- Swedish Energy Agency
  - Largest financier of Vindforsk
  - Environmental effects research programme, ”Vindval
  - Individual projects
- In-house R&D at the power industry

”Vindforsk”

- Basic and applied research
- User-oriented:
  - O&M
  - Noise issues
  - Grid issues within the farm
  - Grid integration on a power system level
  - Meteorology
  - Wakes
  - Design tool optimisation wind farm topology (EU-project)
  - Statistics on wind energy production
  - Estimation of wind energy potential
  - Standardisation
  - Cold climate

5 MEUR during 2006-2008



Performers

– Royal Institute of Technology (KTH)
– Chalmers University
– Uppsala university

– Technical consultant companies
– Manufacturing companies

Public spending through Swedish Energy Agency 2006 budget.

Programme to support market introduction (”Pilot projects”) excluded

Project/programme	K€
Vindforsk, R&D to support implementation of wind power	1030
Vindval, environmental effects programme	750
NewGen demo project	1020
Radar disturbance flight test	520
Other projects	215
Sum	**3535**

R&D Needs 2010 - 2020

- Forestry landscape
  - Wind resources, measurements
  - Dimensioning of wind turbines
- O&M, primarily offshore:
  - Optimisation of maintenance
  - Condition monitoring
- Cold climate
  - Ice map
  - De-icing tools
  - Availability and effect on energy production
  - Life-time of components
- Grid integration
  - Large amount of wind power in power system
  - Analyses of transients
  - Farm design

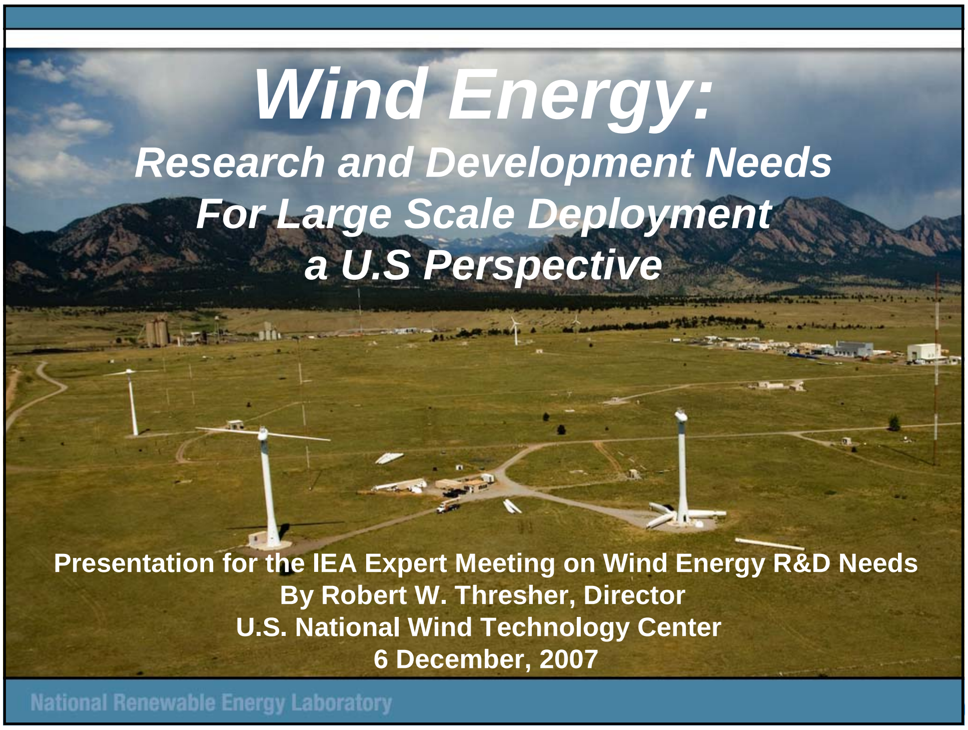
Activities going on in Sweden

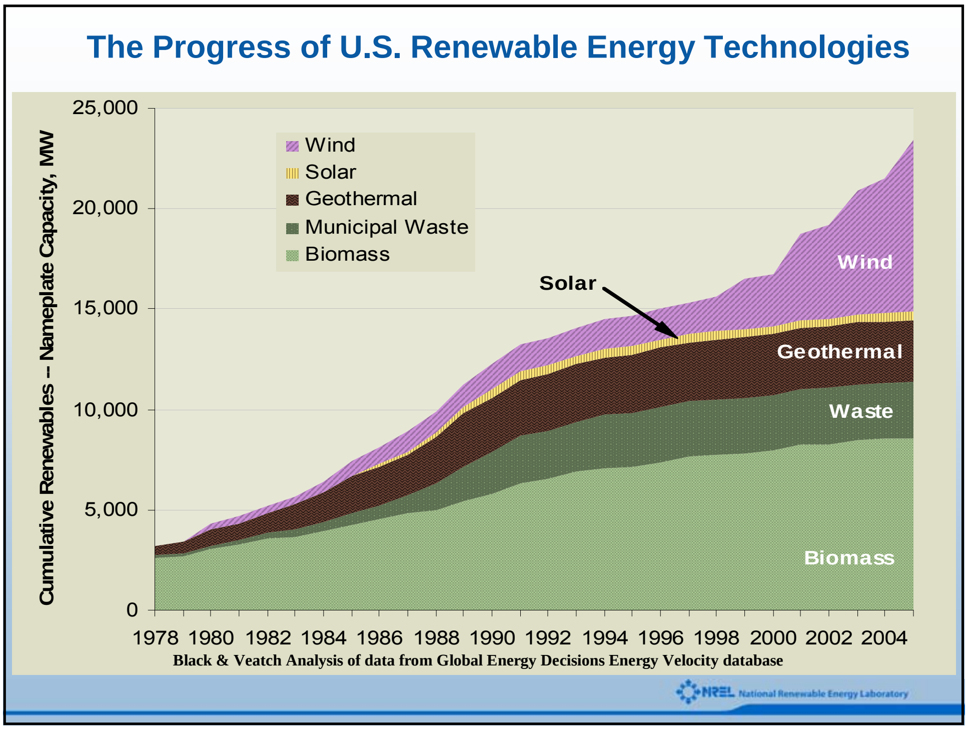
- Use wind electricity for **plug-in vehicles**, fuel (=share of a wind power plant) included in the car price, utilise car battery as power reserve
- Swedish Energy Agency set new planning goal for wind energy **30 TWh to 2020** (whereof 10 TWh offshore). Today 1 TWh.
- Swedish Energy Agency designate new geographical **areas of national interest** for wind energy
- A new 5 year round of the **market introduction** program with 38 M€ funding starts 2008.

Thank you for your attention.

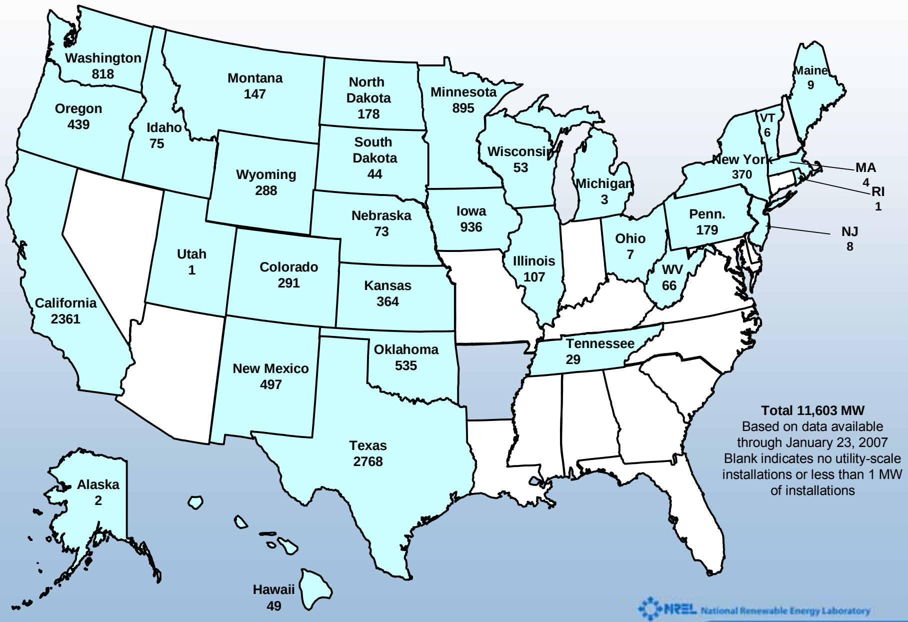
Sara Hallert, Elforsk, programme manager for the wind energy R&D programme ”Vindforsk”

Sara.hallert@elforsk.se


Wind Energy:
Research and Development Needs
For Large Scale Deployment
a U.S Perspective
Presentation for the IEA Expert Meeting on Wind Energy R&D Needs
By Robert W. Thresher, Director
U.S. National Wind Technology Center
6 December, 2007
National Renewable Energy Laboratory


The Progress of U.S. Renewable Energy Technologies
Cumulative Renewables – Nameplate Capacity, MW
25,000
20,000
15,000
10,000
5,000
0
1978 1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004
Wind
Solar
Geothermal
Municipal Waste
Biomass
Solar
Wind
Geothermal
Waste
Biomass
Black & Veatch Analysis of data from Global Energy Decisions Energy Velocity database
NREL National Renewable Energy Laboratory

Megawatts of Installed Utility-Scale Wind Power at December 31, 2006



A New Vision

For Wind Energy in the U.S.

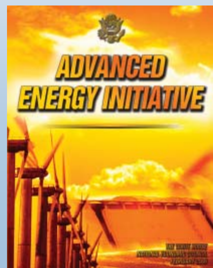
White House photo by Eric Draper

State of the Union Address

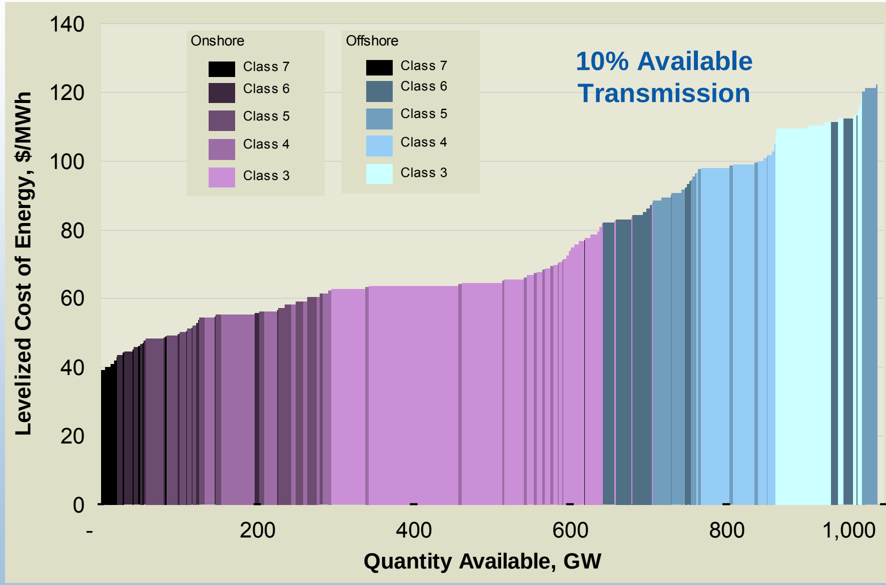
"…We will invest more in … **revolutionary** and solar **wind technologies**"

Advanced Energy Initiative

"Areas with good wind resources have the potential to **supply up to 20% of the electricity** consumption of the United States."



Wind Electricity Supply Curve for the U.S.



2010 Costs w/ PTC, $1,600/MW-mile, w/o Integration costs

U.S. Wind Energy Challenge

- Rising costs driven by inconsistent policies and increased competition
  - PTC inconsistency
  - Copper and Steel prices
  - Transportation
  - Permitting and siting costs
- Poor performance and reliability
  - Drivetrains
  - Other components
- Understanding and acceptance by financial sector, regulators, utilities, public
  - A disruptive technology
  - A new technology with limited experience
  - Different operating characteristics
  - Highly visible generating a NIMBY reaction
  - Wildlife and environmental concerns
- Integrating wind onto the grid at a large scale
  - Fluctuating output
  - Not Dispatchable
  - Transmission access

Needed to Address the Challenges

- Research and development to improve performance and reliability, while driving down the costs requiring complex large-scale testing capabilities:
  - 70m Blade Testing capabilities growing to 100m
  - 6 MW Scale Dynamometer growing to 15 MW
  - Field R&D experiments for both large and small turbines
- Study how best to deploy and integrate wind energy:
  - Integration studies accounting for wind diversity effects
  - Transmission studies with wind inputs
  - Control area aggregation
- Provide unbiased education and outreach:
  - A center for undergraduate and graduate education
  - Factual unbiased information for regulators, financiers, regulators, utilities and the public
  - Environmental and wildlife and siting R&D and education
  - Economic development facts and comparisons
  - Public policy studies and education
- New wind application market development:
  - Offshore wind technology and ocean kinetic energy technology R&D
  - New applications such as plug hybrids, desalination, compressed air turbines and storage, and electrolysis for hydrogen production

Today's Technology Challenges

Technology Challenge

- Capital cost
- Gearbox reliability
- Transportation costs
- Crane capacity & availability
- Operational expenses to high
- Rotor expansion reaching limits
- Innovation risk is high

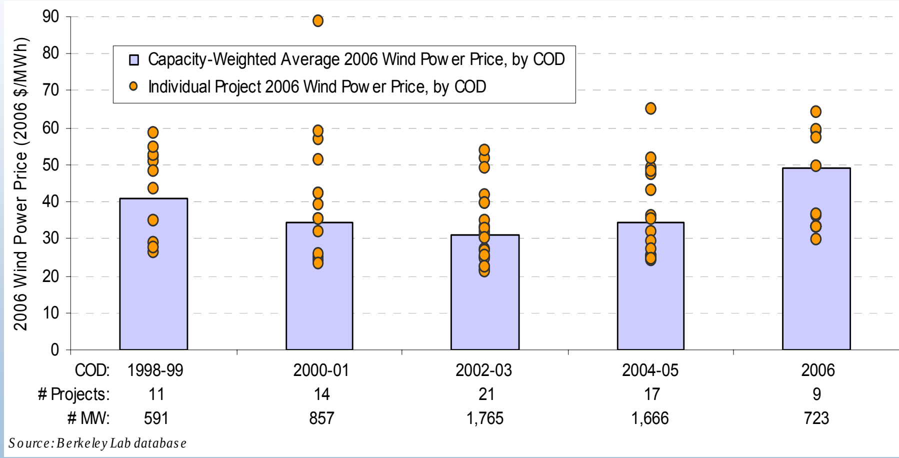
Possible Reasons

- Bearing Failures, inaccurate loads?
- Unscheduled maintenance costs
- Poor reliability of some components
- Head mass too heavy
- Lack of automatic O&M self diagnosis
- Lack of fatigue load and blade deflection control
- Lack of low cost stiff blade material
- Aeroacoustics limiting tip speeds

Modern turbines represent a complex & highly integrated structure and technology improvements must be evaluated as a system, because of the coupled interactions between components can greatly affect the optimum configuration and resulting cost.

Wind Energy Price to Utilities

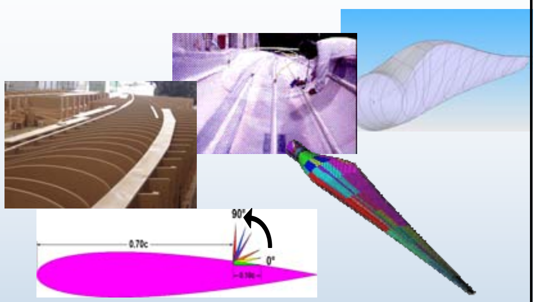
(Includes PTC & Other State Incentives)



Land Based Technology Improvement Options

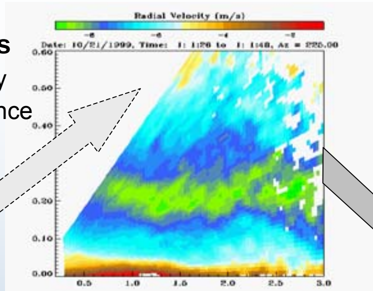
Advanced Rotor Technology

- Extended rotor architectures through **load control**
- Incorporate advanced materials for hybrid blades
- Cyclic & independent blade pitch control for load mitigation
- Sweep and flap twist coupled architectures
- Light weight, high TSR with attenuated aeroacoustics



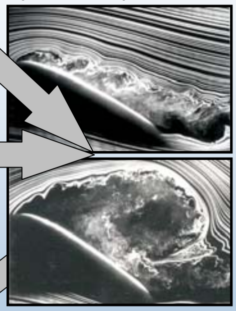
Power Train Enhancements

- Permanent Magnet DD Architectures
- Split load path multi-stage generation topologies
- Reduced stage (1-2) integrated gearbox designs
- Convoloid gearing for load distribution



Powerful winds
U_∞, direction vary
Coherent turbulence
Turbine wakes

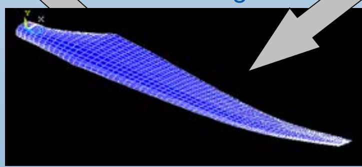
Energetic flowfield
Globally separated
Steep gradients
Dynamically active



Basic R&D Needs: Aeroelasticity

Nonlinear & coupled
Multiple physics
Scale range

Complex wake
Trailed vortices
Shed vortices
Persistent

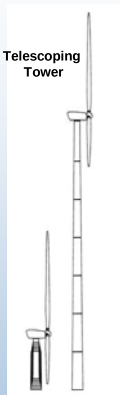


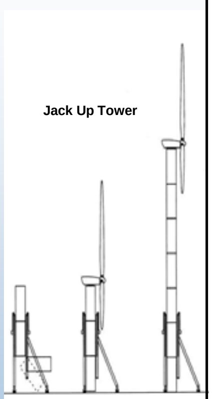
Responsive structure
Light and flexible
Advanced materials
Aeroelastic load control

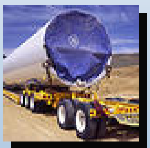
Land Based Technology Improvement Options

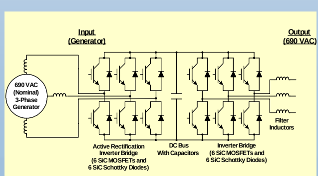
Power Conversion

- High temperature silicon carbide device; improved reliability & reduce hardware volume
- Novel circuit topologies for high voltage & power quality improvement
- Medium voltage designs for multi-megawatt architectures









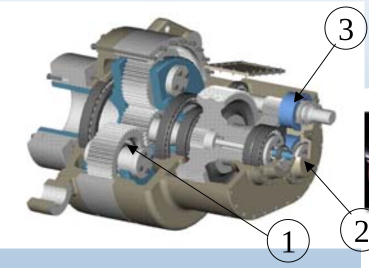
Tower Support Structures

- Tall tower & complex terrain deployment
- Advanced structures & foundations
- New materials and processes
- Self erecting designs

NREL’s Gearbox Reliability Collaborative

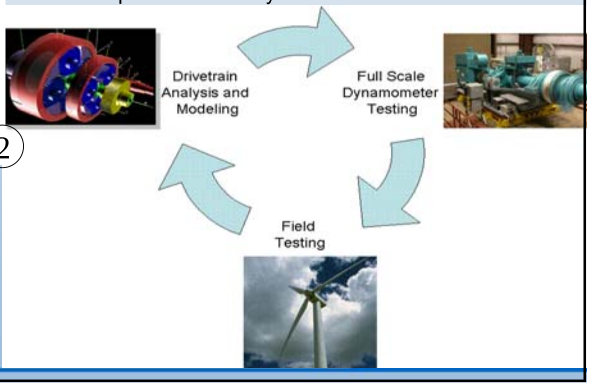
Problem Areas:

- Planet bearings
- Intermediate shaft-locating bearings
- High-speed locating bearings



Approach:

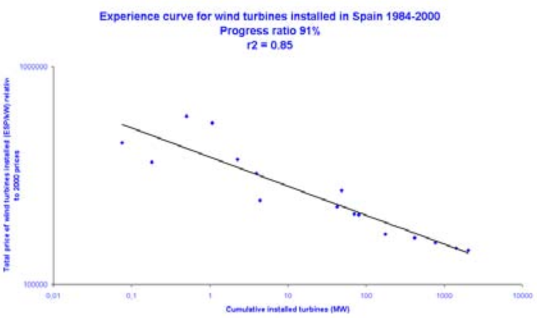
- Test platform; two 750 kW gearboxes with identical instrumentation.
- Upgrade both units to state-of-the art.
  - Cooling, filtration, gar finish, lubrication, and bearing types.
- Measure External and internal loads and displacements.
- Thermal measurements
- Condition monitoring
- Expert failure analysis and forensics



Land Based Technology Improvement Options

Manufacturing and Learning Curve

- Larger volume and steady markets drive toward more automated manufacturing
- Historical progress ratios (price reduction for each doubling in production) for wind turbines have been 90-95%
- Getting to 20% requires five doublings
- Reduced Capital Cost 4-6% per doubling; 20-30% total
- Improved Quality and Reliability



Experience curve: a tool for energy policy assessment (EXTOOL)
Analysis sponsored by European Union
http://www.iset.uni-kassel.de/extool/Extoolframe.htm

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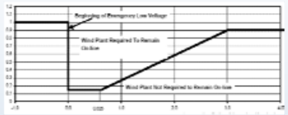
Multi-Megawatt Test & Validation Facilities

Dynamometer

Fault Test

Fault Response



Blade Test

Offshore Field Validation

Areas of Potential Technology Improvement to Reach 20%

Technical Area	Potential Advances	Cost Increments (Best/Expected/Least, Percent)	
		Annual Energy Production	Turbine Capital Cost
Advanced Tower Concepts	• Taller towers in difficult locations • New materials and/or processes • Advanced structures/foundations • Self-erecting, initial or for service	+11/+11/+11	+8/+12/+20
Advanced (Enlarged) Rotors	• Advanced materials • Improved structural-aero design • Active controls • Passive controls • Higher Tip Speed/lower acoustics	+35/+25/+10	-6/-3/+3
Reduced Energy Losses and Improved Availability	• Reduced blade soiling losses • Damage tolerant sensors • Robust control systems • Prognostic maintenance	+7/+5/0	0/0/0

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Areas of Potential Technology Improvement to Reach 20%
(continued)

Technical Area	Potential Advances	Cost Increments (Best/Expected/Least, Percent)	
		Annual Energy Production	Turbine Capital Cost
Drivetrain (Gearboxes, Generators, and Power Electronics	• Fewer gear stages or direct drive • Medium/low speed generators • Distributed gearbox topologies • Permanent-magnet generators • Medium voltage equipment • Advanced gear tooth profiles • New circuit topologies • New semiconductor devices • New materials (GaAs, SiC)	+8/+4/0	-11/-6/+1
Manufacturing and Learning Curve*	• Sustained, incremental design and process improvements • Large-scale manufacturing • Reduced design loads	0/0/0	-27/-13/-3
Totals – Potential Improvement		+61/+45/+21	-36/-10/+21

*The learning curve results are for 4.7 doublings by 2030

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Small Wind Power Applications in the U.S.

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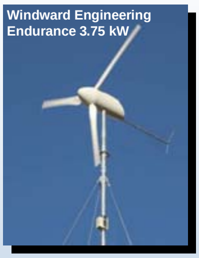
Medium & Small Distributed Wind Systems

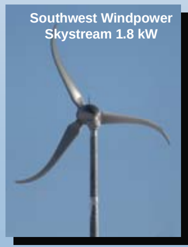


Today's Technology Trends:

- Advanced blade manufacturing methods
- Rare earth magnets
- Induction generators for small turbines, single-phase applications
- Alternatives to furling for rotor over-speed control
- Improved energy capture in low wind speeds
- Current installed costs: 1 kW, \$5-6K/kW; 50 to 100 kW, \$3-4K/kW

Technology Needs:

- Improved reliability remains the prominent need for distributed systems; isolated, single installations
- Applications close to inhabited structures; sounds emission critical for market acceptance & zoning
- Significant improvements needed to lower capital & installation costs, improve performance, incorporate robust PE & grid interconnection capabilities
- Use of turbine design & rating standards for certification
- Lack of turbine availability > 100 kW



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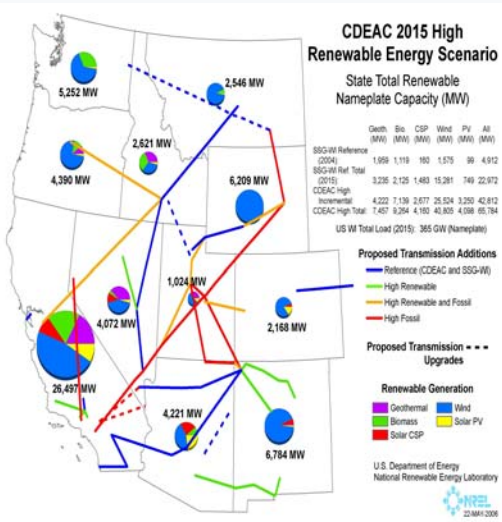
Grid Integration Driving Technology



Technology Improvements:

- Power electronics have change wind technology from a detriment to an attribute
- Fault tolerance and ride through capability
- Is improving grid performance overall
- Grid VAR support available even without wind power being supplied
- Operators are exploring modest ramping capability using advanced controls
- Forecasting is significantly improving scheduling, penetration & integrated system performance

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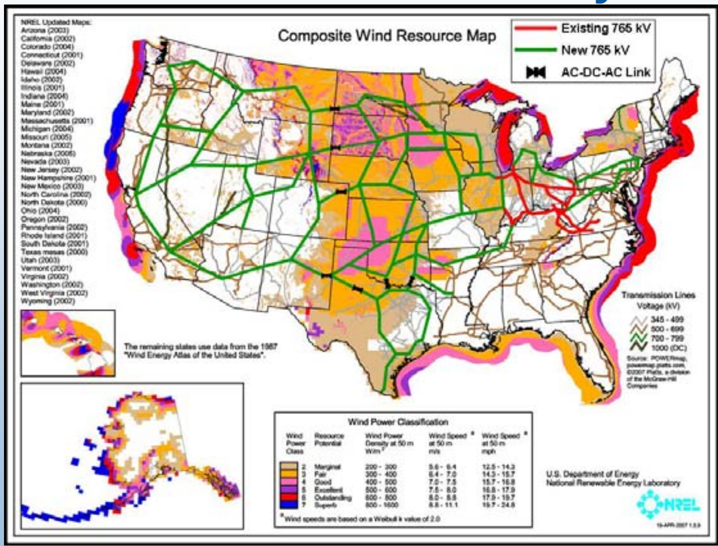
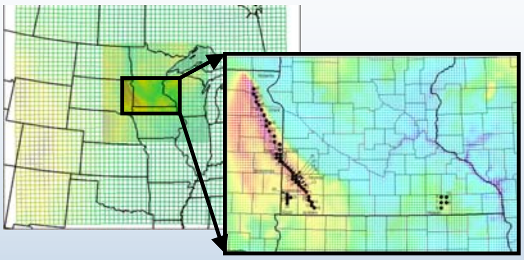
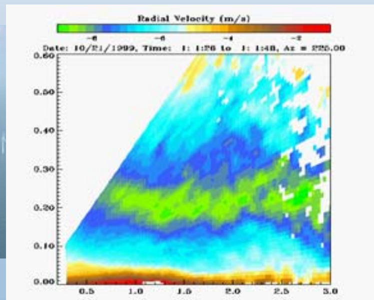
Conceptual EHV Transmission Overlay

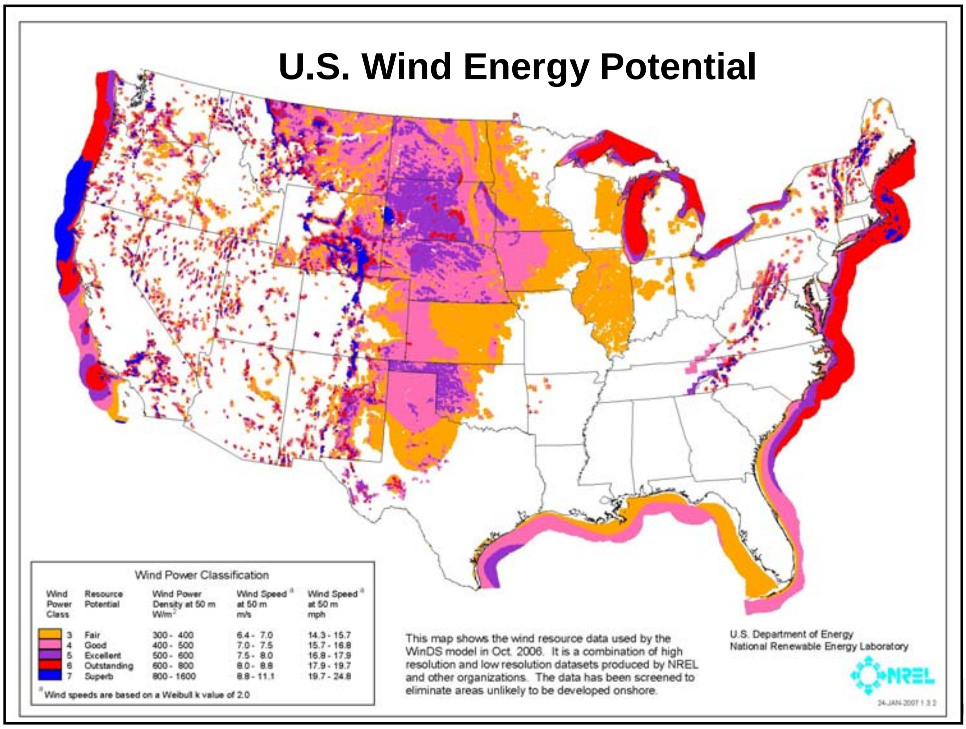


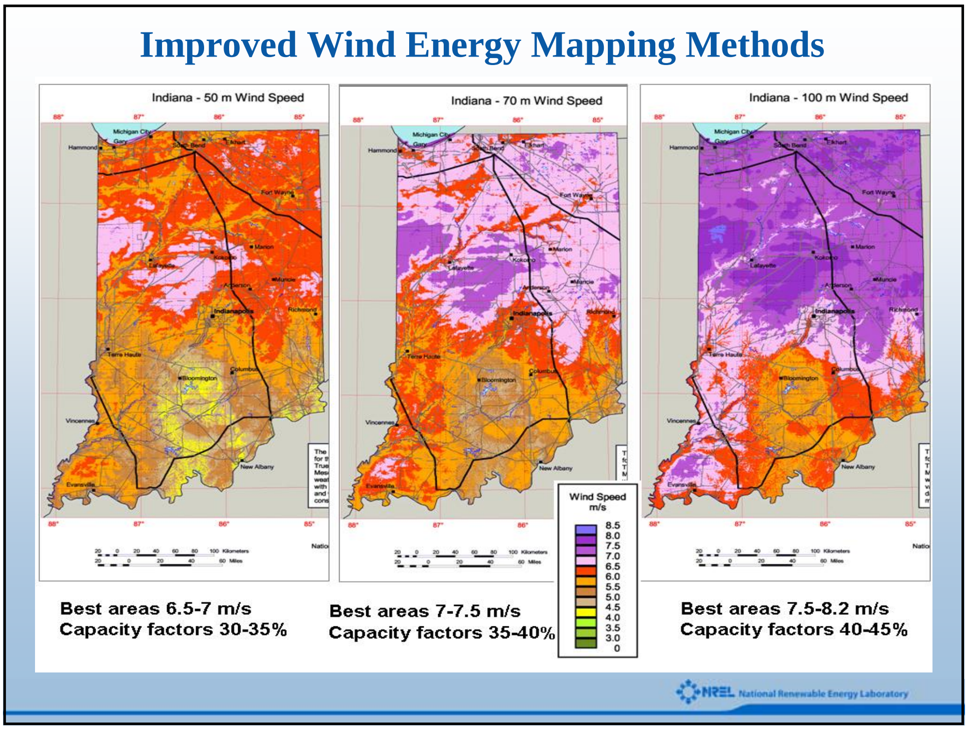
Atmospheric Physics R&D for Wind Energy

- **Grid integration**
  - Short term forecasting
  - Wind farm power delivery
- **Resource assessment**
  - Long term hindcasting
  - Resolution enhancement
- **Site specific design**
  - Inflow turbulence & shear
  - Local topography
  - Wind farm array effects
- **Modeling impact**
  - Design & analysis
  - Ops & maintenance
  - Direct financial impact






U.S. Wind Energy Potential
Wind Power Classification
Wind Power Class | Resource Potential | Wind Power Density at 50 m W/m² | Wind Speed a at 50 m m/s | Wind Speed a at 50 m mph
3 Fair 300 - 400 6.4 - 7.0 14.3 - 15.7
4 Good 400 - 500 7.0 - 7.5 15.7 - 16.8
5 Excellent 500 - 600 7.5 - 8.0 16.8 - 17.9
6 Outstanding 600 - 800 8.0 - 8.8 17.9 - 19.7
7 Superb 800 - 1600 8.8 - 11.1 19.7 - 24.8
a Wind speeds are based on a Weibull k value of 2.0
This map shows the wind resource data used by the WinDS model in Oct. 2006. It is a combination of high resolution and low resolution datasets produced by NREL and other organizations. The data has been screened to eliminate areas unlikely to be developed onshore.
U.S. Department of Energy
National Renewable Energy Laboratory
NREL
24-JAN-2007 1.3.2


Improved Wind Energy Mapping Methods
Indiana - 50 m Wind Speed
Indiana - 70 m Wind Speed
Indiana - 100 m Wind Speed
Wind Speed m/s
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
0
Best areas 6.5-7 m/s
Capacity factors 30-35%
Best areas 7-7.5 m/s
Capacity factors 35-40%
Best areas 7.5-8.2 m/s
Capacity factors 40-45%
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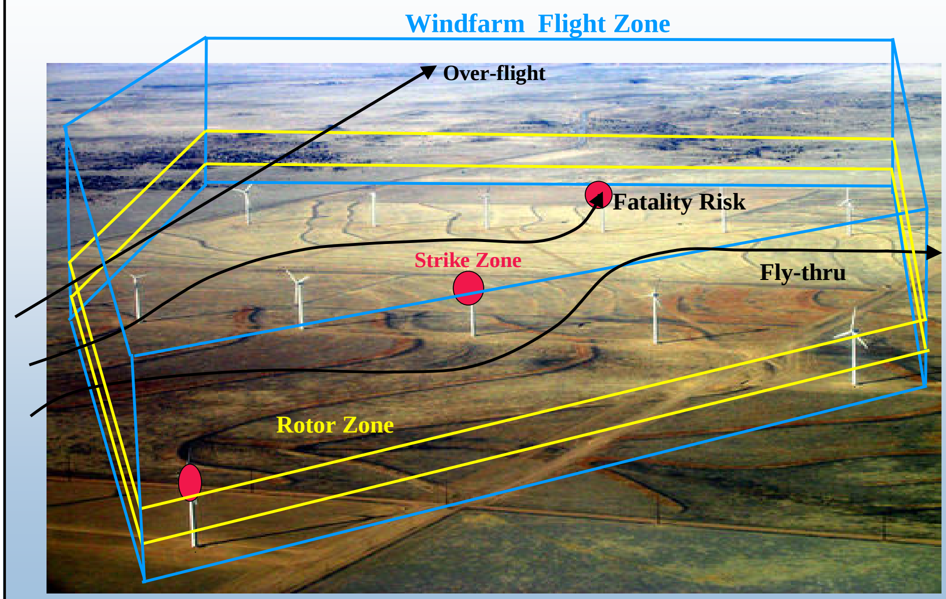
Environmental and Wildlife R&D Needs

Wind Power Planning Meeting I - July 1994

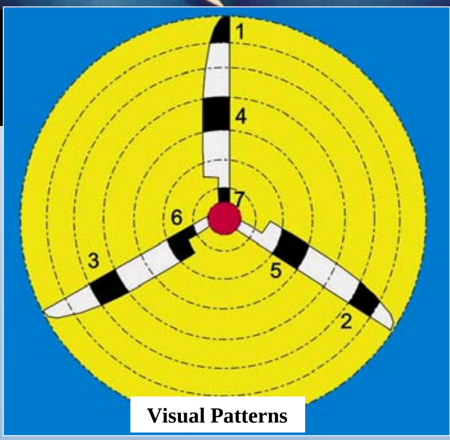
Meeting Outcome: Five Major Research Areas

- Assess mortality attributable to wind turbines at existing sites (including control data from "no turbine" sites)
- Predict mortality at planned wind power sites, based in part on previous bullet
- Predict population consequences
- Identify ways to reduce bird kills at wind plants
- Understand wildlife displacement and habitat impacts (2007)
- Set values for off-site mitigation

Visualization of Avian Interaction Zones



Avian Risk Reduction: Visual Enhancement to Increase Avoidance



Visual Patterns

American Kestrel

Source: *The Role of Visual Deterrents in Reducing Avian Collisions;* William Hodos, University of Maryland

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Infrared Image of a Bat Flying Through a Wind Turbine Rotor

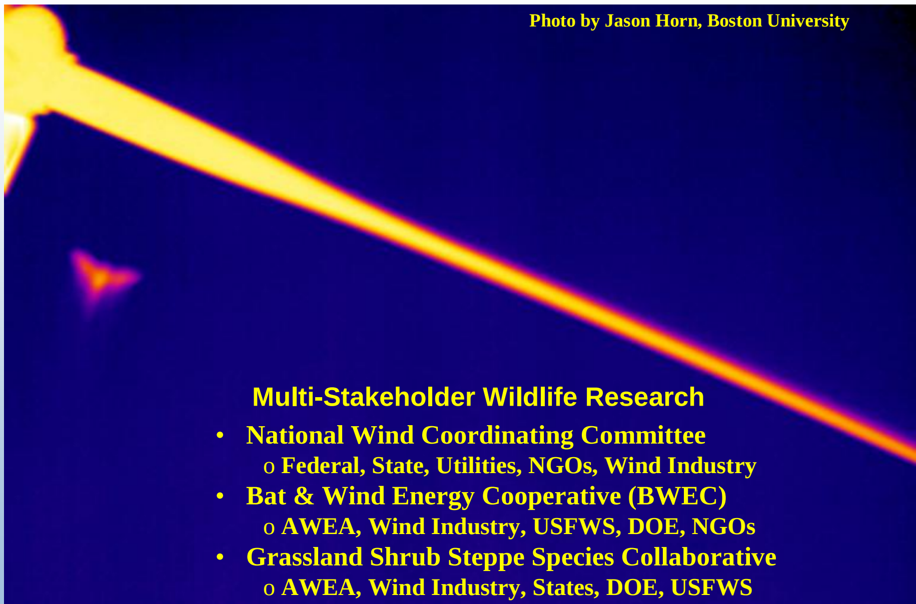

Photo by Jason Horn, Boston University

Multi-Stakeholder Wildlife Research

- National Wind Coordinating Committee
  - o Federal, State, Utilities, NGOs, Wind Industry
- Bat & Wind Energy Cooperative (BWEC)
  - o AWEA, Wind Industry, USFWS, DOE, NGOs
- Grassland Shrub Steppe Species Collaborative
  - o AWEA, Wind Industry, States, DOE, USFWS

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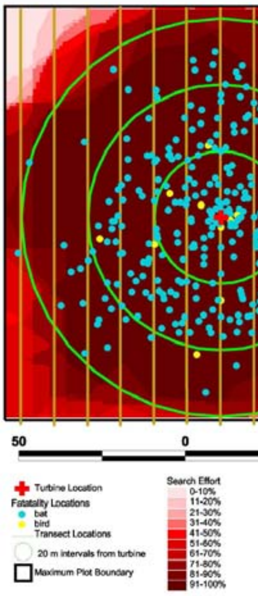
BWEC Study Results



Meyersdale Site

Meyersdale Wind farm:

- NEG – Micon 1.5 MW Turbine
- 72 meter rotor Diameter
- 17 revs/min = 102 deg/sec
- Constant rotor rpm
- Green dots are bat carcasses
- Yellow dots are birds
- Bird and bat fatalities for all 20 turbines are overlaid

Observations:

- Bird and bat fatalities appear to be fairly uniformly distributed out to 40m
- Beyond a radius of about 40m fatalities drop off rapidly indicating carcasses are not thrown far outside of the blades span
- The higher velocity tip regions of the blade do not seem to be more dangerous than the root near the tower
- Bats are much more vulnerable than birds

Source: BWEC Report 2005

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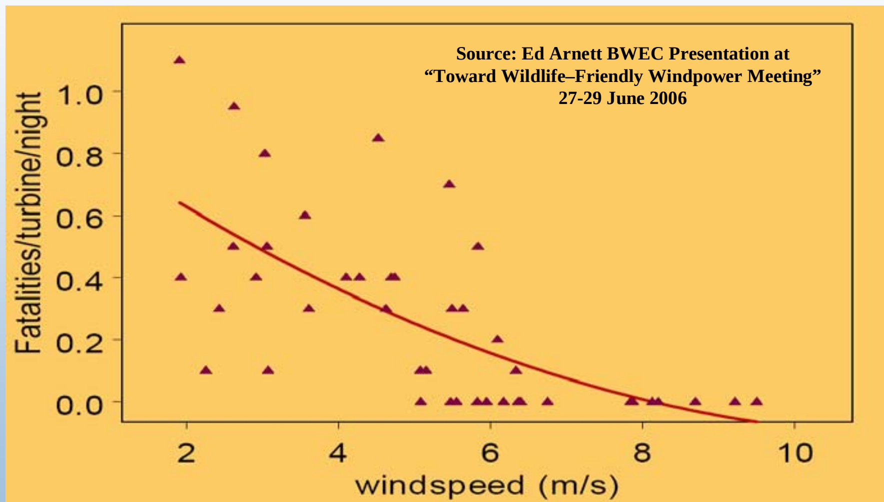
BWEC Study Results

Fatalities decrease with increasing wind speed



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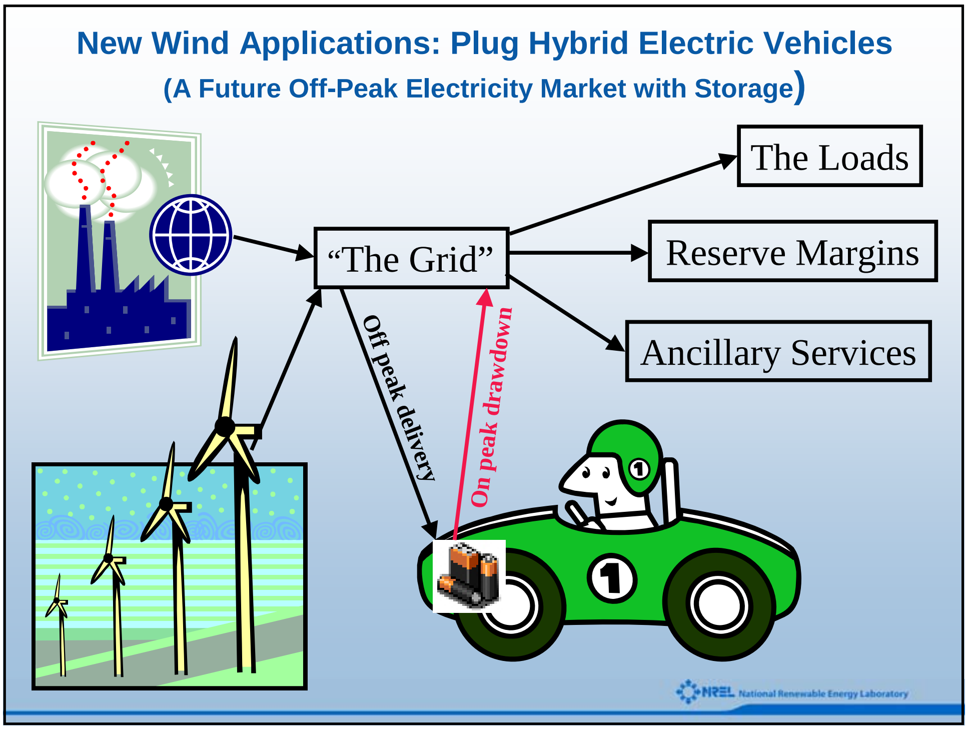
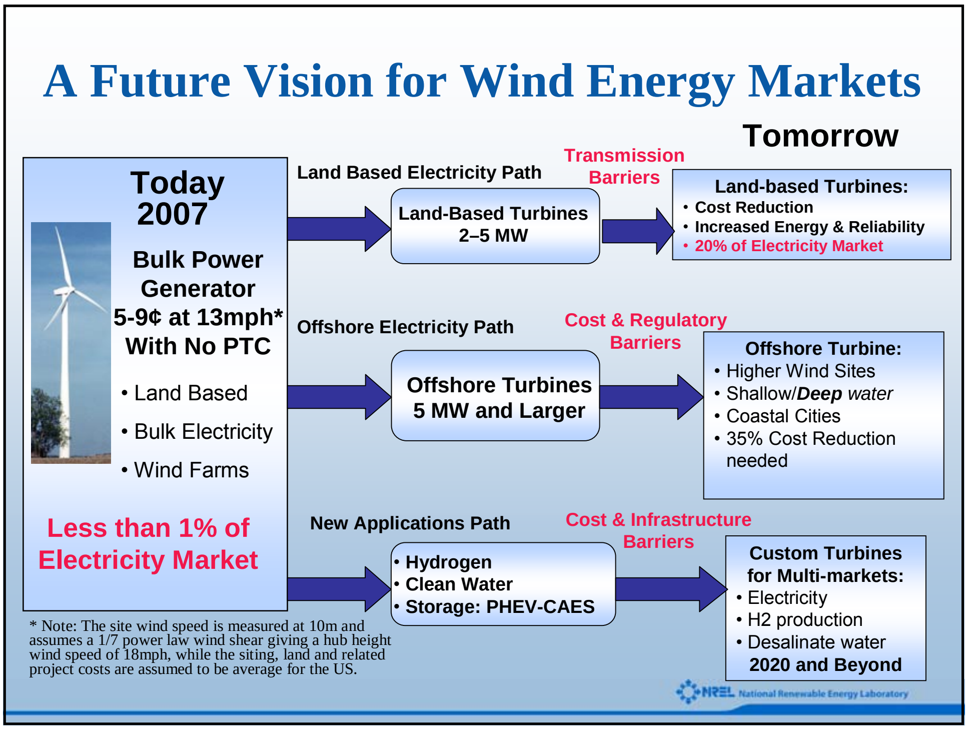


New Wind Applications: Plug Hybrid Electric Vehicles
(A Future Off-Peak Electricity Market with Storage)
The Loads
"The Grid"
Reserve Margins
Ancillary Services
Off peak delivery
On peak drawdown
NREL National Renewable Energy Laboratory



A Future Vision for Wind Energy Markets
Tomorrow
Today
2007
Bulk Power
Generator
5-9¢ at 13mph*
With No PTC
• Land Based
• Bulk Electricity
• Wind Farms
Less than 1% of
Electricity Market
Land Based Electricity Path
Transmission
Barriers
Land-Based Turbines
2–5 MW
Land-based Turbines:
• Cost Reduction
• Increased Energy & Reliability
• 20% of Electricity Market
Offshore Electricity Path
Cost & Regulatory
Barriers
Offshore Turbines
5 MW and Larger
Offshore Turbine:
• Higher Wind Sites
• Shallow/Deep water
• Coastal Cities
• 35% Cost Reduction
needed
New Applications Path
Cost & Infrastructure
Barriers
• Hydrogen
• Clean Water
• Storage: PHEV-CAES
Custom Turbines
for Multi-markets:
• Electricity
• H2 production
• Desalinate water
2020 and Beyond
* Note: The site wind speed is measured at 10m and assumes a 1/7 power law wind shear giving a hub height wind speed of 18mph, while the siting, land and related project costs are assumed to be average for the US.
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Linking and Informing Technologists with Policy and Decision Makers

- Education, information and, technical analysis for policy makers and regulators
- Education, technical data, for market development and deployment

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Summary

- Getting to 20% wind penetration requires R&D investment to increase turbine size, improve capacity factor, drive down capital costs, enhance the grid infrastructure, and facilitate siting and permitting.
- No single component improvement can achieve the necessary cost reduction or performance increase; system improvements are required.
- Technology investments can have a large payoff; at 20% penetration wind supplies 1200TWh/year with each cent/kWh COE reduction worth $12 billion/year in savings
- There are no critical barriers in raw materials or industrial supply chain capacity and comparable growth has been managed in other industries
- Capital cost Improvements must rely heavily on manufacturing learning curve effects
- Investments in advanced design codes and test facilities will be required to mitigate innovation risk and insure the development of viable future turbine technology at multi-megawatt scales
- All of the project risk factors must be addressed, including technology market and policy factors in order to maintain both political and investor support for expanding wind to 20% of the U.S. energy supply.

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DANISH ENERGY AUTHORITY RISØ

Some key point of the wind power R&D program in Denmark 2007

iea wind

Task 11 Long Term Research Needs

6-7 Dec. 2007

Lene Nielsen
Danish Energy Authority
and
Jørgen Lemming
Risø National Laboratory
Technical University of Denmark

DANISH ENERGY AUTHORITY RISØ

Programs and available funds for RE R& projects including wind energy (in million DKK)

	2003	2004	2005	2006	2007	2010
Energy Research Program (EFP)	41	72	73	74.0	76	
Energy R&D and Demonstration Program					110	☺
PSO-electricity production	100	130	130	130.0	130	
PSO-electricity utilisation	25	25	25	25.0	25	
Renewable energy R&D – Danish Agency for Science Technology and Innovation	35	45	45	108.3	107,1	☺
Total	**201**	**242**	**273**	**337.3**	**448.1**	**1,000**

The total funds of 1,000 million DKK in 2010 correspond to 135 million Euro (1,000 DKK = 135 EURO)

Projects funded in 2007 by Danish EFP R&D program

Title	Institut	Project cost mill. DKK	Grants Mill DKK
• Physical and numerical modeling of monopiles for offshore wind turbines	Aalborg University	4.058	2.335
• Program for research in applied aeroelastics	Risø, DTU	5.752	3.495
• Methods for mapping wind conditions in complex terrain	Risø, DTU	6.037	2.495
• Experimental Rotor- and Airfoil Aerodynamics on MW Wind Turbines	Risø, DTU	11.115	3.939
• Anistrop beam model for analyses and design of passive controlled blades	Risø, DTU	5.502	2.378
• Improved methods for evaluation of fatigue strength	Risø, DTU	1.579	0.850
Total		34.043	15.492

1 Euro = 7.44 DKK

Comments to allocations

- In addition to these six projects another two projects (EFP) were funded with a total amount of 0.9 million DKK.
- The total grants to wind energy projects supported by EFP in 2006 was 11.3 million DDK (9.5 million DKK in 2005).
- A funding of 2 million DKK for quality assurance of wind turbines is allocated to the Secretariat for Danish Wind Turbine Certification Scheme to manage the scheme.

DANISH ENERGY AUTHORITY

RISØ

Projects funded in 2006 by Danish R&D programs

Title	Applicant	Support (mill DKK)
• Program for Research in Applied Aeroelasticity (2) (EFP)	Risø	2.9
• Simulation for Generalization of Wind Loads (EFP)	Risø	2.0
• Improved Performance Measurements. Characterization of the Wind Field (EFP)	Risø	2.6
• Mesoscale Atmospheric Variability and the Variation of Wind and Production for Offshore Wind Farms (PSO)	Risø	2.5
• Noise and Optimization of Wind Farms (PSO)	Delta	2.0
• Low frequency Noise from Large Wind Turbines (EFP)	Delta	2.9

DANISH ENERGY AUTHORITY

RISØ

The new Support scheme EUDP (An Energy technology development and demonstration program)

- EUDP is going to substitute the existing EFP program.
- New 477 mill. DKK for the period 2007 to 2010 on top of EPF.
- In 2007 110 mill. will be allocated (hereoff 50 mio. to 2. generation biofuels).
- I 2008 132 mill. will be allocated (hereoff 50 mio. to 2. generation biofuels).
- The objective is to establish an energy technology development and **demonstration** program to strengthen the development of new technologies within energy security, cost effectiveness and the development of new industries in the area
- Partnerships / clusters / public private network are key players in developing strategies for developing the technologies.

DANISH ENERGY AUTHORITY

RISØ

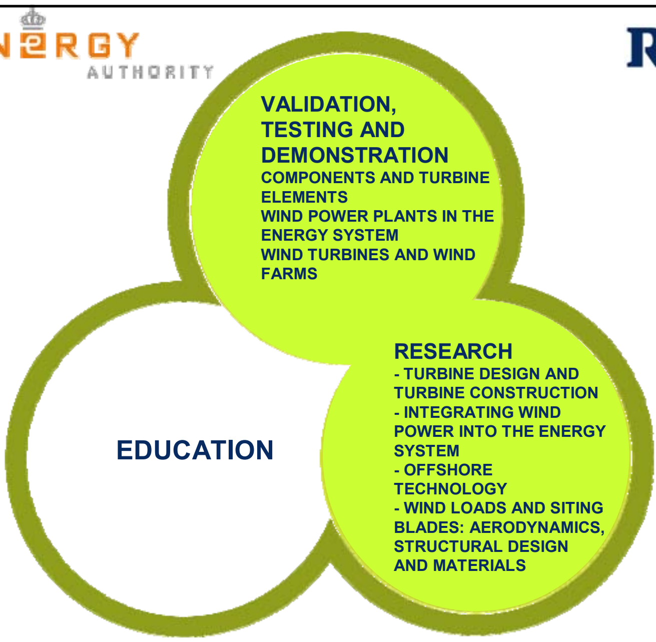
New partnership for wind established: MEGA-WIND

- Danish Energy Authority
- Energinet.DK
- DONG
- Danish Technival University
- Aalborg University
- RISØ
- Vestas
- Siemens

- Secretariat: Danish Windpower Organisation

DANISH ENERGY AUTHORITY

RISØ



MEGAVIND

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Test site at Høvsøre

DANISH ENERGY AUTHORITY

RISØ

8 New Onshore test sites for testing of large wind turbines

1. **2 sites on West Lolland (Kappel I og Kappel II)**
2. **1 near Asnæs Power Station (Kalundborg)**
3. **1 near Esbjerg Havn**
4. **1 in Nissum Bredning (near ‘Cheminova’)**
5. **1 north of Limfjorden ved ‘Nordjyllandsværket’**
6. **1 east of Hirtshals Harbor**
7. **1 in the sea outside Frederikshavn Harbor.**

Will allow turbines up 200 meter’s hight

More Information on Danish Wind Energy R,D&D

- Danish Energy Authority (Energy and R,D&D Policy)
  - www.ens.dk
- Risø DTU, National Laboratory for Sustainable Energy
  - www.risoe.dk
- Megawind (Partnership with industry)
  - www.windpower.org/megawind
- Wind Energy Consortium (partnership between research institutes)
  - www.risoe.dk/
- or
- Joergen K. Lemming, Risø DTU
  - joergen.lemming@risoe.dk
- Lene Nielsen, Danish Energy Authority
  - ln@ens.dk

Wind Energy R&D in Canada

Natural Resources Canada

CANMET Energy Technology Centre

- The CANMET Energy Technology Centre (CETC) is Canada's principal performer of federal energy S&T.
- Part of Natural Resources Canada, the federal department responsible for energy
- CETC provides expertise, performs in-house S&T and manages technology programs
- CETC partners with other federal departments, industry, provinces, universities and international organizations.

Devon, Alberta

Ottawa, Ontario

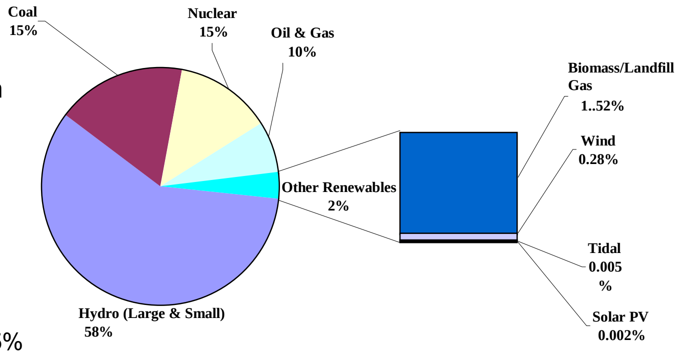
Varennes, Québec

Renewable Electricity Program Scope

- Focus on Renewable Electricity Production Technologies Science and Technology
- Four main technologies are supported:
  - Wind (small, large, offshore)
  - Hydro (small, low-head)
  - Ocean (tidal and kinetic, wave)
  - Solar (PV)
- Objective → to increase the proportion of Canada's electricity supply from renewables

Canadian Electricity Supply

- Total generation of roughly 614 TWh in 2006
  - **Hydro makes up roughly 58% of generation capacity**
  - Nuclear around 15%
  - Thermal about 25%
  - ***Emerging renewables around 2%***



Canada's Natural Resources – *Now and for the Future*

Each Province Has a Different Story

Ontario (2006)
Nuclear - 54%
Hydro - 22%
Coal - 16%
Other - 8%

Quebec (2005)
Hydro - 96.7%
Other - 3.3%

Alberta (2005)
Coal - 48.3%
Natural gas - 40.5%
Hydro - 7.4%
Wind - 2.2%
Biomass - 1.4%
Fuel Oil - 0.06%

Wind Energy – Positioned for Rapid Growth in the Near Term

- Current installed capacity 1,670 MW
- Average annual growth rate >51% between 2000 and 2006
- National Energy Board estimates installed capacity will be 11,400 MW by 2015

BUT …

- Issues remain with wind energy in Canada that must be addressed for wind energy to fulfill its potential

Canada's Wind Tracker

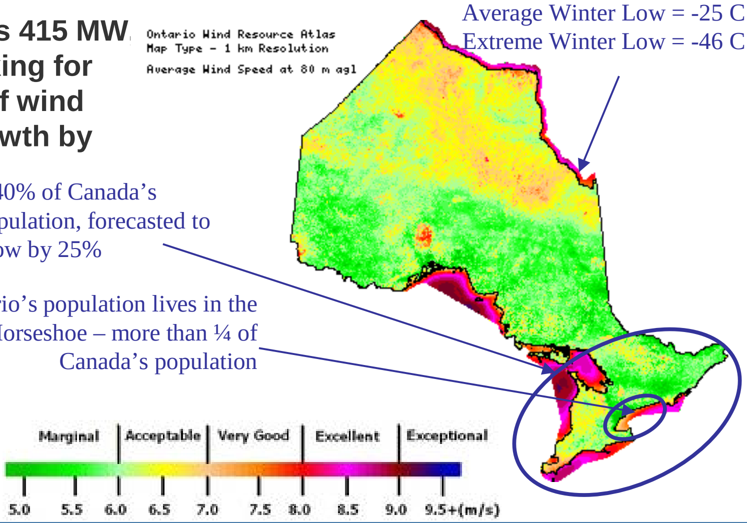
Province	Installed	Proposed*
BC	0	325.2 MW
Alberta	384.97 MW	134 MW
Saskatchewan	171.18 MW	24.75 MW
Manitoba	103.95 MW	0 MW
Ontario	415.31 MW	994.85 MW
Quebec	321.75 MW	1105.5 MW
Newfoundland	390 kW	51 MW
PEI	43.56 MW	28.8 MW
Nova Scotia	49.26 MW	23.2 MW
New Brunswick	0	96 MW
Yukon	810 kW	0
NWT	0	0
Nunavut	0	0
Total	**1491.18 MW**	**2783.3 MW**

* Under construction or awarded a PPA

Canada's Natural Resources – *Now and for the Future*

Case Study: Wind Energy in Ontario

- **Ontario has 415 MW and is looking for 5000 MW of wind energy growth by 2025**



Moosonee, Ontario
Average Winter Low = -25 C
Extreme Winter Low = -46 C

~ 40% of Canada's population, forecasted to grow by 25%

~ 70% of Ontario's population lives in the Golden Horseshoe – more than ¼ of Canada's population

Current Wind R&D Direction

- The R&D program will focus in four key areas:

1. Technology Development:
   - Improving cold climate & icing performance
   - Improving the Reliability of Small Wind Turbines
   - Foundations and Deployment for Offshore Wind Turbines
2. Strengthening R&D Capacity
   - Wind Energy Institute of Canada
   - Wind Energy Strategic Network
3. Resource Assessment and Forecasting
4. Environmental Impacts & Social Acceptance

Other Key Wind R&D Initiatives in Canada

- The Wind Energy Institute of Canada (www.weican.ca)
  - A wind energy research institute and test site
- The Wind Energy Strategic Network
  - An academic wind research network with strong government and industry partners
- Additional federal R&D programs in:
  - Grid Integration
  - Battery Storage
  - Electric Vehicles
  - Hydrogen

The Wind Energy Institute of Canada North Cape, Prince Edward Island

Potential Areas of Collaboration

- Continued R&D on Offshore Wind Energy
  - Explore innovative offshore wind foundation and deployment concepts
- Continued R&D on Cold Climates
- Rime Ice forecasting:
  - Accurately forecast rime icing events and factor it into production forecast
- Wind Energy Forecasting
  - Develop forecasting tools with increased accuracy in both wind prediction and wind energy prediction.
- Environmental Impacts & Social Acceptance.

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Agenda

- Introduction to Statkraft
- R&D tasks - Wind Power

Statkraft

Introduction to Statkraft

- Head Office in Oslo
- Subsidiaries
- European offices
- Associated companies

- 158 hydropower plants
- 3 wind farms
- Baltic Cable
- Gas power

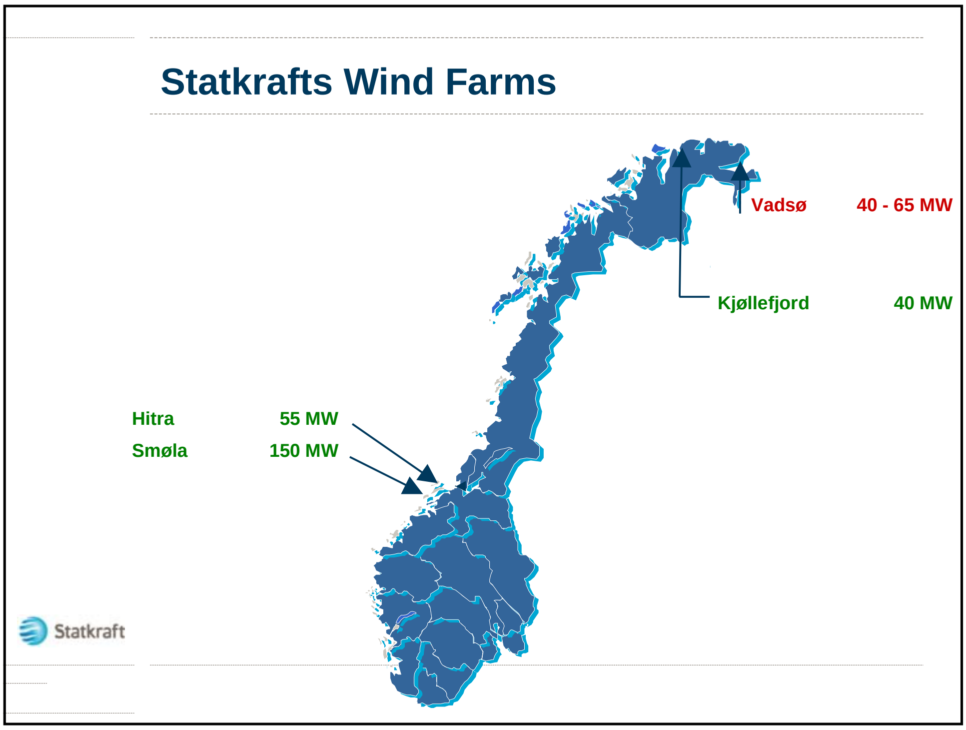
Statkraft

Agenda

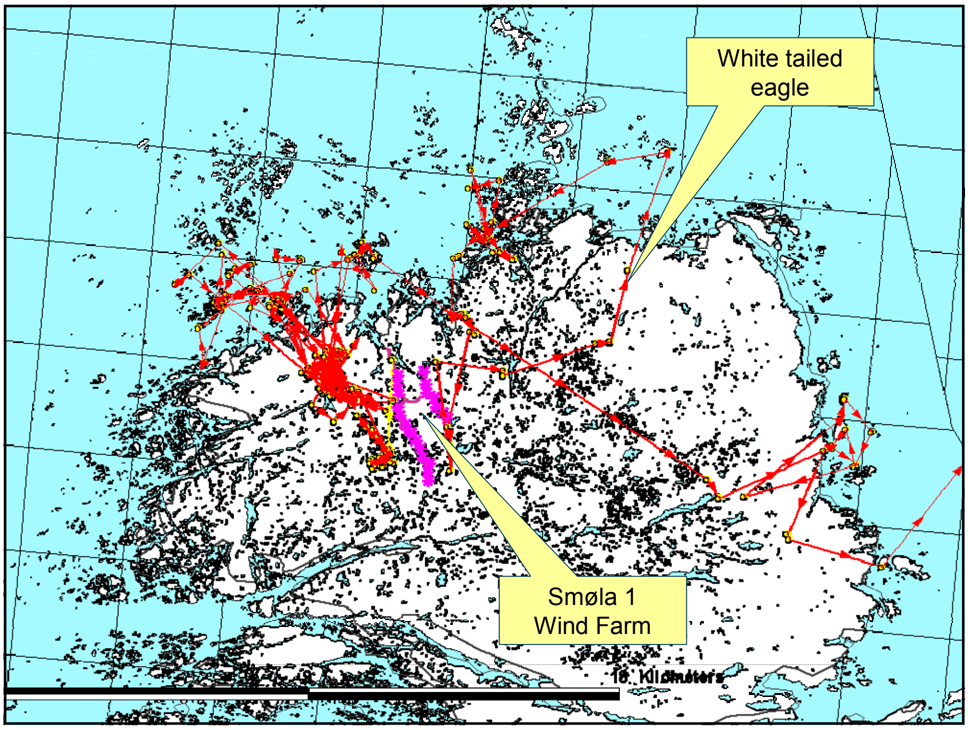
--> Introduction to Statkraft

--> R&D tasks - Wind Power

Statkraft

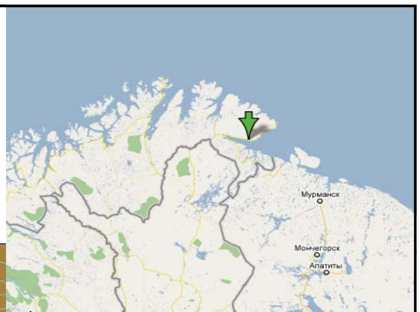

Statkrafts Wind Farms
Vadsø
40 - 65 MW
Kjøllefjord
40 MW
Hitra
55 MW
Smøla
150 MW
Statkraft

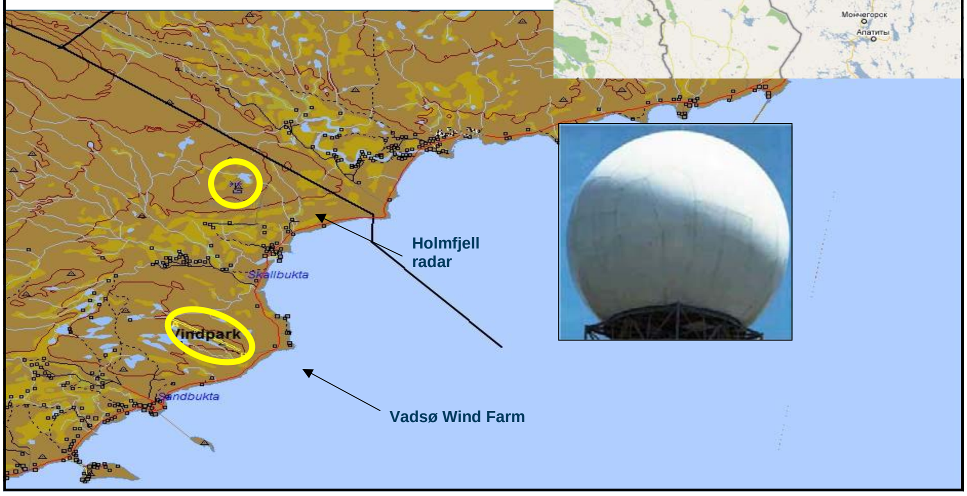

Smøla Wind Farm
- White tailed eagles



Vadsø Wind Farm

- Radar
  - The Norwegian Defense
  - Secret Service





Kjøllefjord Wind Fark
- Cold Climate

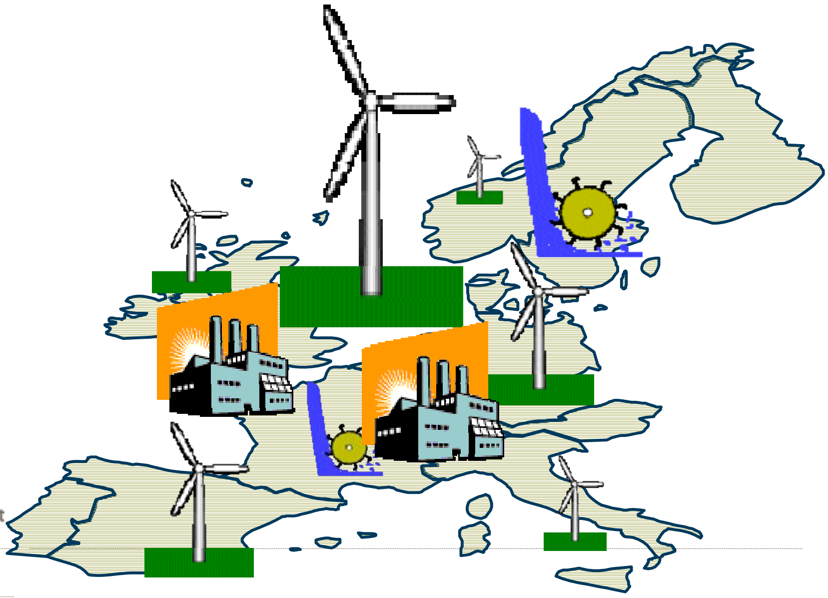
- 72º North
  - Corresponds to middle part of Greenland or north of Alaska
- ~300m above sea level
- The turbines have a cold weather package, but is this enough?

Statkraft

Bottlenecks in the grid

Statkraft

Large offshore plans in the North Sea…



Nordel

Hydro power reservoir in Nordel:

- Norway - 80 TWh
- Sweden – 30 TWh

- The Nordic countries has more than 50 % of the reservoir capacity in Europe


Thank you for your attention!

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I+D+i PLATAFORMA EÓLICA TECNOLÓGICA

Alberto Ceña
Spanish Wind Energy Association (AEE)

Félix Avia
National Centre of Renewable Energies (CENER)

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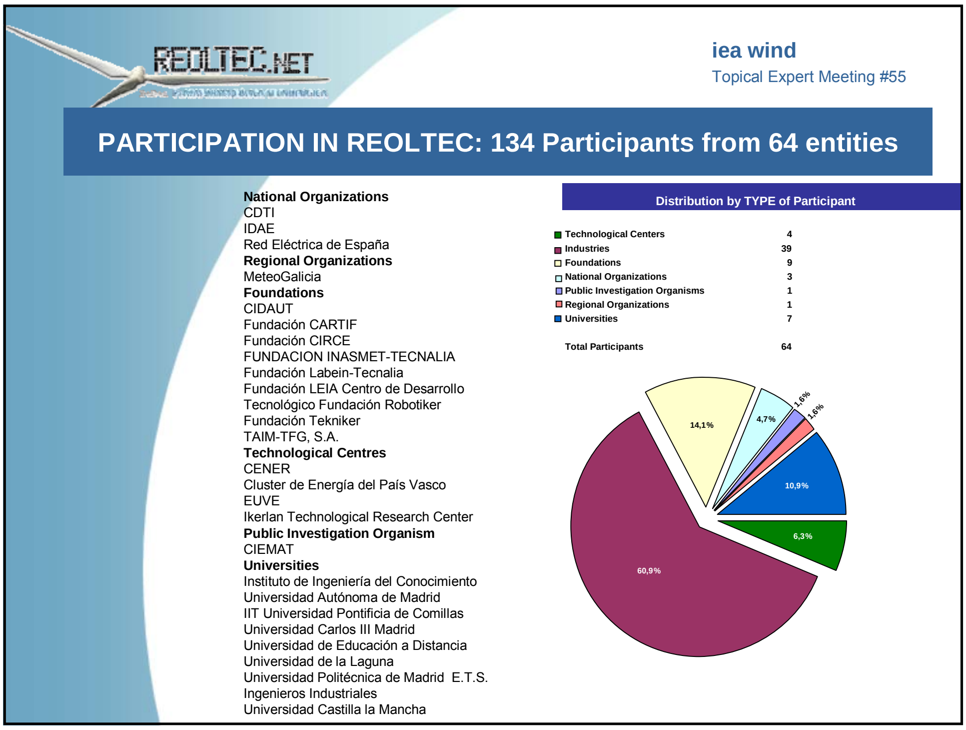
WHAT IS REOLTEC

- **REOLTEC** is the Spanish Wind Energy Technological Platform, created with financial support of the Spanish Ministry of Education and Science (MEC), with the main target of defining the R&D priorities of the sector.

- It is organized through a Managing Group and several Working Groups.


REOLTEC.NET
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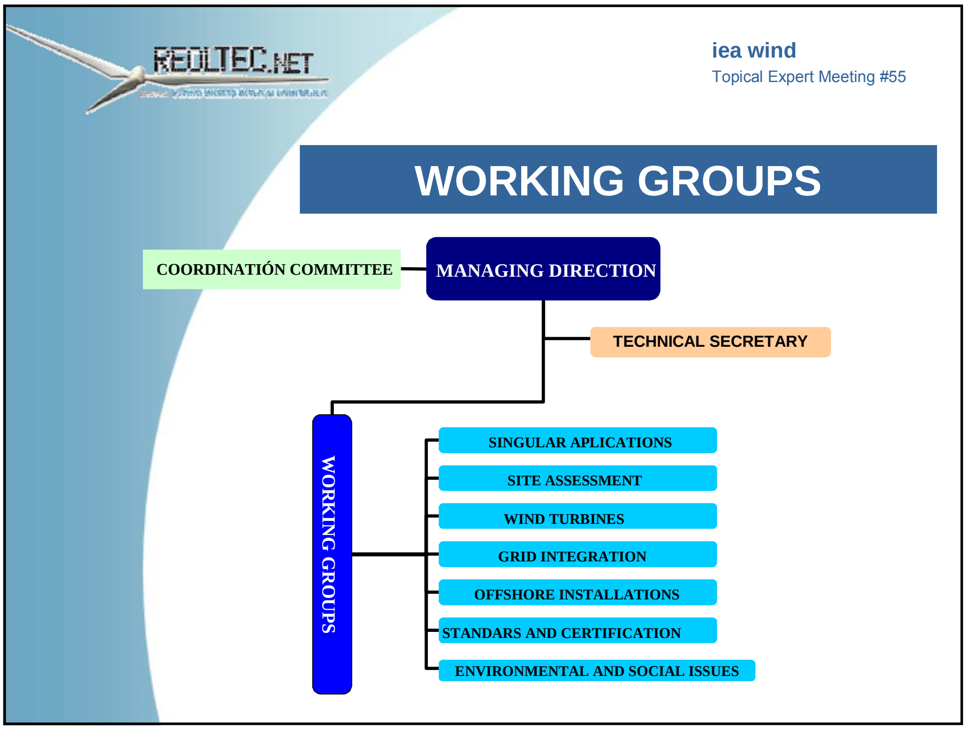
PARTICIPATION IN REOLTEC: 134 Participants from 64 entities
National Organizations
CDTI
IDAE
Red Eléctrica de España
Regional Organizations
MeteoGalicia
Foundations
CIDAUT
Fundación CARTIF
Fundación CIRCE
FUNDACION INASMET-TECNALIA
Fundación Labein-Tecnalia
Fundación LEIA Centro de Desarrollo
Tecnológico Fundación Robotiker
Fundación Tekniker
TAIM-TFG, S.A.
Technological Centres
CENER
Cluster de Energía del País Vasco
EUVE
Ikerlan Technological Research Center
Public Investigation Organism
CIEMAT
Universities
Instituto de Ingeniería del Conocimiento
Universidad Autónoma de Madrid
IIT Universidad Pontificia de Comillas
Universidad Carlos III Madrid
Universidad de Educación a Distancia
Universidad de la Laguna
Universidad Politécnica de Madrid E.T.S.
Ingenieros Industriales
Universidad Castilla la Mancha
Distribution by TYPE of Participant
Technological Centers 4
Industries 39
Foundations 9
National Organizations 3
Public Investigation Organisms 1
Regional Organizations 1
Universities 7
Total Participants 64
14,1%
4,7%
1,6%
1,6%
10,9%
6,3%
60,9%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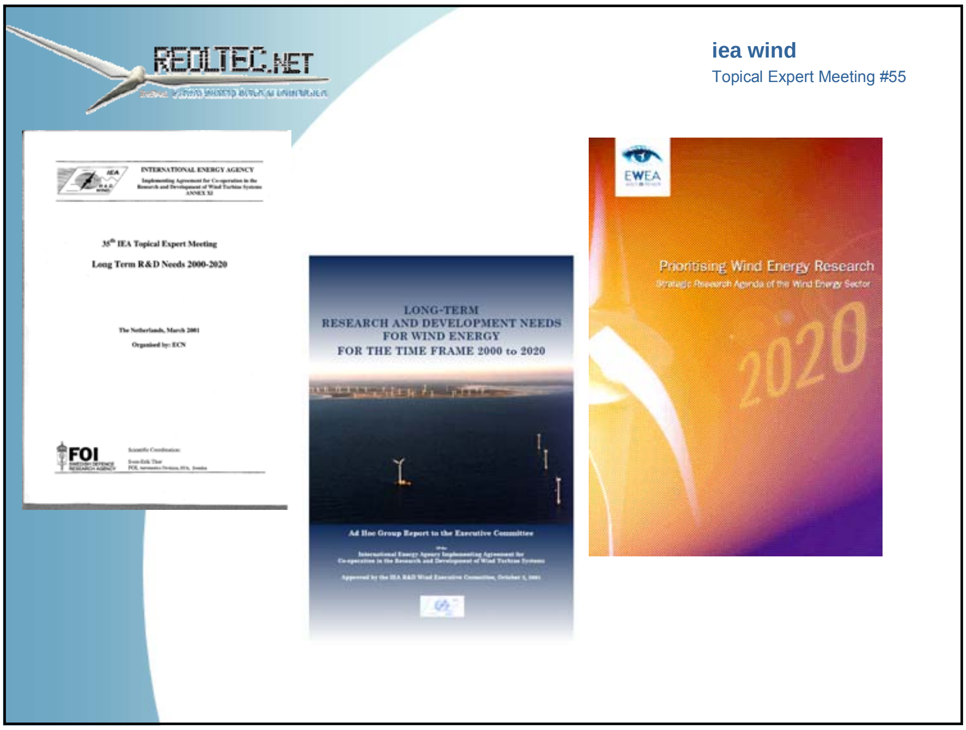
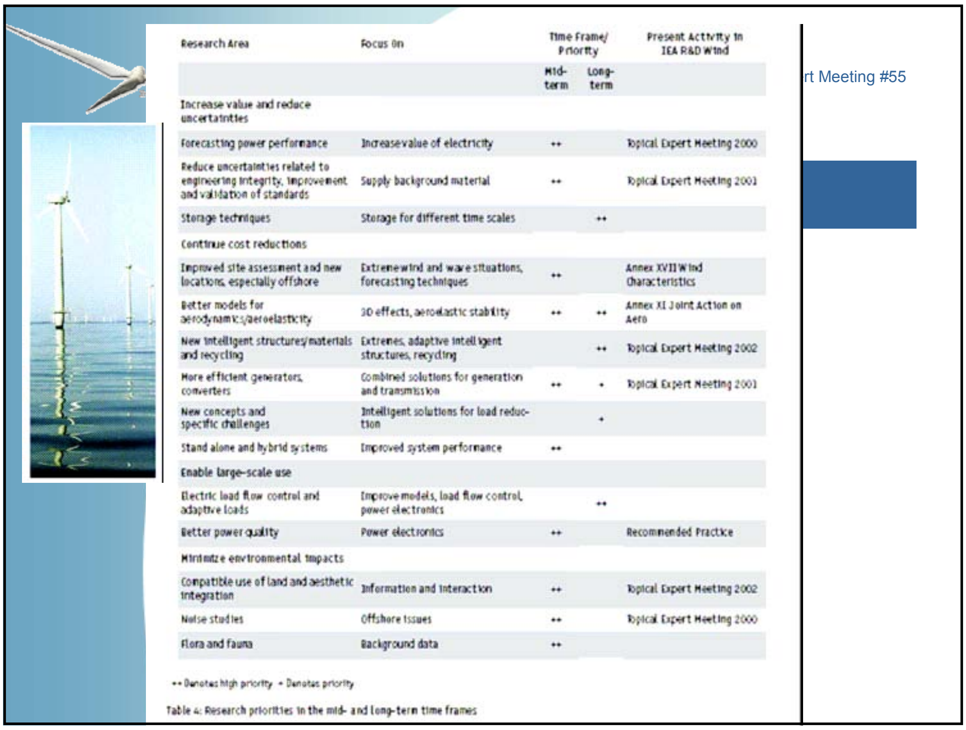
WORKING GROUPS
COORDINATIÓN COMMITTEE
MANAGING DIRECTION
TECHNICAL SECRETARY
WORKING GROUPS
SINGULAR APLICATIONS
SITE ASSESSMENT
WIND TURBINES
GRID INTEGRATION
OFFSHORE INSTALLATIONS
STANDARS AND CERTIFICATION
ENVIRONMENTAL AND SOCIAL ISSUES





Research Area	Focus On	Time Frame/ Priority		Present Activity in IEA R&D Wind
		Mid-term	Long-term	
Increase value and reduce uncertainties				
Forecasting power performance	Increase value of electricity	++		Topical Expert Meeting 2000
Reduce uncertainties related to engineering integrity, improvement and validation of standards	Supply background material	++		Topical Expert Meeting 2001
Storage techniques	Storage for different time scales		++	
Continue cost reductions				
Improved site assessment and new locations, especially offshore	Extreme wind and wave situations, forecasting techniques	++		Annex XVII Wind Characteristics
Better models for aerodynamics/aeroelasticity	3D effects, aeroelastic stability	++	++	Annex XI Joint Action on Aero
New intelligent structures/materials and recycling	Extremes, adaptive intelligent structures, recycling		++	Topical Expert Meeting 2002
More efficient generators, converters	Combined solutions for generation and transmission	++	+	Topical Expert Meeting 2001
New concepts and specific challenges	Intelligent solutions for load reduction		+	
Stand alone and hybrid systems	Improved system performance	++		
Enable large-scale use				
Electric load flow control and adaptive loads	Improve models, load flow control, power electronics		++	
Better power quality	Power electronics	++		Recommended Practice
Minimize environmental impacts				
Compatible use of land and aesthetic integration	Information and interaction	++		Topical Expert Meeting 2002
Noise studies	Offshore issues	++		Topical Expert Meeting 2000
Flora and fauna	Background data	++		

++ Denotes high priority + Denotes priority

Table 4: Research priorities in the mid- and long-term time frames

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GENERAL TARGETS

- **Main targets:**
  - Reduction in generation costs (actually 59€/MWh)
  - Increase of the availability and reliability of the systems
  - Grid integration
- **Other targets:**
- Improvement of the logistic (transport, installation and O&M)
- Security in network operation: Voltage drops, voltage control, regulating services.
- Energy storage at wind farm level
- Hydrogen Production, Desalination…

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R&D Priorities in Site Assessment

- Wind profile at high levels (>150 m).
- Wind structure in wind farms (complex terrain and offshore)
- *Offshore wind measurements*
- New measurements systems (sodar, lidar, etc)
- Long term forecasting

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R&D Priorities in WTs

General priorities:

- ***Aeroelastic codes development***
- ***Simulation algorithms***
- ***New materials***
- ***Design validation***

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R&D Priorities in WTs

- Rotor
  - New profiles
  - ***Split blades***
  - ***Lighter structural designs***
  - Noise reduction

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R&D Priorities in WTs

- **Gearbox**
  - ***Problem characterization***
  - Life span of components
  - High torque couplings
  - New Topologies
  - Dynamic behavior
- **Generator**
  - ***Transient behavior***
  - High voltage generation
  - New Topologies

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R&D Priorities in WTs

- **Control**
  - Load sensors
  - Simulation
  - ***Control strategies for load reduction***
  - Distributed control technologies
- **Monitoring**
  - Load monitoring
  - Long lifespan sensors
  - Signal analysis methods
  - Decision tools

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R&D Priorities in O&M

- Predictive maintenance:
  - Component sensing
  - State monitoring and breakdown forecast
- ***Component reliability***
  - ***Studies of rate and type of failures***
- Failure tolerance

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R&D Priorities in Grid Integration

- Advanced control systems for wind farms
- Monitoring and prediction of voltage dips. Applications of voltage control systems
- ***Studies of the impact and operation of a system with high wind penetration***
- ***Improvement of the use of the energy production forecasting for system operation***
- Specific analysis of electric systems in islands
- Load management

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R&D Priorities in Offshore Wind Farms

- Offshore wind resource assessment
- Wave models
- ***Foundations and support structures***
- Environmental Impact Studies
- Wind Turbine Customizing: Corrosion Protection and High Feasibility
- Electrical substations
- Offshore Wind Farms Logistic
- ***Test and Demonstration Plants***

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R&D Priorities in Certification and Standardization

- Development of test and verification standards applied to :
  - Wind farm design
  - Wind farm security
  - Production capacity of wind farms
  - Wind farm availability
  - Electromagnetic compatibility of wind farms:
    - Active/reactive power control
    - stability in case of voltage dips
  - Development of norms for sub-systems that increase modularity accelerating market development

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R&D Priorities in Singular Applications

- ***Development of short term energy storage systems.***
  - *Supercapacitors.*
  - *Flywheels.*
  - *Batteries.*
  - *Compressed Air*
- ***Development of isolated solutions for hydrogen production and water desalination***
- ***Small WTs for autonomous systems***

Main Objectives

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Sociological R&D Priorities

- Evaluation of the macroeconomic impact of wind farms
- Optimization of socioeconomic returns
- Analysis of the social response and degree of acceptability.

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R&D Priorities in Environment

- ***Recyclability of components: Blades***
- Visual impact
- Impact on birds and sea fauna
- Noise reduction
- Study on the impact on radiofrequency and its limitation

Netherlands LT R&D Needs

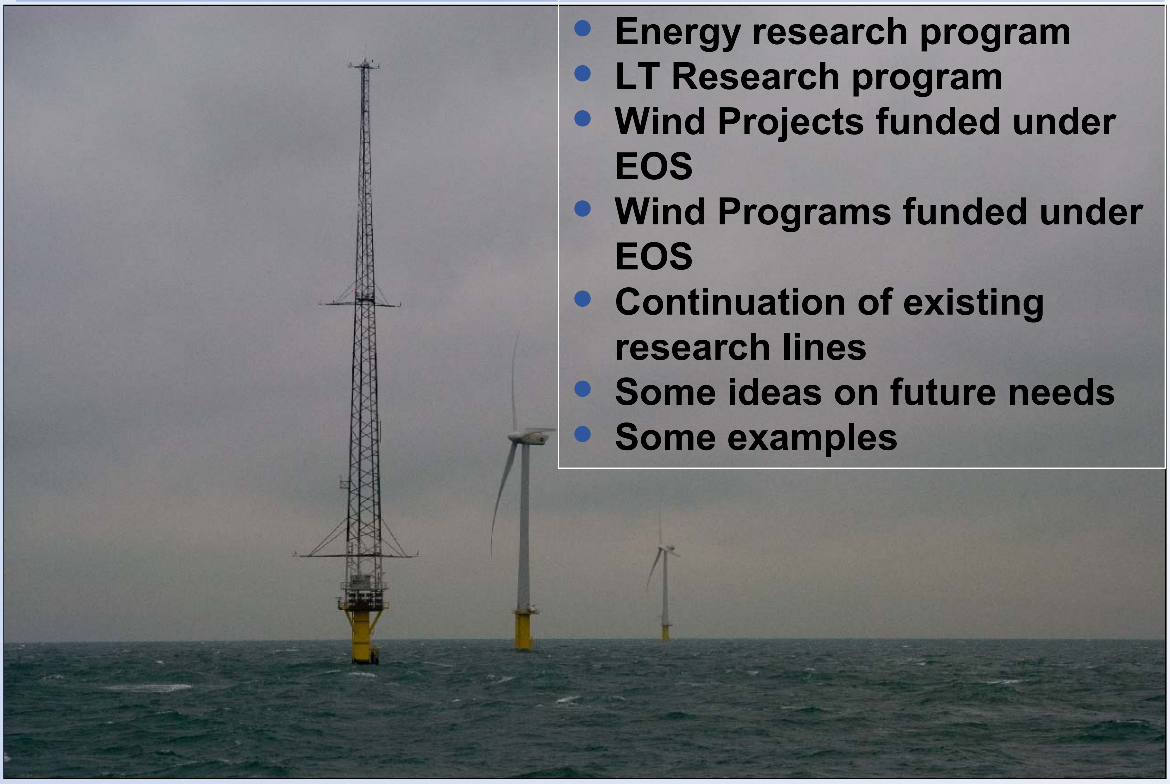
SenterNovem

Jaap 't Hooft

Berlin 6-7 dec 2007

Contents presentation Netherlands

SenterNovem



- Energy research program
- LT Research program
- Wind Projects funded under EOS
- Wind Programs funded under EOS
- Continuation of existing research lines
- Some ideas on future needs
- Some examples

Energy Research Program

SenterNovem

- Supports research that leads to sustainable energy supply (5 themes)
- Aims at research that strengthens the Netherlands knowledge position
- Time frames leads to products on market
- EOS- Demonstration = Short term (ST) 3-5 years
- EOS- Industrial = Medium (MT) 5-10 years
- EOS- Research = Long term (LT) >10 years

LT research program

SenterNovem

Theme 5. Offshore wind generation and electricity grids.

- Design knowledge offshore turbines and farms
- Integration 6000 MW offshore wind
- Technical transition of electricity networks (e.g hybrid plug-in storage cars)
- Management and maintenance of electricity networks

- Focal points offshore
  - Design knowledge: offshore wind competitive with fossil in 2020
  - Integration 6000 MW: make it possible and economic

Wind Projects funded under EOS

SenterNovem

- Rotorflow I (1 M€ 4 year project)
  - New methods for the calculation of aerodynamic loads, between BEM and CFD
- SusCon (1 M€ 4 year project)
  - A new approach to control wind turbines
  - Optimized Feedback Control (OFC)
  - Fault Tolerant Control (FTC)
  - Extreme Event Control (EEC)
  - Optimal Shutdown Control (OSC)

Wind Programs funded under EOS

SenterNovem

- INNWIND project in coop with Upwind (1 M€/ year)
  - Concepts and components
  - Aero-elasticity (Aerodynamics and structural dynamics)
  - Materials and constructions
  - Model development and realization of integrated modular design tool
  - Design guidelines
- ECN research program (4 M€/ year)
  - Aero-elasticity
  - Condition monitoring and measurement techniques,
  - Control technology,
  - Farm -aerodynamics
  - Decision support models for O&M

Continuation of existing research lines

SenterNovem

- Adding intelligence

- For the rotor, smart rotors
- For the drive train, flexibility, flexible generators, magnetic bearings, control to minimize loads
- For the turbine, adapt to anticipated loads in various situations (Suscon)
- For the wind farm optimize and smooth output as a generation unit
- For grid integration, optimize economic value against actual electricity market prices.
- For storage / demand management adding ICT, intelligent transaction agents

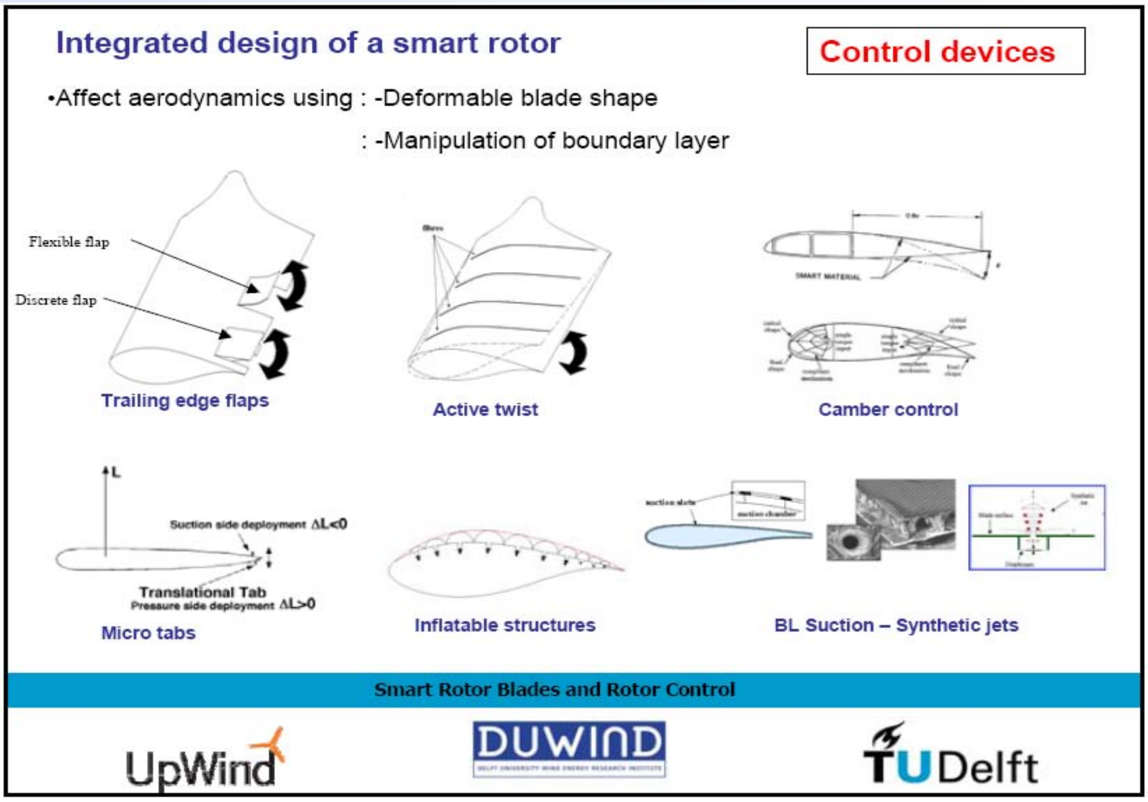
Some ideas on future needs

SenterNovem

- Fast upscaling, 'skip' the first half of a blade, make it a 'truss' tower
- Knowledge of the wind field before the turbine to use it for control.
- Everything that minimizes loads on towers
- Methods to mix new air in wake of turbines/farms
- Clever (and cheap) installation concepts for large offshore wind farms with large turbines
- Cradle 2 cradle (reusability, recycability, of all components, particular blades)

TU Delft research work on smart rotors

SenterNovem



Recyclable thermoplastic composites

SenterNovem

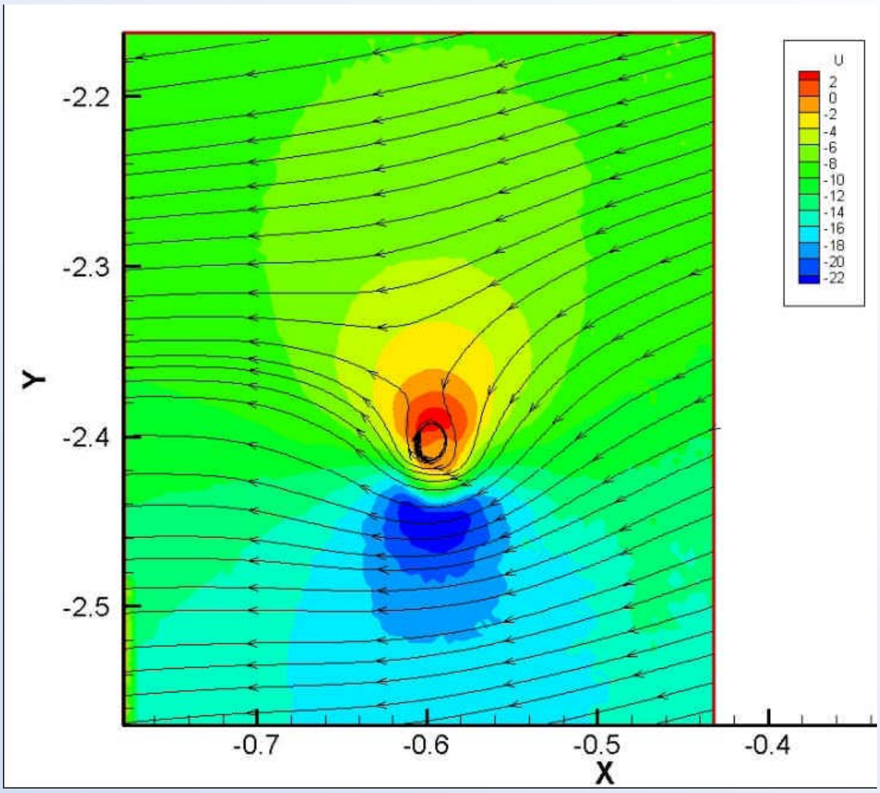
- DTU development
- Vacuum infused anionicpolyamide-6 (PA-6)
- Thermoplastic composites
- Four different blade composite materials
  - glass/epoxy,
  - carbon/epoxy,
  - glass/PA-6, and
  - carbon/PA-6
- weight, costs, natural frequencies compared
- PA-6 = 1.0 glass/epoxy
- PA-6 = 0.9 glass/epoxy

Recyclable thermoplastic composites

- Manufacturing:
- processing temperatures of PA-6
- significantly higher than for epoxy systems;
- the associated cost increase is expected to be compensated for by a reduction in infusion and curing time.

MEXICO Chasing Vortices

- Flow structure around vortex
- Horizontal projections of streamlines
- Vortex position 0.12 D behind rotor.
- 15 m/s bottom (outer flow)
- 10 m/s top (wake flow)



End

Questions?

vrijdag 7 december 2007

13

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UK Energy Technologies Institute

working in collaboration with

CARBON TRUST

OFFSHORE WIND PROGRAMME

presented by

Mike Colechin (E.ON)

The UK Energy Technologies Institute is…

… a 10 Year, £110 M per annum initiative

- **Current Partners:**

…contributing £60M per annum (50% from HMG)

ENERGY TECHNOLOGIES INSTITUTE

Partner or High-Level Desired Outcomes

Overall aim - Address UK and Global Energy Challenges by …..

1. **Reduction in greenhouse gas emissions (UK target - 60% CO_2 reduction by 2050) through demonstration of technology to enable timely commercialisation**
2. **Development, Demonstration and (in some cases) initial Deployment of affordable low carbon technology solutions**
3. **Realisation of security of energy supply in conjunction with GHG mitigation**
4. **Delivery of a step change in funding for Energy R&D in the UK**

ENERGY TECHNOLOGIES INSTITUTE

How ETI will Deliver Outcomes…

a) **Creation of a favourable operating environment for Energy Research Development, Demonstration and Deployment**

b) Increasing the profile, visibility & impact of Energy Research

c) Development of an effective Energy Innovation Process in the UK

d) **Effective and focused R&D support resulting in a strong (low carbon) Energy Innovation Chain**

e) Creation of a favourable operating environment for Applied Research Programmes and Early Stage Demonstration

f) Operation of an 'Incubator' approach for disruptive technologies

g) Developing Technology Road Maps at an 'energy systems' level

h) **Maximising (International) Collaboration and Partnerships**

i) Developing new human capital and capacity

j) Delivery of trained personnel (with appropriate skills, leadership and talent) to meet commercial investor needs to enable full deployment

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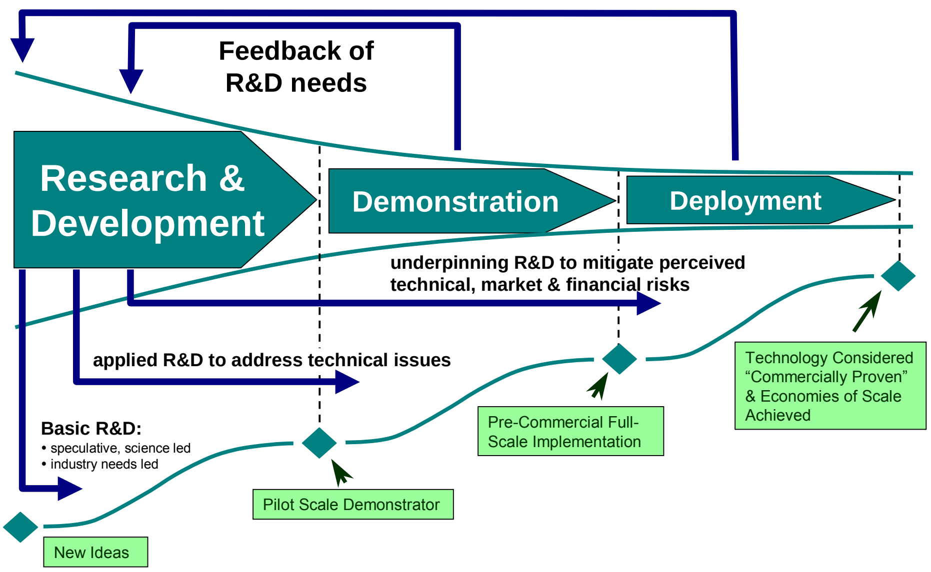
Energy Innovation Process



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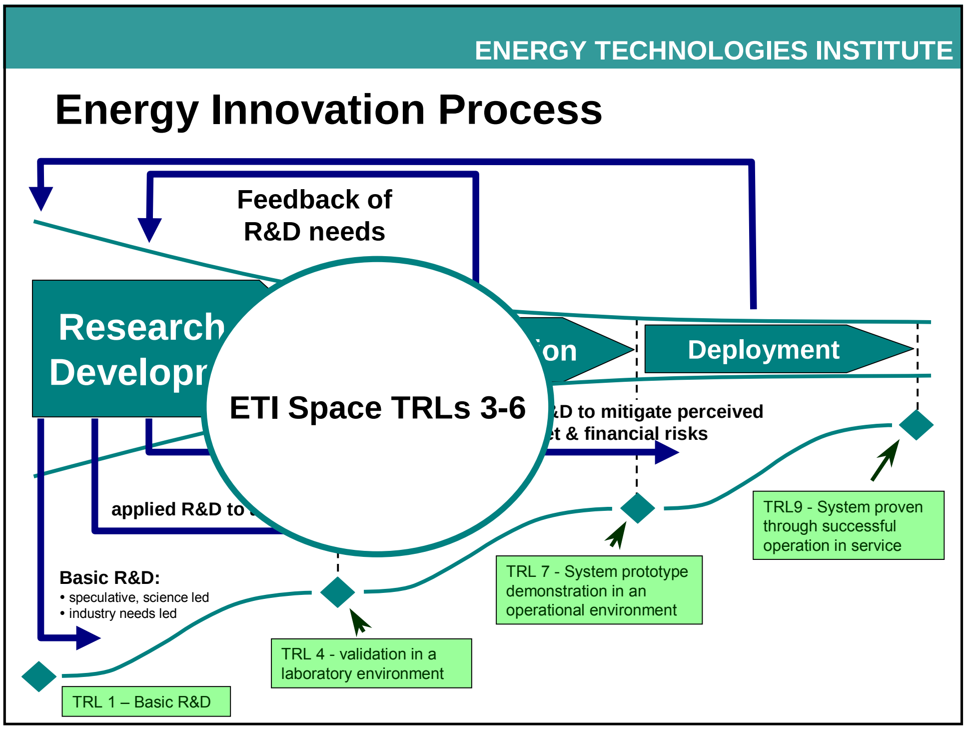
Technology Readiness Levels - Design and systems engineering
- ETI role is in TRLs 3-6

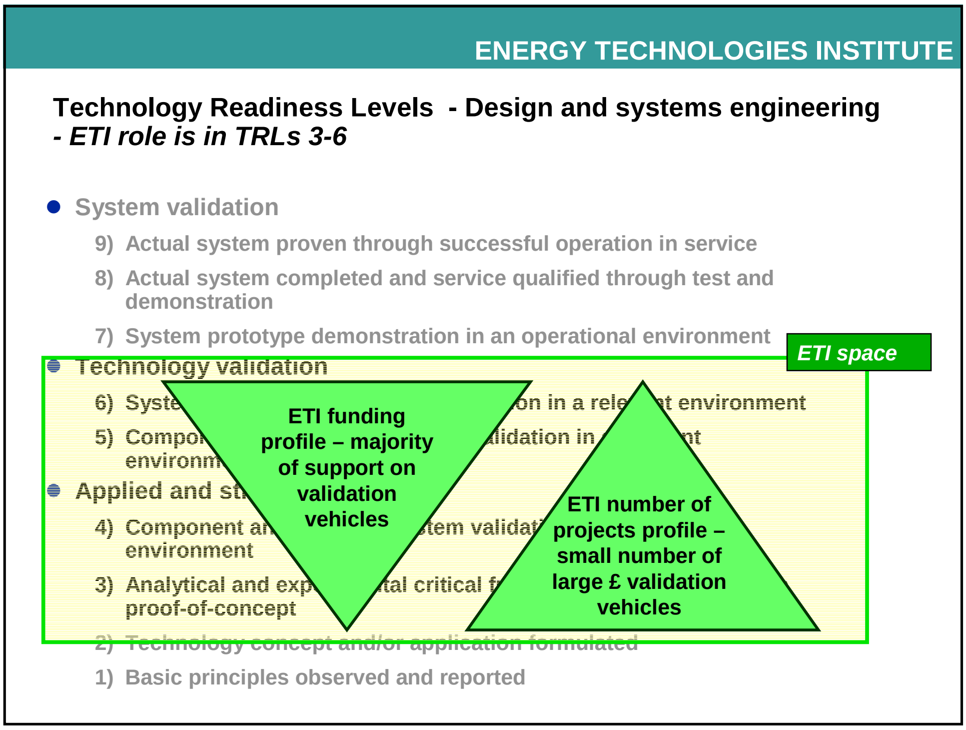
- System validation
  9) Actual system proven through successful operation in service
  8) Actual system completed and service qualified through test and demonstration
  7) System prototype demonstration in an operational environment
- Technology validation
  6) System/subsystem model demonstration in a relevant environment
  5) Component and/or partial system validation in a relevant environment
- Applied and strategic research:
  4) Component and/or partial system validation in a laboratory environment
  3) Analytical and experimental critical function and/or characteristic proof-of-concept
  2) Technology concept and/or application formulated
  1) Basic principles observed and reported

Final technology validation in *deployment* of a prototype product

Technology Validation / *demonstration* – (ETI primary role, enabling technology pull-through)

Strategic and Applied *research*


ENERGY TECHNOLOGIES INSTITUTE
Energy Innovation Process
Feedback of
R&D needs
Research
Developr
ETI Space TRLs 3-6
Deployment
D to mitigate perceived
t & financial risks
applied R&D to
Basic R&D:
• speculative, science led
• industry needs led
TRL 1 – Basic R&D
TRL 4 - validation in a laboratory environment
TRL 7 - System prototype demonstration in an operational environment
TRL9 - System proven through successful operation in service


ENERGY TECHNOLOGIES INSTITUTE
Technology Readiness Levels - Design and systems engineering
- ETI role is in TRLs 3-6
System validation
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ETI space
Technology validation
6) Syste
on in a rele
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5) Compo
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nt
Applied and st
4) Component a
environment
tem validat
3) Analytical and exp
tal critical f
proof-of-concept
2) Technology concept and/or application formulated
1) Basic principles observed and reported
ETI funding profile – majority of support on validation vehicles
ETI number of projects profile – small number of large £ validation vehicles

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ETI Programme Working Groups: Wind

- ***Current Landscape***
  - **UK on-shore capacity: 1.8 GW**
    (3 TWh per annum)
  - **UK off-shore capacity: 400 MW**
    (0.8 TWh per annum)
  - **Government Offshore Wind Scheme:**
    - Round 1 - 1GW off-shore by 2010
    - Round 2 – further 7GW by 2015

- ***Future Potential***
  - BWEA 2020 prediction: 24 GW (~70 TWh per annum).
  - Up to 20% of annual electricity demand (~80 TWh in 2020) could be met from wind before transmission system stability an issue.
  - 80 TWh wind saves around 30 million tonnes of CO_2 per year (5% of total current UK emissions from all sectors of the economy).
  - Theoretical maximum off-shore capacity: 100 GW (~300 TWh p.a.)

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ETI Programme Working Groups: Wind

- ***Opportunities for ETI***
  (barriers to realising full technology potential)
  - **Design and Demonstration of Novel Off-Shore Systems**
    - specific off-shore turbine designs, deep water installations, optimal wind farm designs
  - **Technology/Operational Improvements**
    - component reliability, lightning resistance, reduced radar visibility, control & instrumentation, electrical networking, energy storage
  - **Supporting Studies on Generic Deployment Issues**
    - off-shore resource mapping, health & safety, public acceptability, environmental impacts, standards

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ETI Programme Working Groups: Wind

- ***ETI Additionality***
  - **UK is an excellent test bed**
    - wind resources, off-shore seabed conditions and unique government support for demonstration and deployment make.
  - **Unique combination of skills among partners**
    - existing wind plant operators (E.ON, EDF), off-shore oil and gas experience (BP, Shell), high reliability / high integrity equipment manufacturers (Rolls-Royce, Caterpillar), management of novel system and technology development and demonstration at full-scale (Rolls-Royce)
  - **Capacity limitations in exisiting supply chain (little incentive to develop offshore specific designs)**
    - ETI partner capabilities and funding system provides significant boost compared to mechanisms such as the TSB, which require additional private sector financial support.
  - **Existing (but limited) UK R&D capacity**
    - ETI can build on this to make UK world leader in off-shore wind

ENERGY TECHNOLOGIES INSTITUTE

ETI Programme Working Groups: Wind

- ***Risk***
  - **Design and Demonstration of Novel Off-Shore Systems**
    - Potential for significant impact against ETI outcomes.

    BUT, high risk:
    - objectives technically difficult to achieve
    - projects aimed at developing new IP – may require protracted negotiation

  - **Technology/Operational Improvements**
    - best balance between risks and outcomes
    - IP issues likely to be dominated by concerns around protection of background IP
  - **Supporting Studies on Generic Deployment Issues**
    - minimal risk as an ETI investment
    - very unlikely to raise any time risks around IP management issues.

    BUT
    - requires ongoing interaction with range of other bodies, hence unlikely to deliver impact quickly

Wind: Potential Work Packages

- ***Design and Demonstration of Novel Off-Shore Systems***

specific off-shore turbine designs	deep water installations	optimal wind farm designs

- ***Technology/Operational Improvements***

component reliability	lightning resistance	reduced radar visibility
electrical networking	control & instrumentation	energy storage

- ***Supporting Studies on Generic Deployment Issues***

environmental impacts	off-shore resource mapping	public acceptability,
health & safety	standards	

CARBON TRUST

OFFSHORE WIND PROGRAMME

Aspirational Timetable

17 Dec - Call for:
- Expressions of Interest
- Programme Associates

Feb-Mar
- Develop project consortia

July
- Award Contracts

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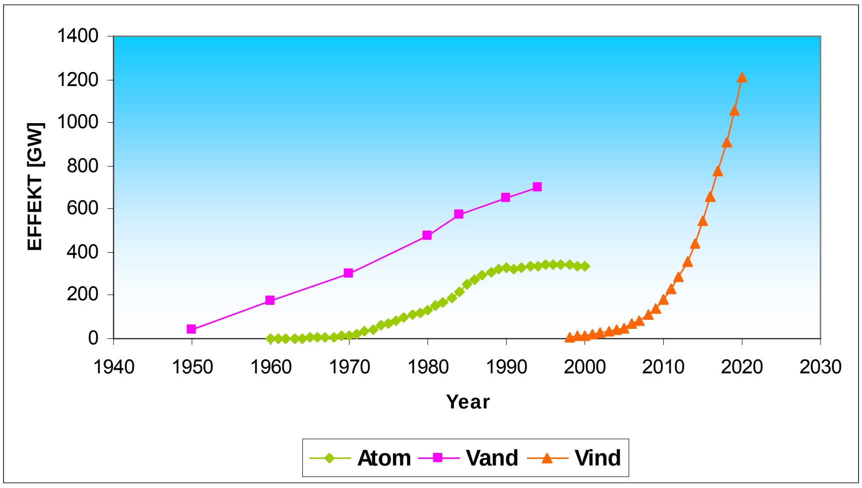
IEA-meeting on long term research needs

Flemming Rasmussen

Head of Aeroelastic Design

Wind Energy Department
Risø DTU National Laboratory for Sustainable Energy
Technical University of Denmark

Accumulated power in the world
10 % Wind energy-scenario



DTU

RISØ

New era for wind energy

Driver so far has mainly been cost

New situation:

- Greenhouse effect
- Security of supply
- Economic development

DTU

RISØ

Wind power from supplementary to "Base load" (first priority)

- Stability of society
- Electricity supply system
- Energy supply system

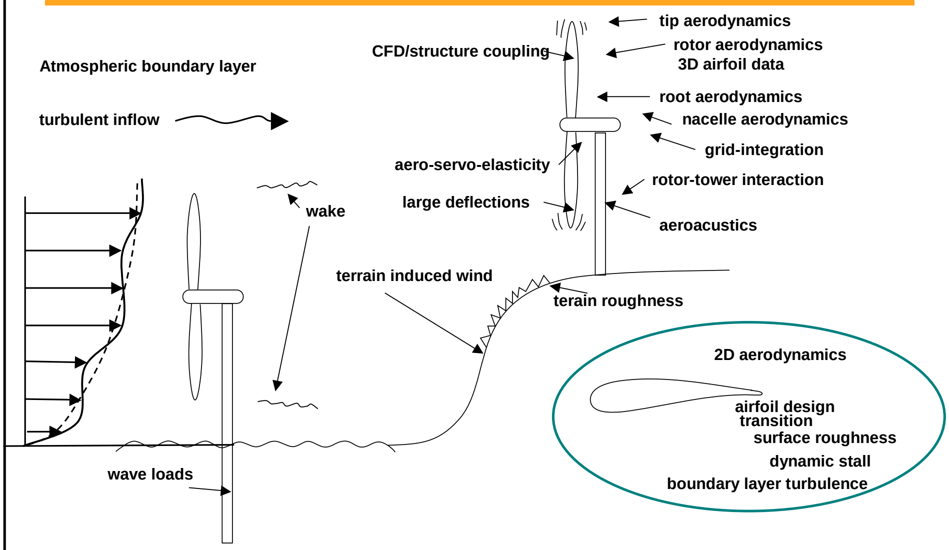
The perception of wind energy as ”Base load”

- Consider a wind power station in combination with a hydro power station including pumped storage.
- Fossile fuel is considered a storage (only burned, when extra energy is needed).

Needed: Two large demonstration projects

- Wind – hydro –pumped storage
- Wind driven electric cars plug-in (storage/transportation)

Aeroelastic interaction



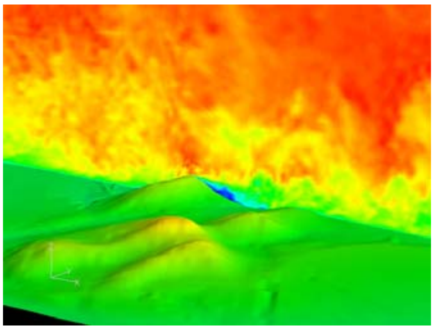
Progress

Full description of turbine in interaction with surroundings
Reliability is the key issue presently

- Wind field description
- Aero-servo-hydro elastic interaction
- Ultimate strength and fatique damage
- Interaction with grid and surroundings
- Operation and maintenence, installation and dismantling

Progress/ achievements

- Terrain turbine interaction →
- Non-linear aeroelastic models
- Dynamic wake modelling
- Aero-servo-hydro elastic modelling
- Stability characteristics
- Advanced airfoil control
- Gearbox dynamics included
- Structural modelling
- Fatigue modelling
- Remote censing (lidar)



Re-starting, New beginning (consolidation and exploitation)

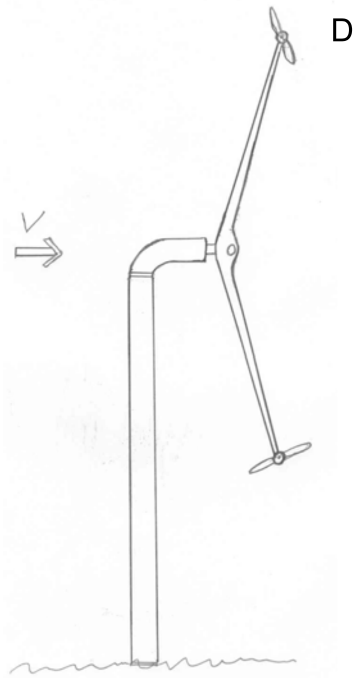
- New manufacturers
- New concepts

Three development lines

- Incremental developments (1) (Reliability)
- Change of component and subsystem concepts (2)
- Change of wind turbine concept (3)

Research necessary basis for technology changes

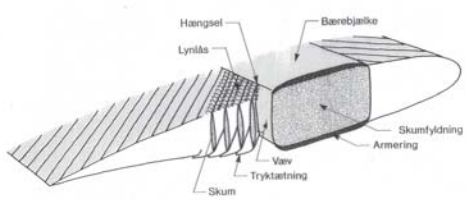
Drive train concepts

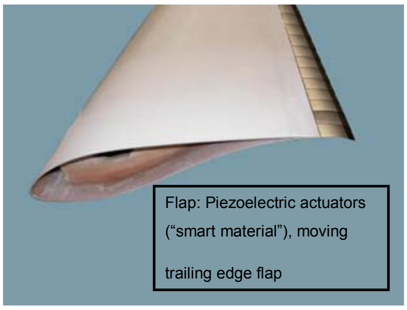


Multipole generator (super conduction)

Main carrier, Generator rotor/stator, Axle pin/hub

Combined passive built-in and multi-variable control

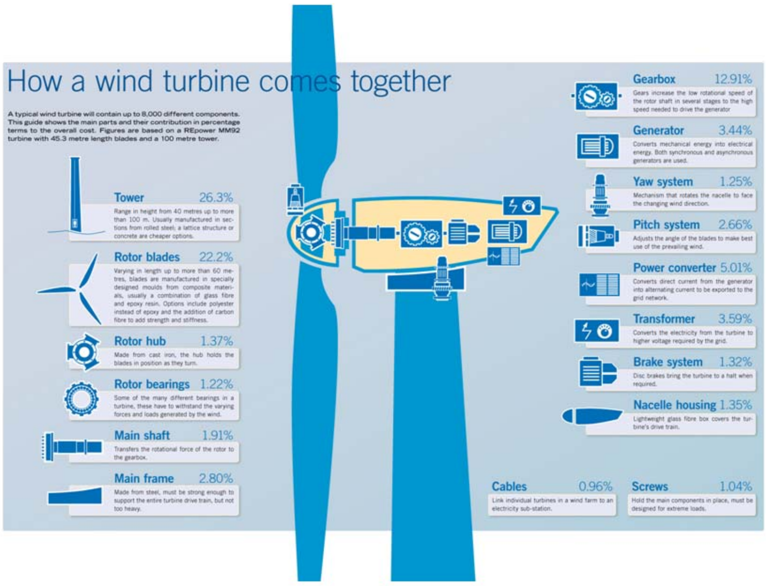




Flap: Piezoelectric actuators ("smart material"), moving

trailing edge flap

Cost break down



DTU

RISØ

Tower design

The Beatrice wind farm consisting of two 5 MW wind turbines
in 42 m deep water.
Source www.beatricewind.co.uk

DTU

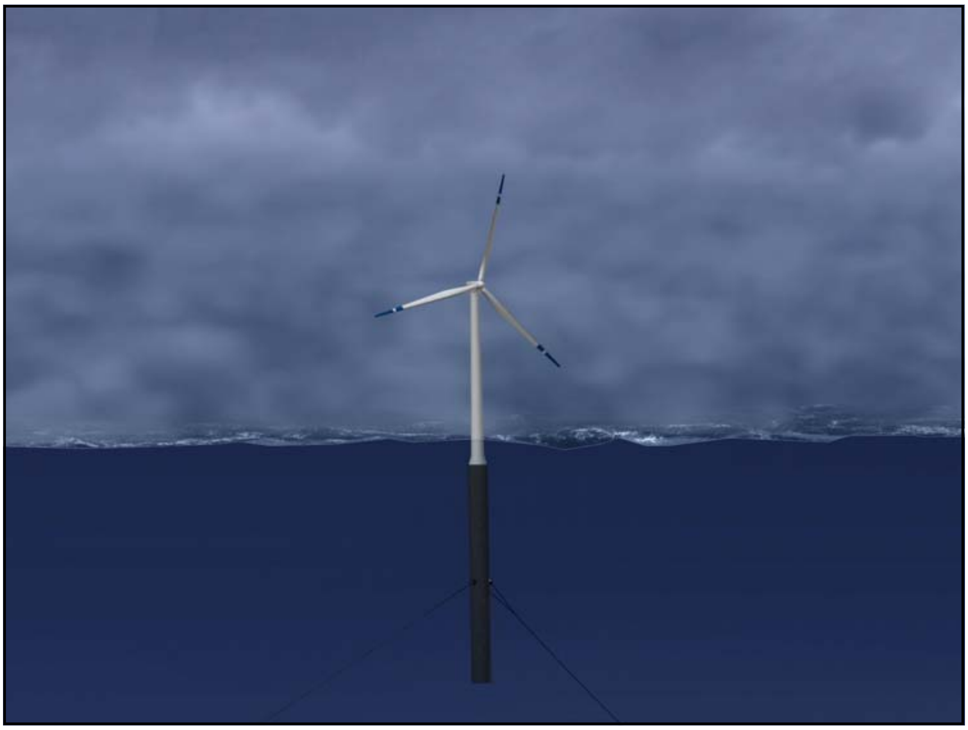
RISØ

New materials

- New fibres (materials) for blades and towers (to supplement steel)
- Wind powered carbon fibre blades production (carbon segregation)

UHMW-PE - Ultra-high molecular weight polyethylene fibres (Dyneema)

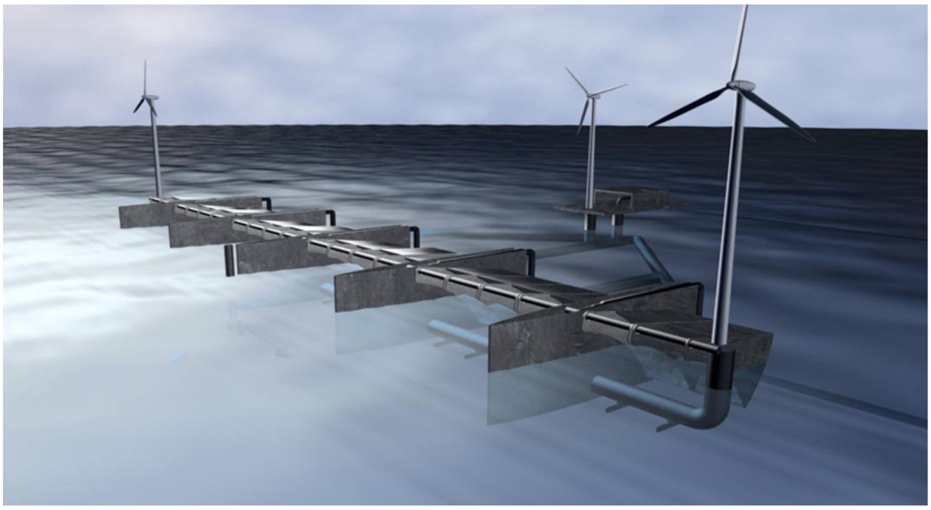
- These fibres have a tensile strength 20 times greater than that of steel. Their free breaking length is around 330 km (steel breaks at 25, glass at 135, carbon at 195 and aramid at 235).
  E-modulus 0.1-0.2 GPa; Tensile strength: 20-40 MPa.



DTU

RISØ

Combined floating wind- and wave energy converter



UMassAmherst

Wind Energy Activities at the University of Massachusetts

December 7, 2007

James F. Manwell, Professor and Director

Renewable Energy Research Laboratory
Mechanical & Industrial Engineering
College of Engineering

UMassAmherst

Wind Energy at UMass

- Begun in 1972 with an NSF award leading to the foundation of the Renewable Energy Research laboratory (RERL)
  - RERL was created to promote research and education in renewable energy
  - Have worked with solar, ocean thermal, small hydro, energy storage
- RERL wind energy focus:
  - Research on wind resource assessment, turbine dynamics, hybrid power systems, grid integration, offshore wind energy
  - Pre-development support for residential, farm, community, municipal, and commercial projects in New England

UMassAmherst

Personnel

- Two main faculty
- Four involved faculty
  - CFD, controls, materials, condition monitoring
- Six staff
- ~Ten graduate students
- Supported by Commonwealth of Massachusetts, industry, and DOE/NREL

Mechanical & Industrial Engineering 3

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Recent Wind Energy Activity Areas

- Hybrid power systems
- Wind electrical systems
- Wind resource
- Offshore wind energy
- Education
- State and community support
- Wind turbine blade test facility
- International Cooperation

Mechanical & Industrial Engineering 4

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Hybrid Power Systems

- Long history
  - IEA Annex VIII "Wind/diesel systems"
  - Hardware and software modeling (Hybrid3)
  - Battery performance modeling (Kinetic Battery Model)
    - Recently with European "battery benchmarking" project
- Most recently:
  - Development of "plug and play" concept for hybrid power systems
- **Future**:
  - Apply experience from smaller, high penetration networks to larger networks
  - Revive hybrid power system development for remote applications and developing countries

Mechanical & Industrial Engineering 5

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Wind Electrical Systems Investigations

- Resonant link converter developed
  - Successfully applied to stall regulated turbine with induction generator for variable speed →
- Turbine installation/operation in difficult terrain →
- High penetration system opportunities:
  - Hydrogen for transportation
  - Pure water via sea water desalination
- Integration study for community scale (13.8 kV) offshore wind project

- **Future**: Apply lessons learned and continue R&D to facilitate eventual commercial viability of such concepts, including:

•Demand side management, fuel production, product storage

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Wind Resource

- Long history with conventional anemometry
- Recently:
  - SODAR
  - LIDAR
  - Tall tower measurements (wind, temperature)
    - LIDAR comparison
  - Measure-correlate-predict algorithms
  - Application of uncertainty analysis
- **Future**: continue to refine and apply remote sensing techniques, especially for turbulence, forecasting, and control

Mechanical & Industrial Engineering 7

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SODAR

- Investigation of applicability and resolution of numerous issues

- **Future**: comparisons with other remote sensing options

Mechanical & Industrial Engineering 8

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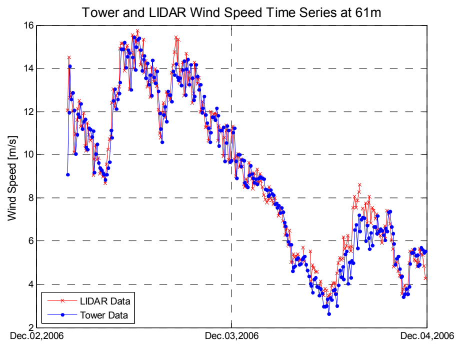
Tall Tower/LIDAR comparisons



- **Future**: turbulent time scale studies
  - Other LIDAR topologies

Mechanical & Industrial Engineering 9

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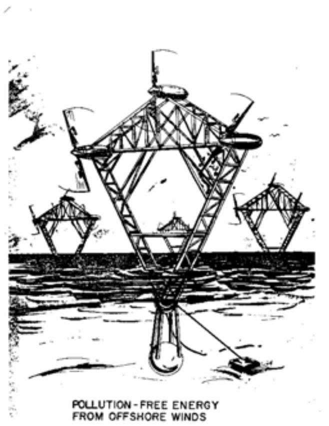
Offshore Wind

- Long history in early concepts
- More recently
  - Re-introduction of offshore wind concepts in the US
  - Assessment of external conditions (wind + waves)
  - Participation in IEC 61400-3
  - Hull (Massachusetts) offshore wind project
    - Feasibility, permitting, site investigations
- **Future**:
  - Collaborate with Cape Wind
  - Deeper waters



Heronemus, UMass, 1972

Mechanical & Industrial Engineering 10

Hull Offshore Pilot Project

- Project conceptualized in 2003
- Field studies and permitting presently underway

- **Future**: continue towards project operation
- Add significant R&D component
- Mesh with planned Offshore Wind Energy Collaborative

LIDAR for Offshore

- **Future**: many opportunities for LIDAR and other remote sensing devices

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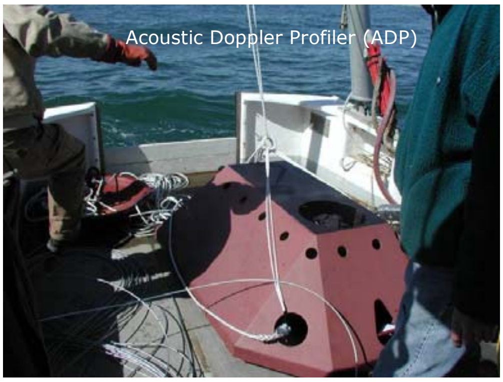
Wave Monitoring

- Acoustic Doppler Profiler for offshore wind site assessment



- **Future**: increased coordination with marine technology sector

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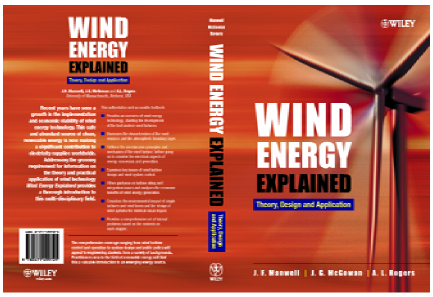
Education

- Wind energy courses offered regularly
  - Approx. 40 students/yr in first course
- Graduates through US wind industry
- Text book: Wind Energy Explained: Theory, Design and Application



- **Future**:
  - •Continuing updates of text book and courses
  - •More courses, e.g. offshore, special topics

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Observations Regarding Education

- Many highly qualified applicants
- Acceptances limited by availability of financial support
- **Future**:
  - Increased opportunities for more students
  - Coordination with European educational programs would be of interest

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Community Support: Hull Onshore

- 660 kW turbine, 2001
- 1.8 MW turbine, 2006

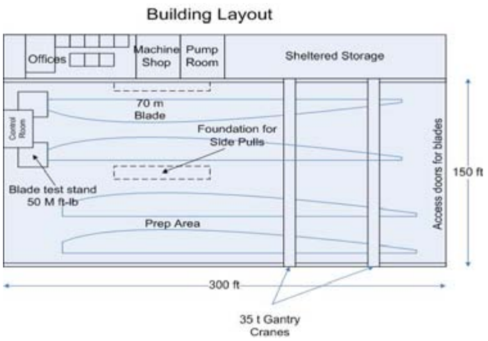

Hull Wind I, 660 kW, 2001


Hull Wind II, 1800 kW, 2006

- **Future**: Similar support for other communities
- Policy adaptations needed

Wind Turbine Blade Test Facility

- Massachusetts/NREL facility planned for testing large blades
- **Future**:
  - Scheduled to built in Charlestown (Boston), beginning in 2008
  - Mesh with offshore wind energy opportunities



Typical Blade Test Facility

International Activities

- International Electrotechnical Commission 61400-3 (Offshore Wind Standard)
- International Science Panel on Renewable Energy
  - R&D recommendations for range of renewable energy technologies; our focus is wind
- **Future**: continued and strengthened cooperation with Europe and Latin America

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TOPICAL EXPERT MEETING #55
ON
LONG TERM RESEARCH NEEDS – IN THE FRAME OF THE IEA WIND COOPERATIVE AGREEMENT

Prof. Dr. Jürgen Schmid

President of the European Academy of Wind Energy
“EAWE”

Member of German Advisory Council on Global Change
“WBGU”

Chairman of the Executive Board of the
Institute for Solar Energy Technology “ISET”

Professor and Dean at
Kassel University

Member of the European Research Cluster on Integration
of Renewable Energy Sources “IRED”

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EAWE - European Academy of Wind Energy

National nodes:

**ISET - Institut für Solare Energieversorgungstechnik e.V.
Germany**

**CRES - Centre for Renewable Energy Sources
Greece**

ECN - Energy Research Centre of the Netherlands

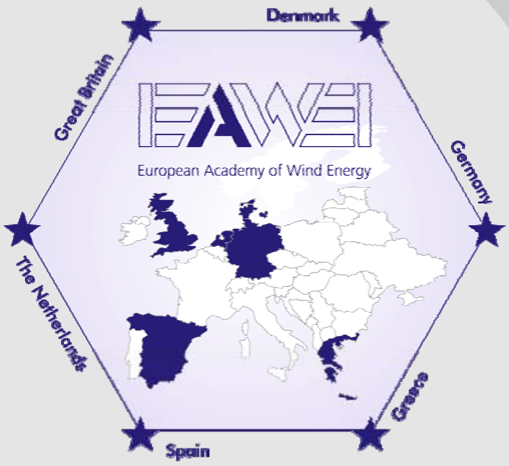
**Risø National Laboratory
Denmark**

CENER Spain

University of Strathclyde, UK

SINTEF, Norway

7 nodes, 29 members



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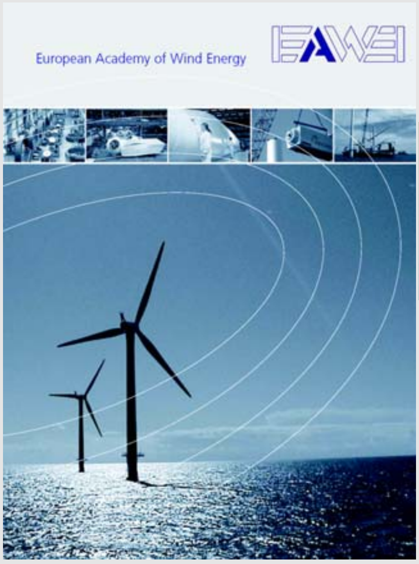

EAWE foundation 2003 in Delft

Key Data for Wind Energy Roadmap 2020

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	1990	1995	1998	2005	Target 2010	Target 2020
Power Provision and Energy Production						
Installed Capacity Onshore / MW	60	1140	2880	18.430	24.000	28.000
Installed Capacity Offshore / MW	0	0	0	0	1000	15.000
Mean Capacity per new installed WT / MW	170	480	790	1720	2000	4000
Technology						
Spec. Annual Energy Yield kWh/m²a (Reference Yield)	640	810	890	1250	1340	1400
Economics						
Generating Costs $€_{Ct}$ / kWh for Sites of medium Quality						
Without Export	13,3	9,5	8,7	8,4	8,0	7,3
Export Ratio: → +30% of Inland Turnover					7,9	7,2
→ +50% of Inland Turnover					7,8	7,1
→ +100% of Inland Turnover					7,7	6,9

The values for generating costs are inflation-adjusted. All prices are normalized (price level of 2005)

Main R&D focal points of EAWE

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University of Oldenburg, Institute of Physics, ForWind

- Assimilation of wind monitoring data for nowcasting and short-term wind and wind power forecasting
- Uncertainties of wind power forecasts using probabilistic methods
- Inter-annual variability of wind availability
- Frequency and predictability of extreme wind situations and the development of intelligent cut-off strategies (offshore)
- Wind power at sub-station level and at single wind farm level
- Meteorology based load forecasts
- Local und regional modelling of offshore wind ratios
- Vertical structure of atmospheric boundary layer offshore
- Interdependency of atmosphere and ocean
- Short-term dynamics of wind power plants and power output
- Power characteristics independent of locations
- Wind field modelling, wind gust statistics and forecasts
- Wind energy plants as dynamic systems
- dynamic stall and maximum loads
- Extreme events in terms of loads and output

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EAWE

Main R&D focal points of EAWE

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iea wind

Institute für Solare Energieversorgungstechnik, Kassel

- Short-term wind power forecasts
- Long-term wind power forecasts
- Wind power forecasts at sub-station level
- Concepts and tools for managing decentralised generators in electric grids
- Virtual power plants: Aggregation of wind farms and other decentralised and renewable generators
- Ancillary services of wind farms
- Load management
- Microgrids / decentralised energy supply for newly industrialising countries and developing nations
- External conditions, Energy meteorology
- Reliability and maintenance
- Cost-effectiveness and market developments
- Condition monitoring and fault prediction
- New control strategies for wind energy plants and wind farms
- Offshore wind energy use
- Scenarios for the planning of future power supply structures

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Main R&D focal points of EAWE

University of Stuttgart

- Material construction
- Load monitoring, control and operation
- Dynamics of offshore wind energy plants

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Main R&D focal points of EAWE

University of Hannover, ForWind

- Cost efficiency and reliability of large wind power plants
- Integrated draft and design tools for wind energy plants
- Integrated fault prediction systems for all structural components (tower and blades)
- Improved fatigue detection models for fibre compound blades
- Noise reduction measures during the erection and operation of offshore wind energy plants
- Development of novel bearing structures by using high-solid materials onshore and offshore
- Optimising production and installation workflows
- Prediction methods for offshore ground dynamics
- Prediction methods for scours
- Differentiated description off sea condition loads
- Fluid-structure interaction

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Main R&D focal points of EAWE

Otto-von-Guericke-University, Magdeburg

- Social integration
- Generic modelling of wind power plants
- Grid security management for decentralised energy power generation
- Optimal future grid planning
- New strategies for grid protection

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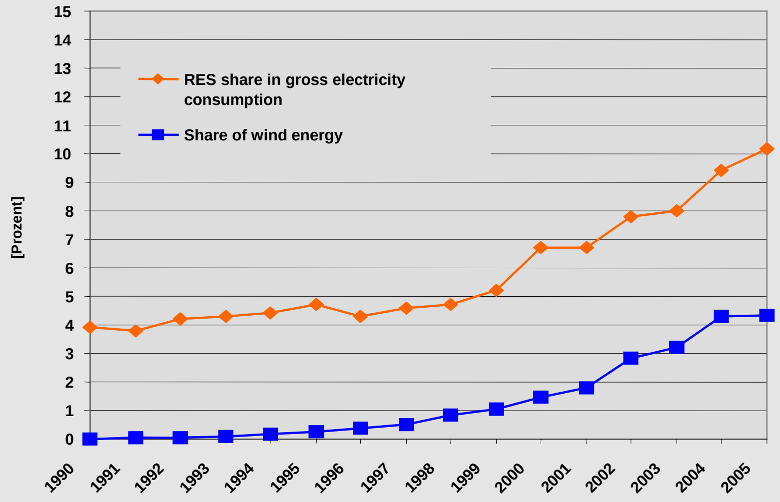
Share of wind energy in gross electricity consumption of Germany



Extended Operational Control

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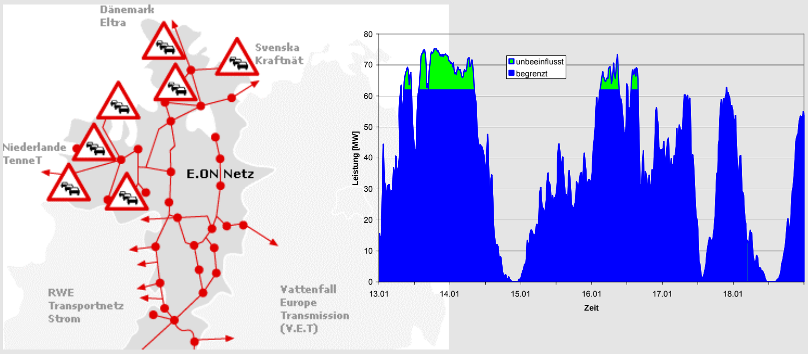

Wind generation management by E.ON Netz, VE-T, E.DIS, E.ON Avacon, ...
Improvement by use of sub-grid area forecasts

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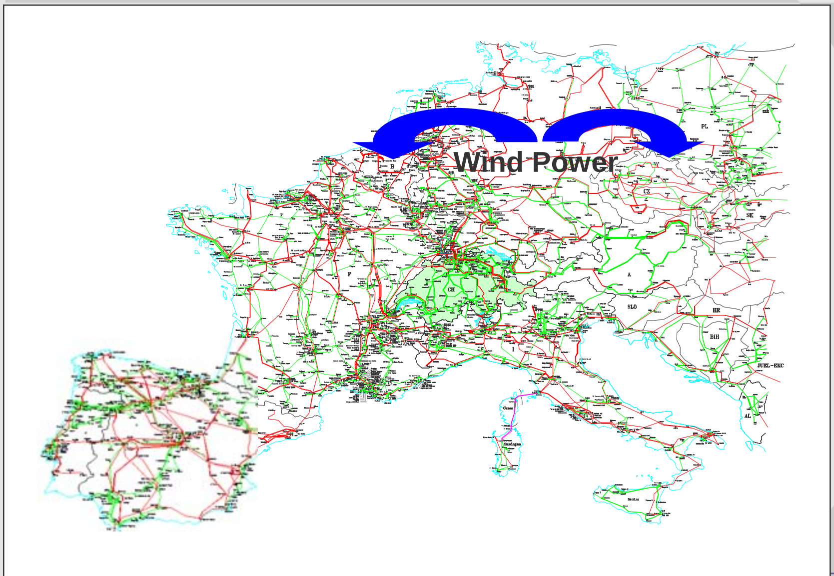

Upexpected power flow – 4.11.2006 ?

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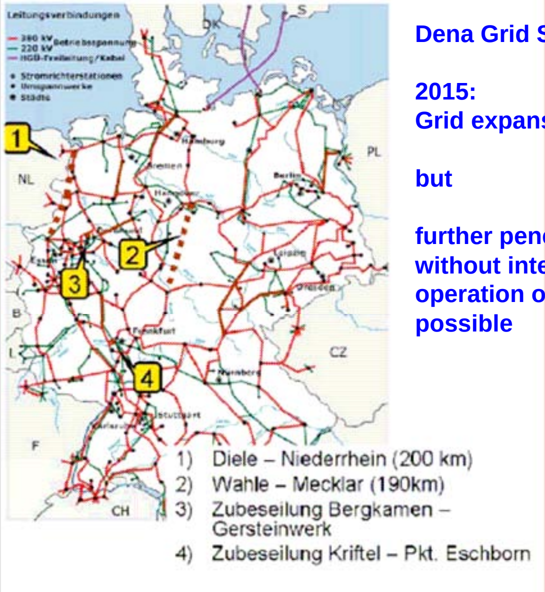

Dena Grid Study:

2015:
Grid expansion and reinforcement

but

further penetration without intervention in operation of RES/DG is not possible

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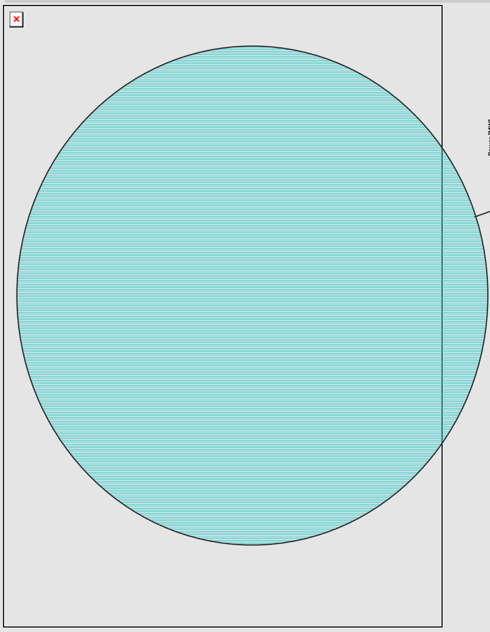
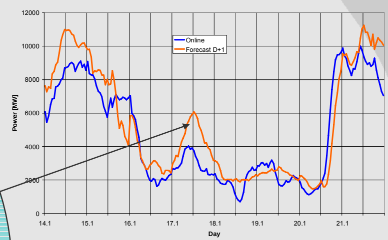
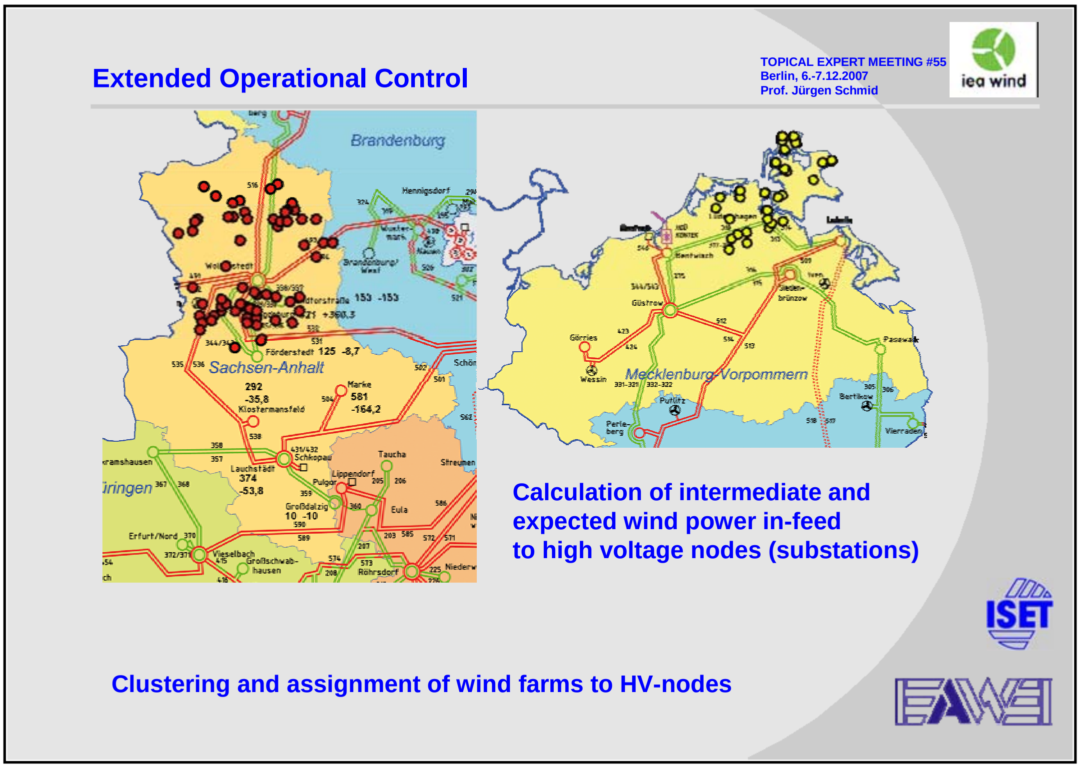




One value for one hour for the entire control zone !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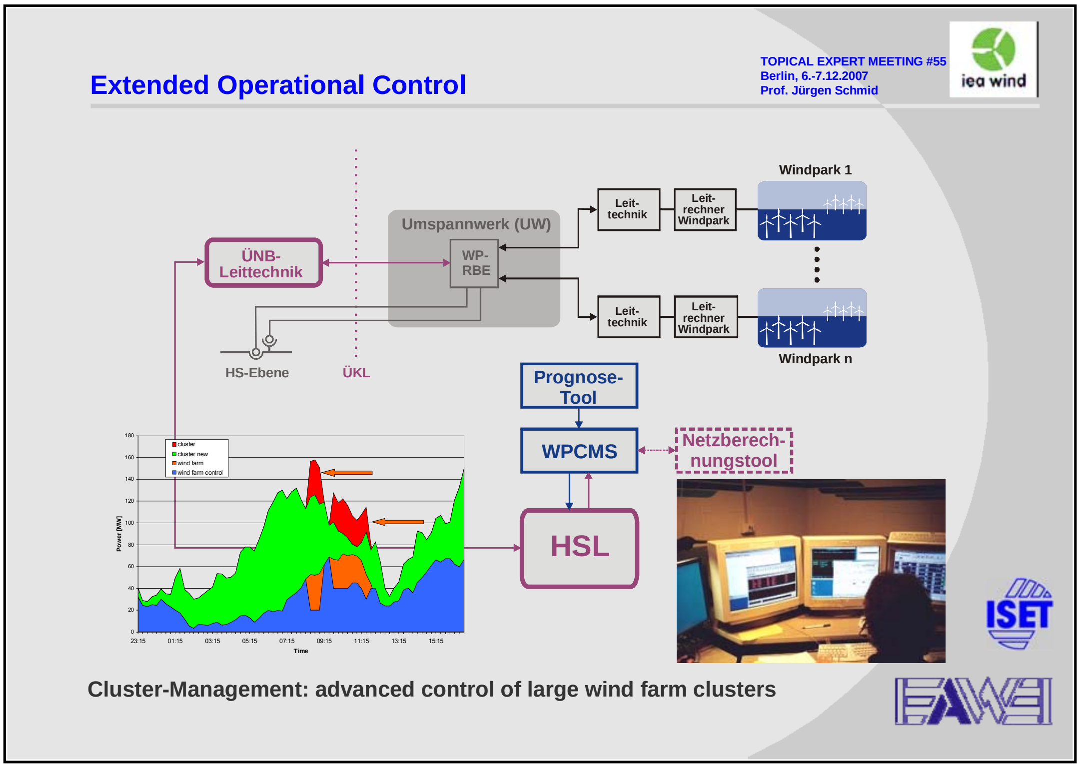
iea wind
Brandenburg
Sachsen-Anhalt
Mecklenburg-Vorpommern
Calculation of intermediate and
expected wind power in-feed
to high voltage nodes (substations)
ISET
Clustering and assignment of wind farms to HV-nodes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iea wind
Windpark 1
Leit-
technik
Leit-
rechner
Windpark
Umspannwerk (UW)
ÜNB-
Leittechnik
WP-
RBE
HS-Ebene
ÜKL
Windpark n
Prognose-
Tool
WPCMS
Netzberech-
nungstool
HSL
ISET
Cluster-Management: advanced control of large wind farm clusters

Extended Operational Control

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Wind Farm control strategies:

- Generation management
- Reduction of gradients
- Supply of reactive power
- Supply of balancing power
- Improvement of wind power feed-in scheduling

Advanced Control:

➔ Represent geographical distributed wind farms as one wind power plant for the system operators purposes

➔ Wind Farm Cluster Management

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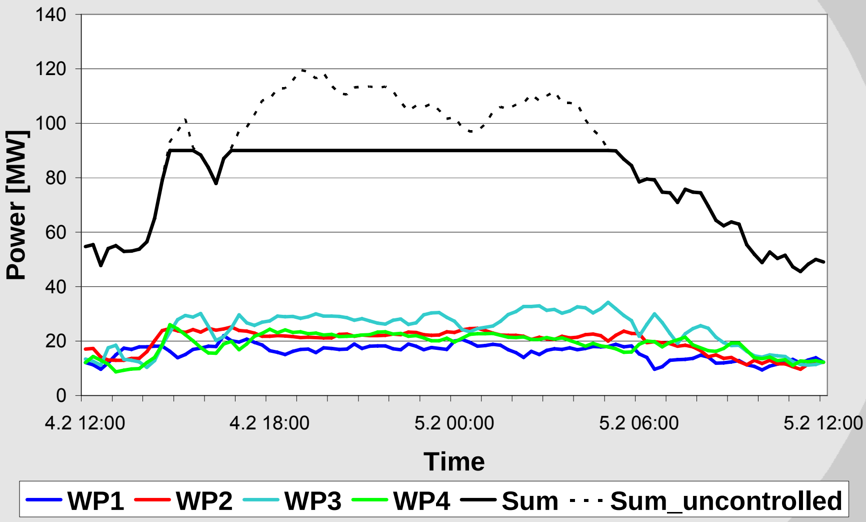

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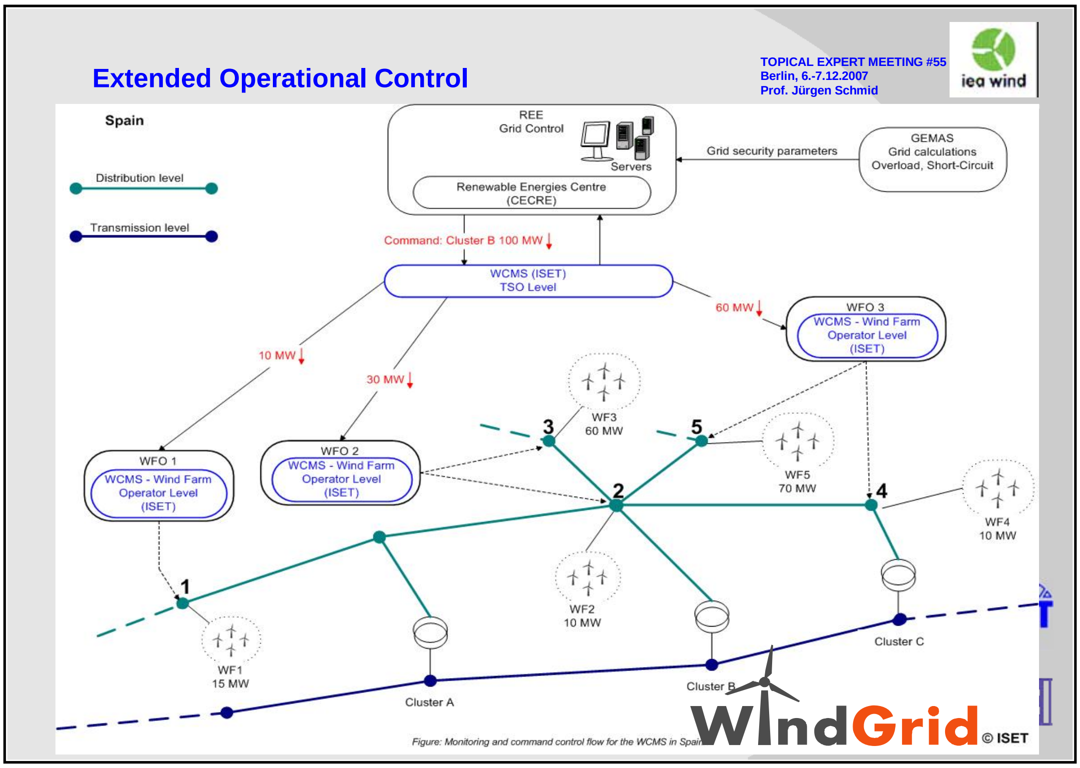
Avoid extreme situations by optimal coordination of wind farms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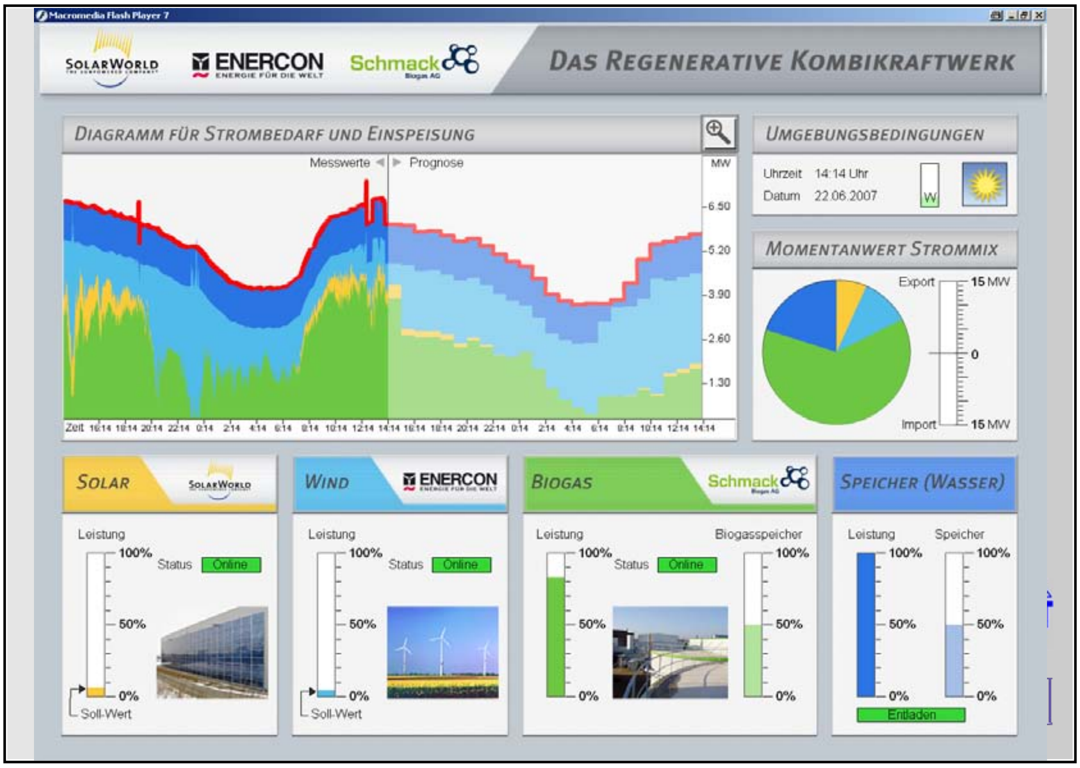
Spain
Distribution level
Transmission level
REE
Grid Control
Servers
Renewable Energies Centre
(CECRE)
Grid security parameters
GEMAS
Grid calculations
Overload, Short-Circuit
Command: Cluster B 100 MW
WCMS (ISET)
TSO Level
10 MW
30 MW
60 MW
WFO 3
WCMS - Wind Farm
Operator Level
(ISET)
WFO 1
WCMS - Wind Farm
Operator Level
(ISET)
WFO 2
WCMS - Wind Farm
Operator Level
(ISET)
WF3
60 MW
WF5
70 MW
WF4
10 MW
WF2
10 MW
WF1
15 MW
1
2
3
4
5
Cluster A
Cluster B
Cluster C
Figure: Monitoring and command control flow for the WCMS in Spain
WindGrid
© ISET


Macromedia Flash Player 7
SOLARWORLD
ENERCON
Schmack
Das Regenerative Kombikraftwerk
Diagramm für Strombedarf und Einspeisung
Messwerte
Prognose
MW
6.50
5.20
3.90
2.60
1.30
Zeit
Umgebungsbedingungen
Uhrzeit 14:14 Uhr
Datum 22.06.2007
Momentanwert Strommix
Export
15 MW
0
Import
15 MW
Solar
Wind
Biogas
Speicher (Wasser)
Leistung
Status
Online
100%
50%
0%
Soll-Wert
Biogasspeicher
Speicher
Entladen

Potential for Development of Power Costs

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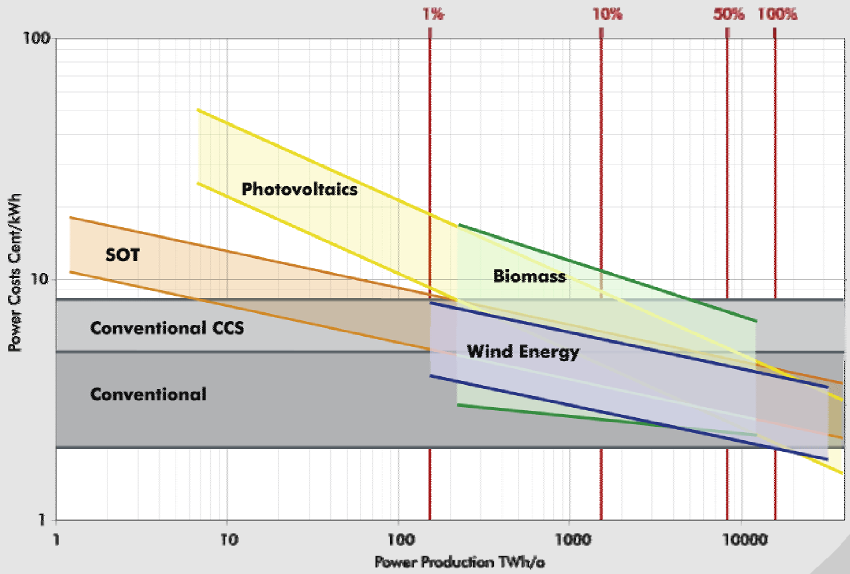

Scenario: Development Renewable Energies

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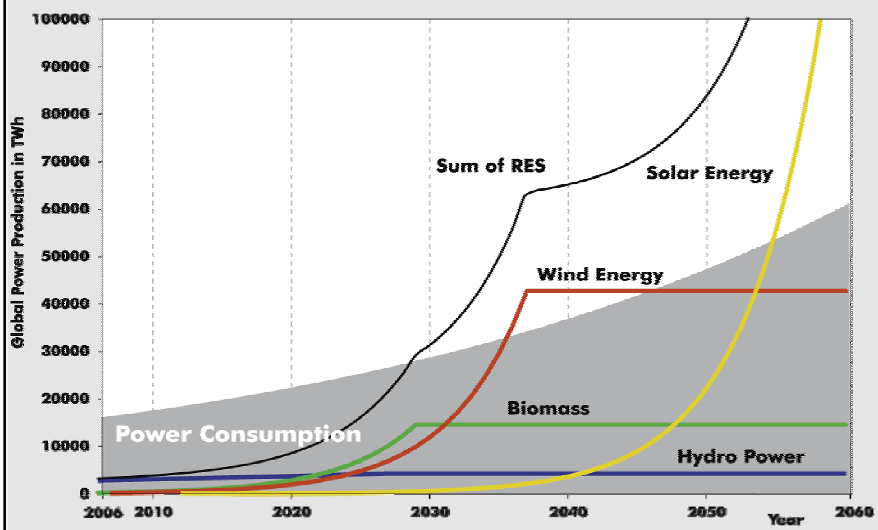

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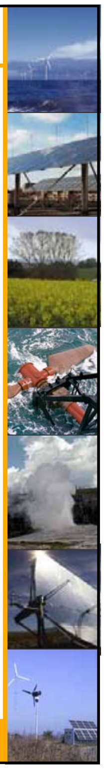
REnKnow.Net
Renewable Energies Knowledge - Transfer Network



REnKnow.Net
Renewable Energy Knowledge Transfer Network

Goals:

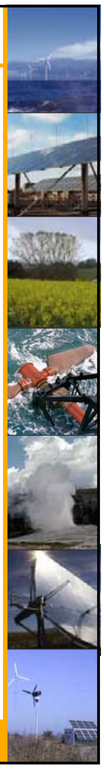
- to build up an internet platform containing a free of charge database for research and education in renewable energies
- to promote and enhance the active worldwide exchange of research and educational material among researcher, lecturers, students and others

Special features:

- its wide range of objects and items, compared to conventional media, e.g.
  * Educational material
  * University lectures and slides
  * Measurement and simulation data
  * Charts and figures
  * Multimedia objects (animations and videos)
- direct and free availability of the items and
- quality of material ensured through peer review process, carried out by a international network of experts

Peer reviewed research and education

REnKnow.Net
Renewable Energies Knowledge - Transfer Network



REnKnow.Net
Renewable Energy Knowledge Transfer Network

Technology Areas:

- Windenergy
- Photovoltaics
- Bioenergy

Peer Review Process:

- objects are certified by internationally recognized scientists and are then given a quality seal to certify a scientifically justified description
- Peer review committees are formed for each technology area

Peer Reviewed REnKnow.Net 2001

International Cooperation:

EAWE

FVS ForschungsVerbund Sonnenenergie

UpWind

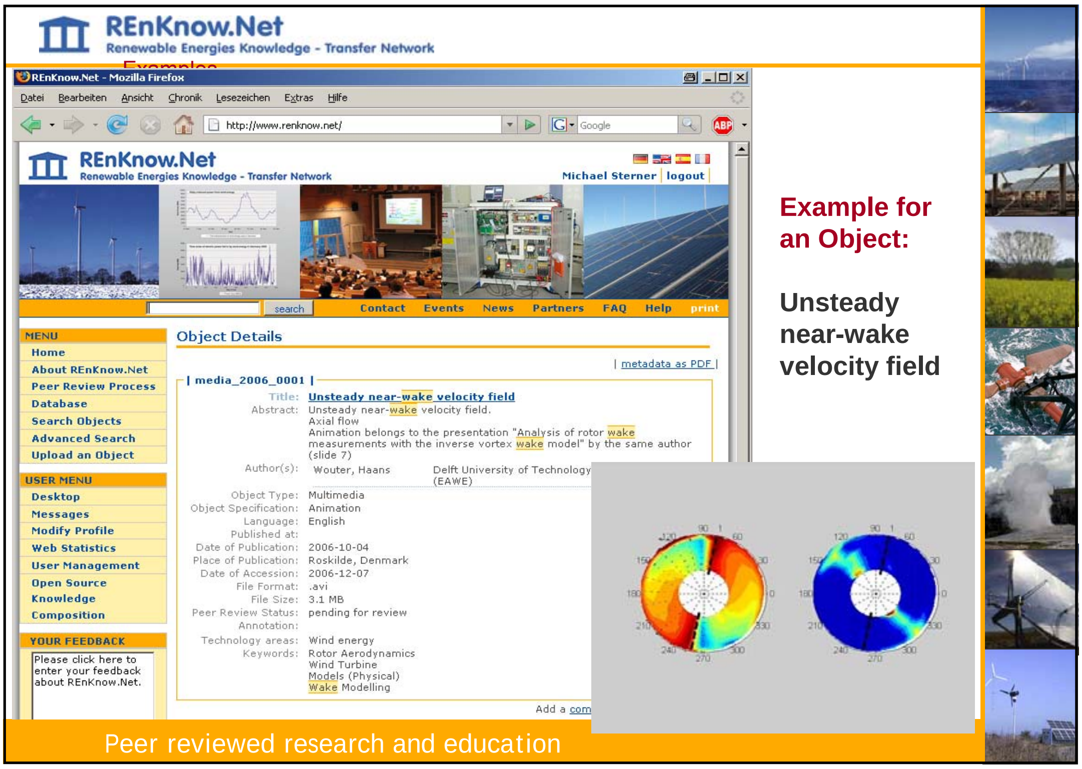
The Online Bookshop International Energy Agency

IEA

UniKasselTransfer Ost-West-Wissenschaftszentrum

China Wind Power Center

Peer reviewed research and education


REnKnow.Net
Renewable Energies Knowledge - Transfer Network
Example for an Object:
Unsteady near-wake velocity field
Object Details
| metadata as PDF |
| media_2006_0001 |
Title: Unsteady near-wake velocity field
Abstract: Unsteady near-wake velocity field.
Axial flow
Animation belongs to the presentation "Analysis of rotor wake measurements with the inverse vortex wake model" by the same author (slide 7)
Author(s): Wouter, Haans
Delft University of Technology (EAWE)
Object Type: Multimedia
Object Specification: Animation
Language: English
Published at:
Date of Publication: 2006-10-04
Place of Publication: Roskilde, Denmark
Date of Accession: 2006-12-07
File Format: .avi
File Size: 3.1 MB
Peer Review Status: pending for review
Annotation:
Technology areas: Wind energy
Keywords: Rotor Aerodynamics
Wind Turbine
Models (Physical)
Wake Modelling
MENU
Home
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Peer Review Process
Database
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Advanced Search
Upload an Object
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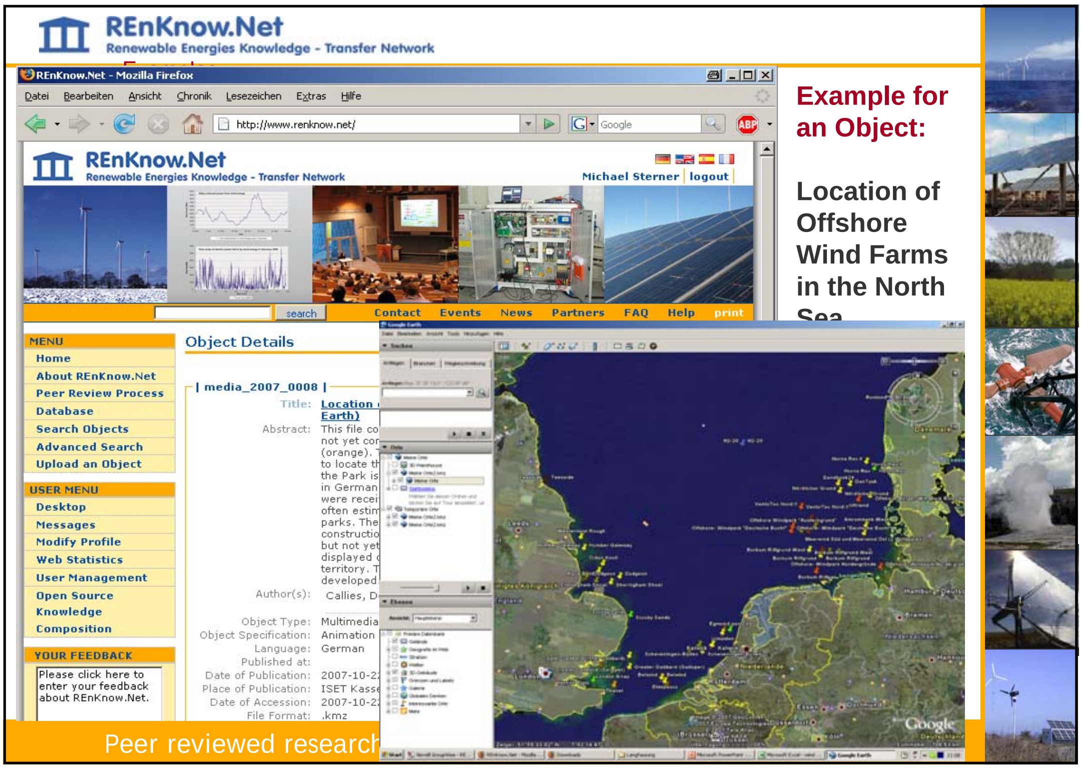
REnKnow.Net
Renewable Energies Knowledge - Transfer Network
Example for an Object:
Location of Offshore Wind Farms in the North Sea
Object Details
| media_2007_0008 |
Title: Location
Abstract: This file co
Author(s): Callies, D
Object Type: Multimedia
Object Specification: Animation
Language: German
Published at:
Date of Publication: 2007-10-2
Place of Publication: ISET Kass
Date of Accession: 2007-10-2
File Format: .kmz
MENU
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Peer reviewed research

Wind R&D in Vattenfall

IEA Meeting, 6-7th December 2007, Berlin

Klaus Udesen, Manager PTT-Wind Engineering

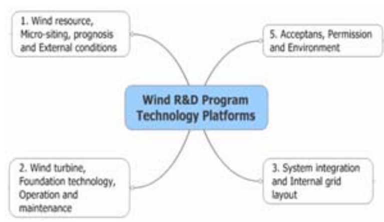
Ambitions for 2007 - 2011

1. Co-ordination of R&D activities in entire VF-group
2. Prioritization and start of new R&D projects
3. Close co-operation with BU's in R&D activities (ex. PY, VE-New Energy and IM)
4. 'Game Planning' process with BU's (Visions, Aims, Needs, Drivers & Performance)
5. Secure availability of competences for R&D
6. Introduce new R&D structure
7. To have such interesting business that we'll see you again ☺

How will it work…

Steering Committee
The Wind R&D Program has a Steering Committee with representatives from BU's involved or affected by wind power. This top level Steering Committee decides upon the overall targets and financing

Technology Platforms
The R&D Program is sub divided into Technology Platforms. Activities in the Technology Platform are organized by Reference Groups who prioritize R&D project proposals, receives results and secure the anchoring of projects in the Business units.



VATTENFALL

Challenges for the Wind R&D Program

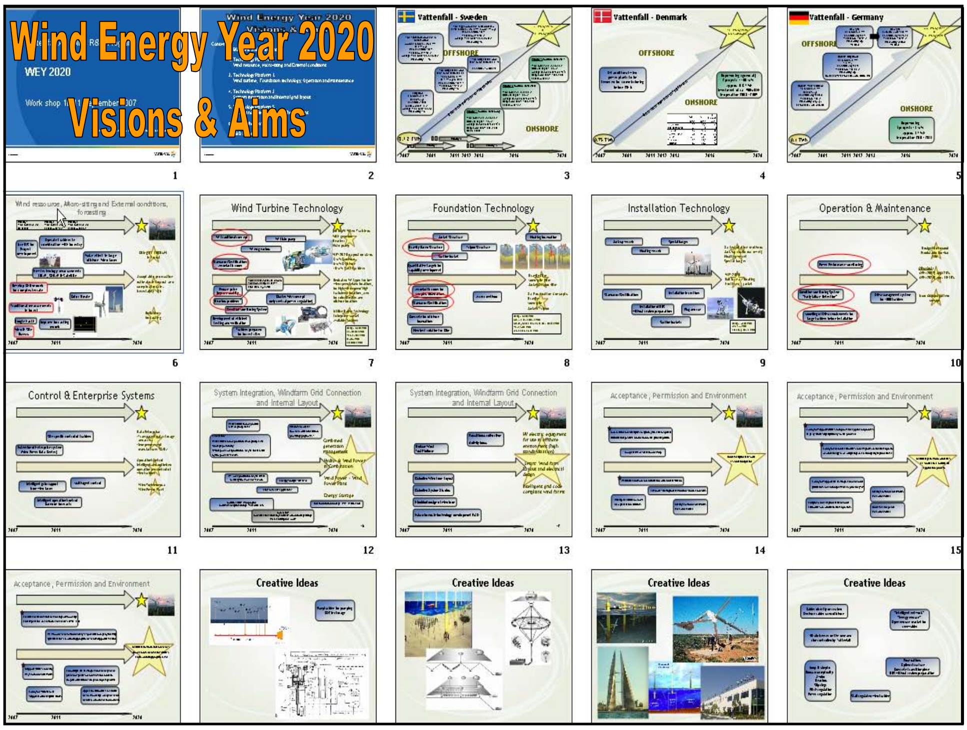
Paint the Picture

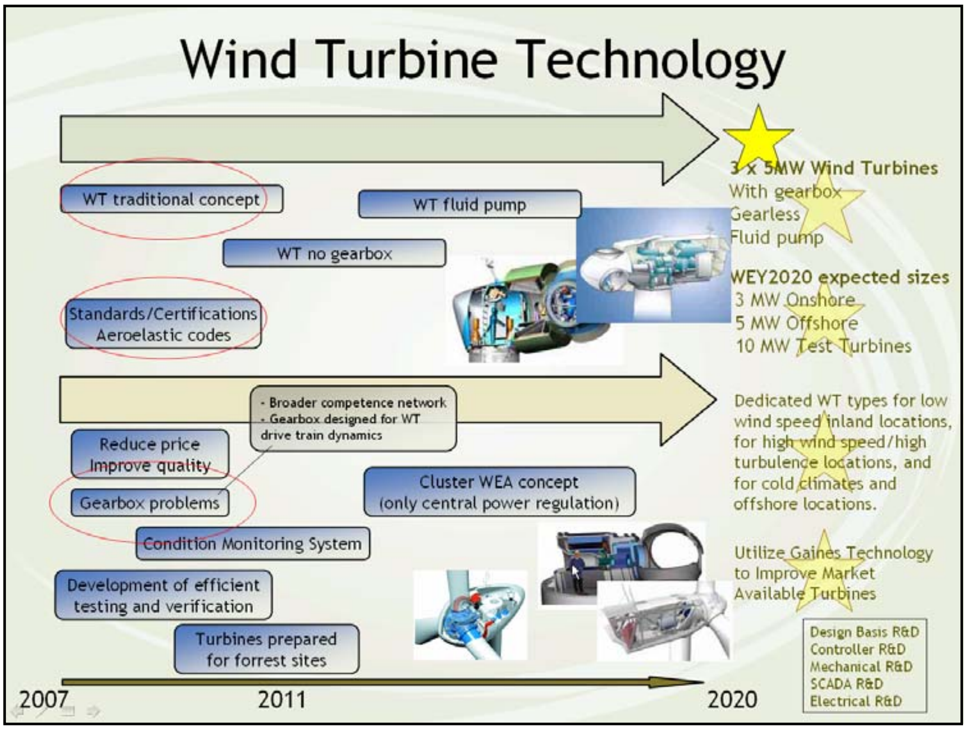
Come with solutions

Make Things Happen

"Which results for how much money, when and by who ?"

VATTENFALL


Wind Energy Year 2020
Visions & Aims
WEY 2020
Vattenfall - Sweden
OFFSHORE
ONSHORE
Vattenfall - Denmark
OFFSHORE
ONSHORE
Vattenfall - Germany
OFFSHORE
ONSHORE
1
2
3
4
5
Wind Turbine Technology
Foundation Technology
Installation Technology
Operation & Maintenance
6
7
8
9
10
Control & Enterprise Systems
System Integration, Windfarm Grid Connection and Internal Layout
System Integration, Windfarm Grid Connection and Internal Layout
Acceptance, Permission and Environment
Acceptance, Permission and Environment
11
12
13
14
15
Acceptance, Permission and Environment
Creative Ideas
Creative Ideas
Creative Ideas
Creative Ideas


Wind Turbine Technology
WT traditional concept
WT fluid pump
WT no gearbox
Standards/Certifications
Aeroelastic codes
3 x 5MW Wind Turbines
With gearbox
Gearless
Fluid pump
WEY2020 expected sizes
3 MW Onshore
5 MW Offshore
10 MW Test Turbines
- Broader competence network
- Gearbox designed for WT drive train dynamics
Reduce price
Improve quality
Gearbox problems
Cluster WEA concept
(only central power regulation)
Condition Monitoring System
Development of efficient testing and verification
Turbines prepared for forrest sites
Dedicated WT types for low wind speed inland locations, for high wind speed/high turbulence locations, and for cold climates and offshore locations.
Utilize Gaines Technology to Improve Market Available Turbines
Design Basis R&D
Controller R&D
Mechanical R&D
SCADA R&D
Electrical R&D
2007
2011
2020

Drivers, Needs, Performance Work Shop

Drivers
Drivers refer to *external* trends or events, and their future development, that *could* impact Vattenfall's markets/business *over time*

Needs
Needs refer to *new or reinforced needs* of the market (customers/other stakeholders) that *may result* from the drivers possible development *over time*

Performance
Performance refer to descriptions of key attributes and performance levels *over time* that would be required in order meet the identified future market needs

Competencies (Technologies)
Competencies (technologies) refer to the capabilities that are required *over time* to deliver the required performance

Projects
Projects refer to required projects that should be performed if the identified technological capabilities are to be achieved *over time*

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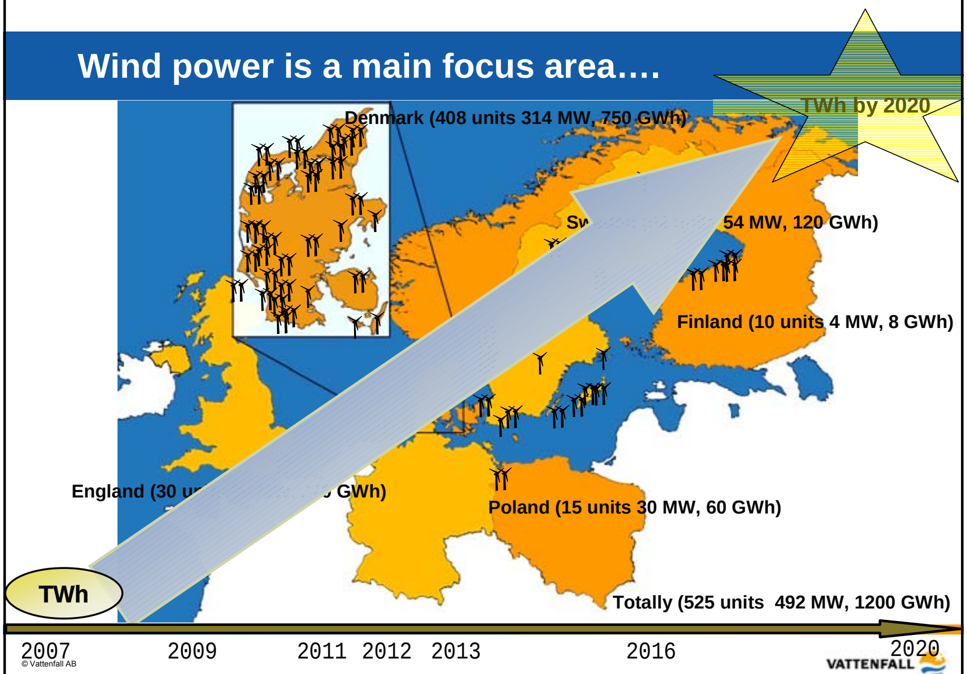
Wind power is a main focus area….



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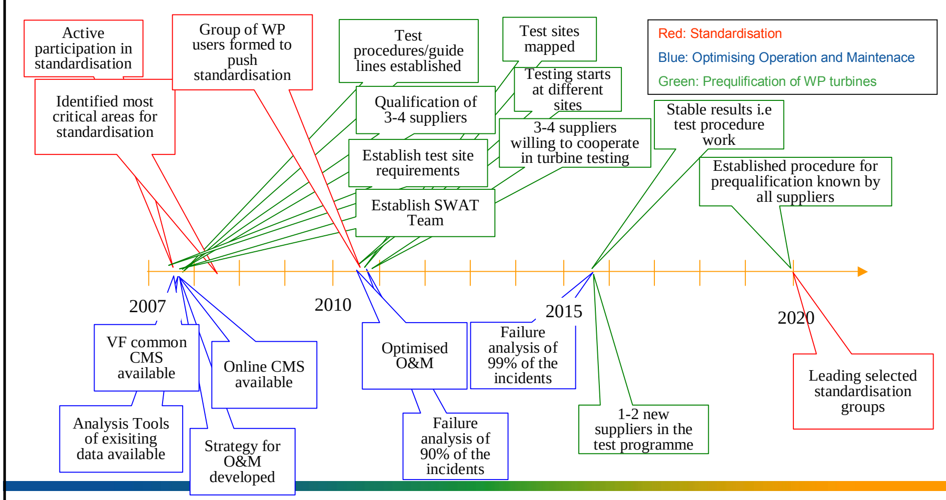
Driving Forces

- “Sellers market” for wind turbines
- Design Life *does not* meet Predictable Service Life
- Complex siting
- O&M cost level high ~ 25%
- 1000’s of turbines to manage
- Wind Turbines as ‘Wind Power Plants’
- Integration in grid and production portfolio
- High expectations - wind as the prime ‘Renewable’

VATTENFALL

How do we respond to the needs ?



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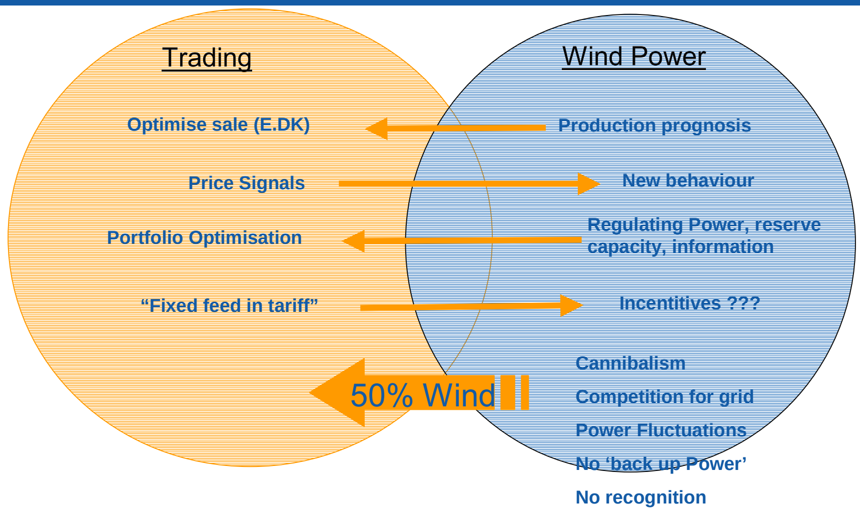
R&D - Common ground and interfaces



VATTENFALL

Thank you for your attention!

VATTENFALL

International Energy Agency (IEA)
RD&D Wind, Task 11

Topical Expert Meeting
on Long Term Research Needs

Research needs in wind energy industry

❑ Vision

- Wind energy is nearly endless available, non-polluting, without any need of import, without any political risks and economically reasonable.
- Due to decreasing resources for conventional energy and for this increasing prices in the mid-term wind has the potential to be the 'cheapmaker' in the future energy mix. Therefore enlarged R&D is needed.
- Overcoming the problems of fluctuations in the power output in the long-term wind will play an absolutely main role in the total future energy supply.

❑ Expectations

- Networking / charing experience on common challenges:
  - Standards, codes and guide lines (grid, H&S, O&M documentation, fire protection..)
  - Offshore (infrastructure, power transmission, access systems,..)

iea wind

REpower Systems

Research needs in wind energy industry

❑ Expectations (2)

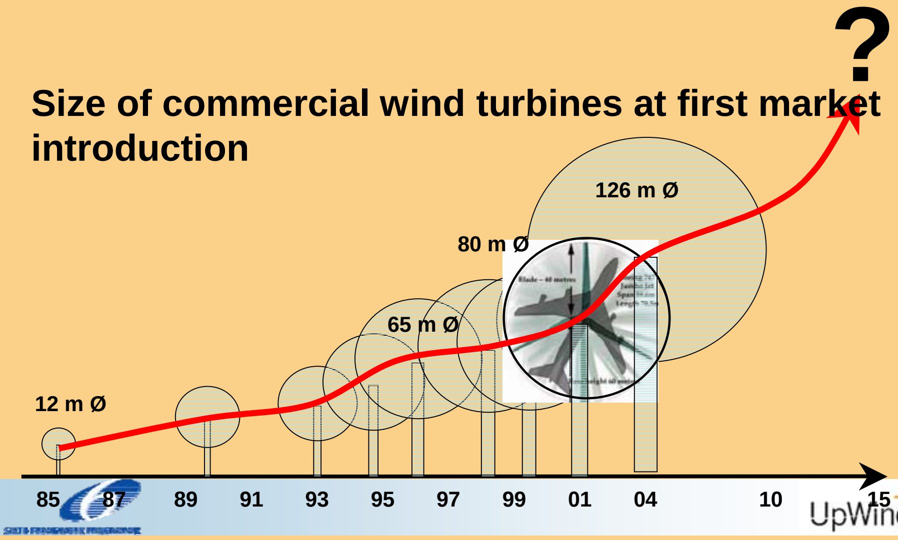
- Definition of future R&D programs:
  - Evaluation of material properties, new materials (Blades, CCV, large components,..)
  - Testing facilities and methods (Large-scale drive trains, bearings, flanges/bolts,..)
  - Integrated design tools
  - Load prediction (short term loads, exceptional events, wind farm managements,..)
  - Sensors (gusts, loads, icing,..)
  - New systems, concepts
- Collaboration with complementary technology for increased growth of wind energy:
  - Power transmission
  - Grid interfacing
  - Virtual power station
  - Energy storage

UpWind

Program Manager
Peter Hjuler Jensen
RISØ National Laboratory
Technical University of Denmark

UpWind

Size of commercial wind turbines at first market introduction



UpWind

UpWind Background

- ***UpWind: FP6 Integrated project***
- UpWind got Wind Energy back in the EU 6 Framework Energy Research program
- ***Result of AOT.'s EWEA Thematic Network(EU-project):***
  1. EWEA Research Strategy
  2. UpWind
  3. EWEA Strategic Research Agenda
  4. Technology Platform
- **Behind UpWind application were EAWE, EWEA and the partners (December 08 2004)**
- **Last minute saving of Wind Research Network in EU**
- **UpWind the glue/network and Lighthouse for EU R&D**

UpWind

The UpWind Project

UpWind subtitle: Integrated Wind Turbine Design

- Start date: 1 March 2006
- Duration: 60 months
- Costs: 22,340,000 EUR
- EC funding: 14,288,000 EUR
- Coordinator Risø National Laboratory, Denmark's Technical University

UpWind

Participants from Start

39 participants

- •11 EU countries
- •10 research institutes
- •11 universities
- •7 turbine & component manufacturers
- •6 consultants & suppliers
- •2 wind farm developers
- •2 standardization bureaus
- •1 branch organisation

UpWind

Partner's first year

- ***39 partners in UpWind Consortium from start***
- Cener added (+1)
- Risø and DTU merged to DTU and RisøDTU (-1)
- Elsam sold to Dong Energy and Wattenfall (+1)
- INCO call added 3 new partners (+3):
  - ISM: Institute for Superhard Materials of the Nat. Academy of Science, Ukraine
  - IITB: Department of Civil Engineering of the Indian Inst. of Technology Bombay
  - CUMTB: China University of Mining and Technology Beijing
- **43 partners in UpWind Consortium May 2007**
- **Other potential partners: NREL USA**

UpWind

Objective - 1

Develop and verify substantially improved design models and verification methods for wind turbine components, industry needs for future design and manufacture of:

1 Very Large Wind Turbines
2 More Cost Efficient Wind Turbines
3 Offshore wind farms of several hundred MW

UpWind

Objective - 2

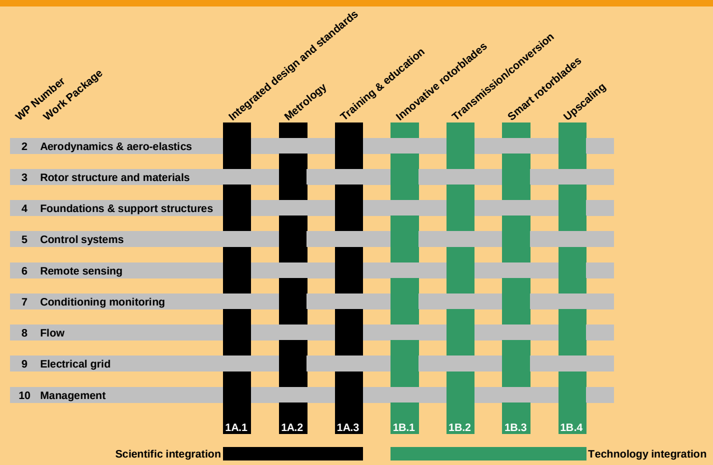
- Consortium **integrates the disciplines and sectors needed** for the entire development chain of wind turbine technology
- 8 Scientific Work Packages – work programme
- 7 Integration Work Packages – work programme

Upscaling

- Today: WT up to P = 5 MW and D = 120 m
- Future: WT upscaling: P = 10 MW and P = 20 MW
- Develop methods to overcome showstoppers/optimize

UpWind

Organisation
Classic and integrated research approach
Advanced Flexibel Modern Organisation



UpWind

Questions?

UpWind

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ECN

Identifying R&D key issues

Jos Beurskens,

ECN Wind Energy
Petten (NL)

IEA Wind Energy Programme
Topical Expert meeting 55 on R&D priorities.
Berlin, 6 -7 December 2007

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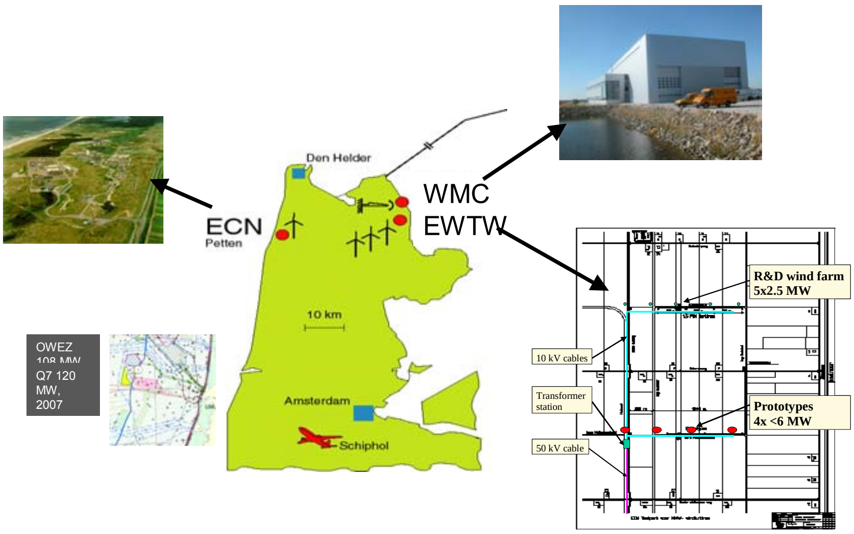

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Challenge of this meeting

- Avoid presenting the **standard list of R&D issues** for the n-th time (which does not mean that the 'standard' topics are not relevant at present).
- Identify **focal points** of R&D and **inter-relations** on the basis of recent developments and industry inputs (Industry is not sitting at this table. It does at TPWind)

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The 'standard list' of R&D issues

- Better understanding wind resources (complex terrain, offshore) power output prediction, better reliability of short term prediction)
- 4-th generation wind turbines (materials, CFD, new generator concepts)
- Better understanding external conditions offshore (wind/waves, sediment transport, icing, extreme winds, turbulence, moist/corrosive atmosphere)
- Grid integration
- Stand-alone and hybrid units
- Socio-environment
- Testing, standardisation, certification

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On the definition of long term research

To solve persistent problems with present technology fundamental research is needed to:
1. understand the problem,
2. resolve the problem.

To develop better technology ‘innovation oriented research’ is needed. This is what usually is meant by ‘long term’ research. However it produces innovations on both short and long term. (Stepping stones)

Which one is more important??

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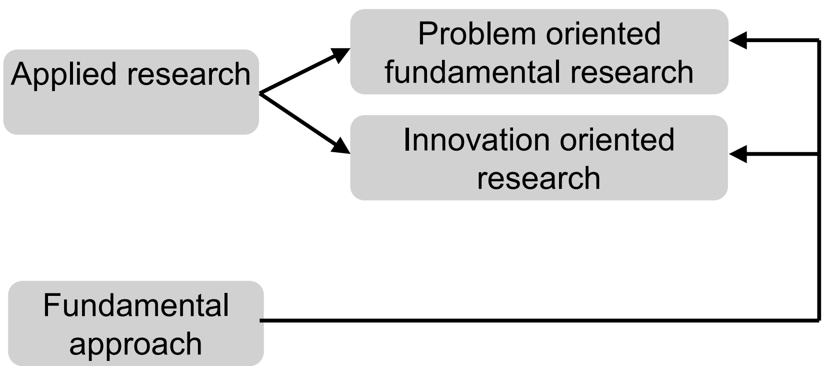
On the definition of long term research



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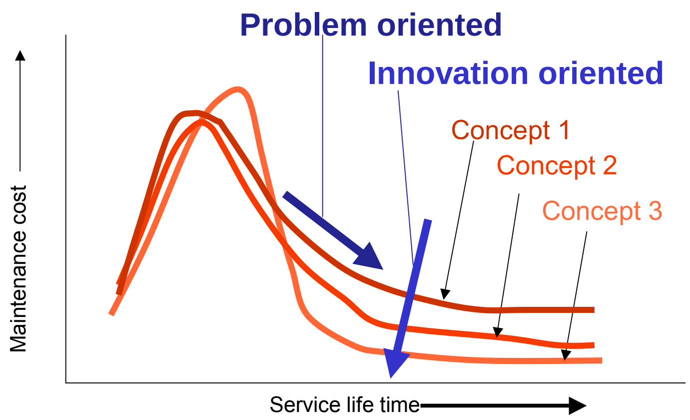
On the definition of long term research



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On the definition of long term research

It seems only symantics,
but
with consequences in practice!

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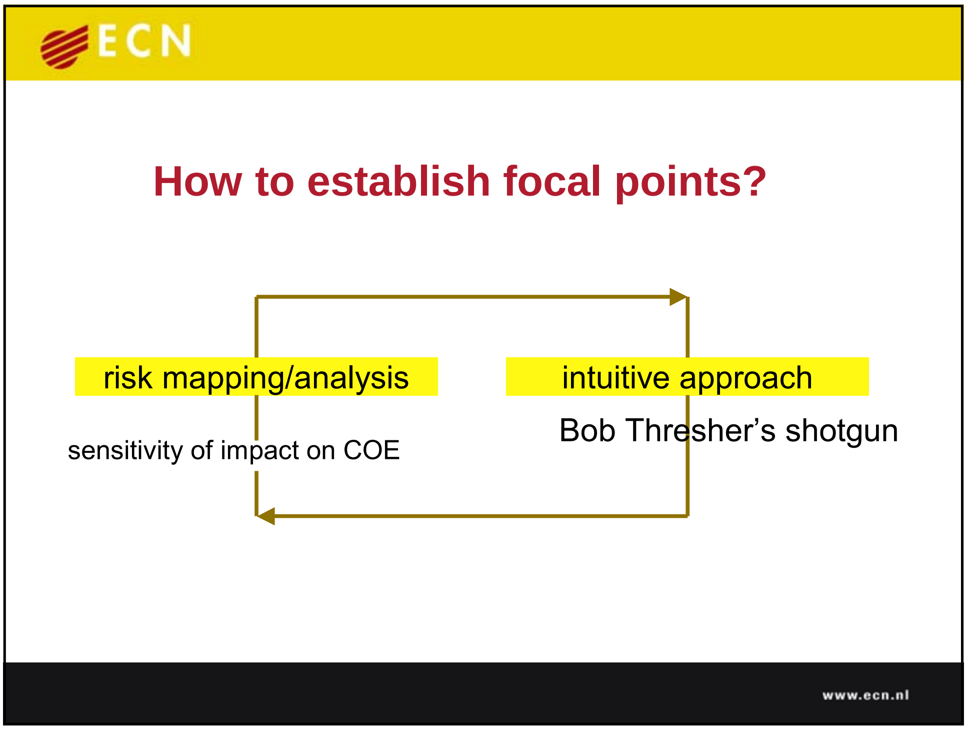
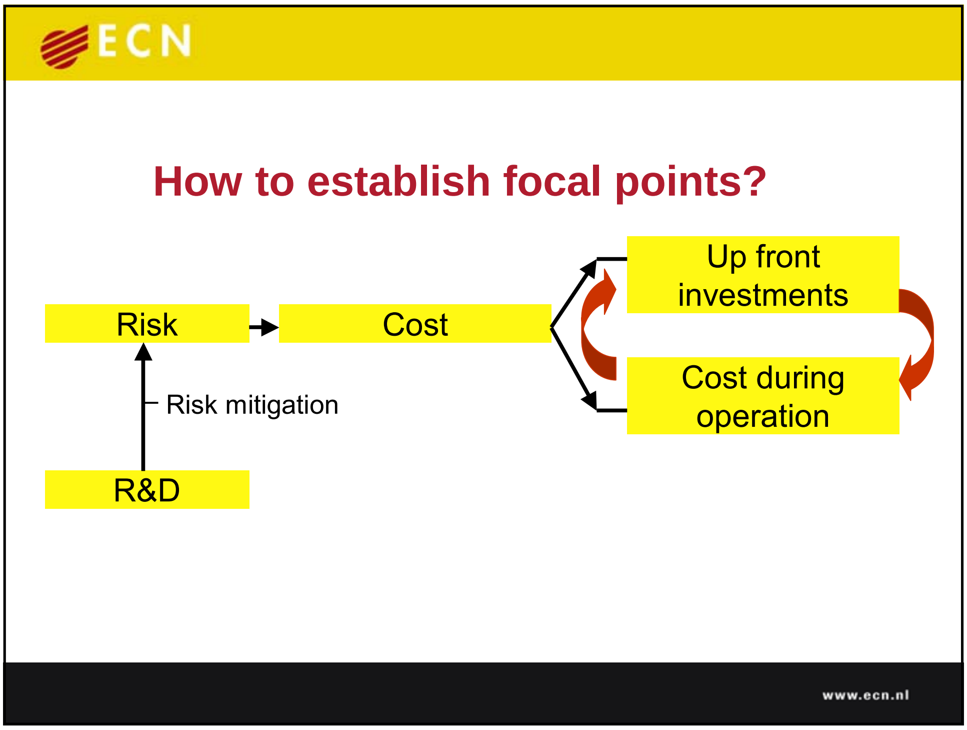

ECN
How to establish focal points?
risk mapping/analysis
intuitive approach
sensitivity of impact on COE
Bob Thresher's shotgun
www.ecn.nl


ECN
How to establish focal points?
Up front investments
Risk
Cost
Cost during operation
Risk mitigation
R&D
www.ecn.nl

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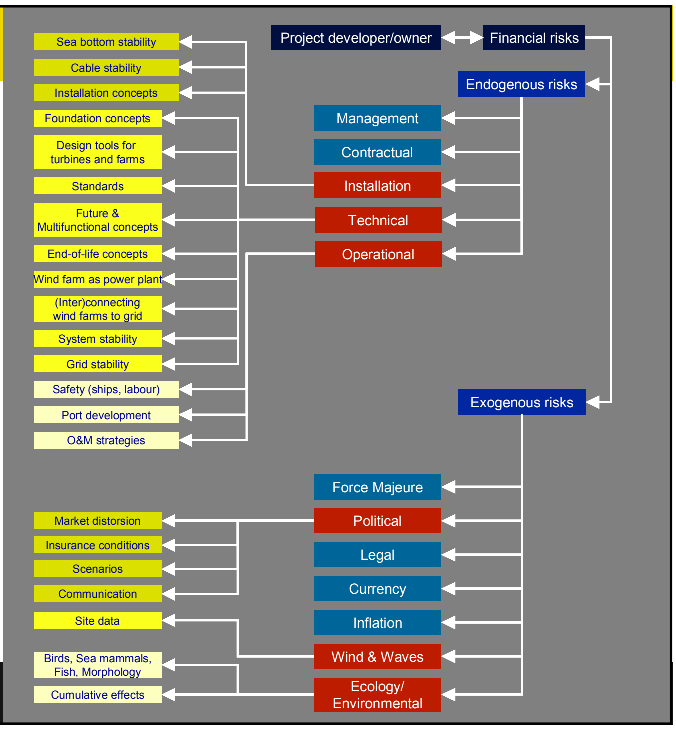
Risks
(example: We@Sea project)

Prioritising on the basis of Risk Analysis has never been done.



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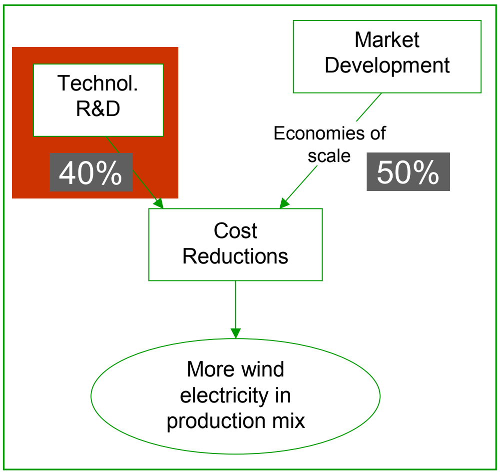
Learning



In 2001, the IEA estimated that +- 50% of cost reductions have been due to market development…and 40% to technology developments

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Intuitive approach; WT system level

- Wind turbine level
- System level
- Labs
- Brains

Note: offshore WE is the real R&D driver

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Wind turbine (1)

- Advanced rotors for large diameters; distributed control along rotor radius, LIDAR for wind field prediction close to rotor (e.g. UpWind)
- Availability = *f* (reliability, accessibility)
- O&M
- Commissioning
- Offshore: support structures, transport, assembly

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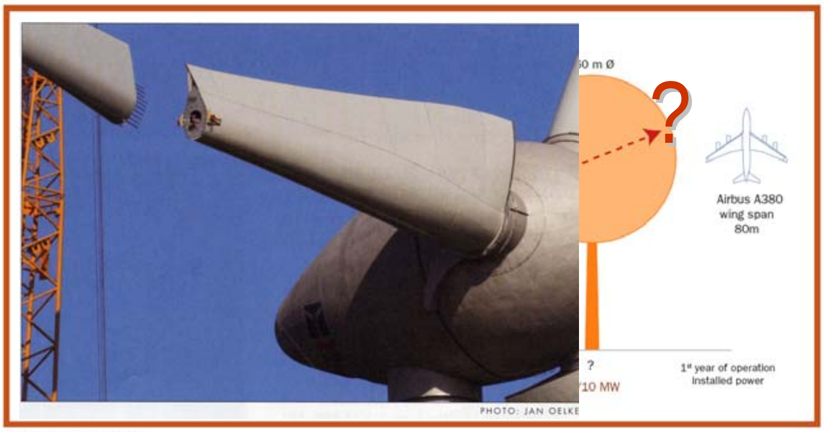
Wind turbine (2); up scaling (*)



(*) Up scaling is a method, not an objective!

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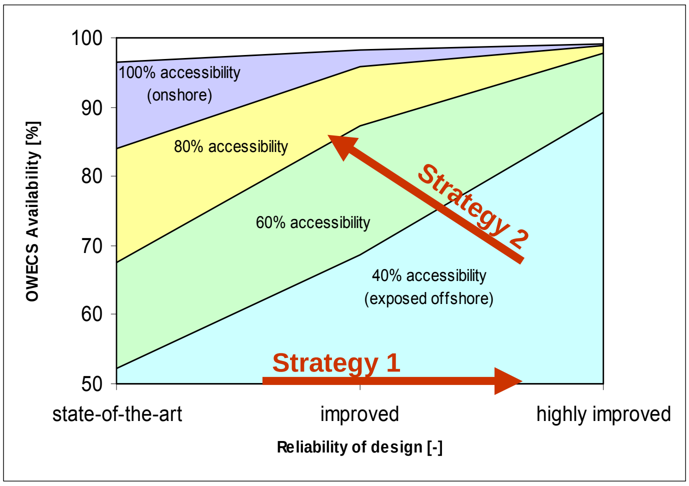
Wind turbine (3); availability



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Wind turbine (4); availability/access

Personnel & Spare Parts:
2 – 5 k€ / access
(80 – 120 k€ / day)

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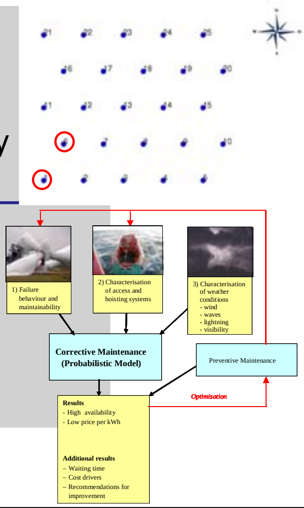
ECN

Wind turbine (5); availability/reliability

- Reliability design
- Analysis of outages > sensor technology
- Condition monitoring
- Flight leader concept (ECN/We@Sea)
- Cost estimator; planning & operational phase (ECN)



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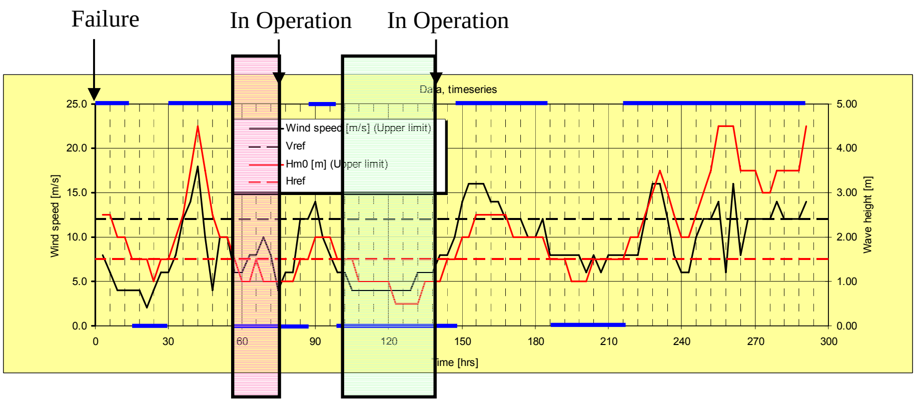
Wind turbine (6); O&M



Repair time for mission of 40 resp. 20 hr?

Hs = 1,5 m   Vw = 12 m/s

$T\_wait_{40\ uur} = 96$ hr

$T\_wait_{20\ uur} = 56$ hr

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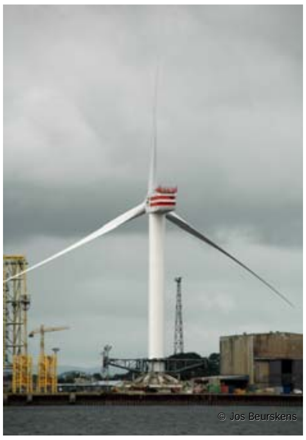
Wind turbine (7); commissioning



- Commissioning on the quay? >
- Transport as a complete top structure

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Wind turbine (8); commissioning

Commissioning methods, standards, certification (control system and sensors, safety systems, dimensions tolerance, electrical conversion system, measuring system, ……)

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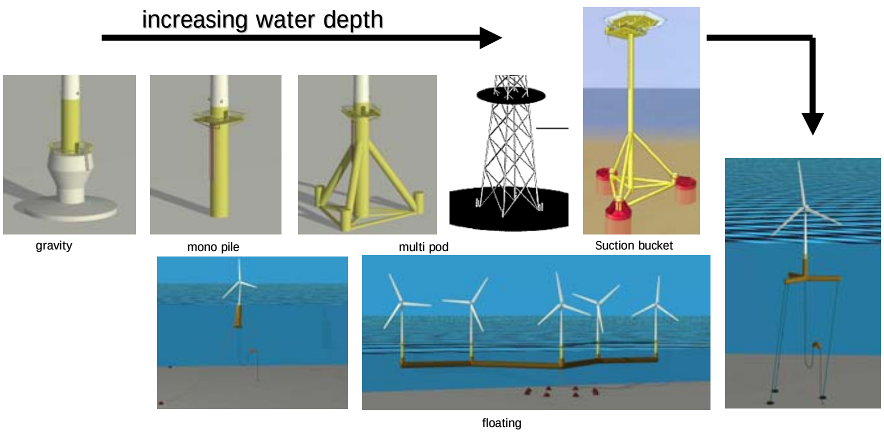
Wind turbine (9); support strucures; transport, assembly



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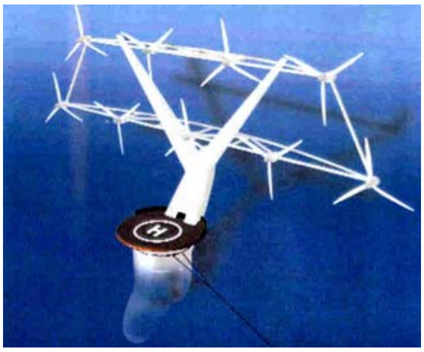
Wind turbine (10); support strucures; transport, assembly



Integration of Support structure and Transport

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Wind turbine (11); support strucures; transport, assembly

- Dediciated offshore wind turbine system transport and installation vessels:
- Market perspective needed
- Cost stability!

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Wind power system

- Wind farm lay out
- Interactions between wind farms (resource assessment, shadowing (financial compensation), spatial planning
- Integral design methods (UpWind)
- Integral design (w.t. & component manufacturers)
- Grid integration (macro scale)
- Grid connection; technology (installation of cables offshore, sub marine technology)
- Capacity factor <> output
- Material intensity
- Nature impacts

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Wind power system: large wind parks

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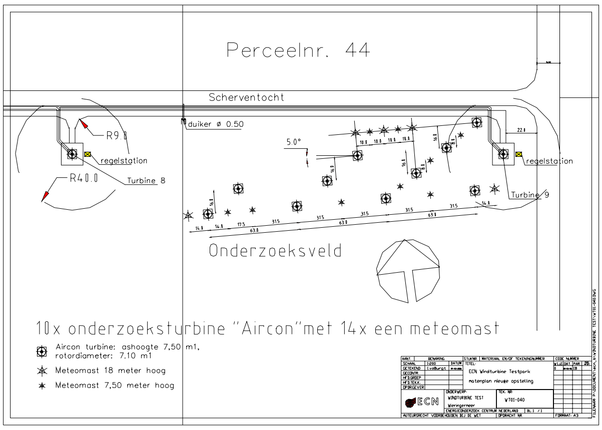
Wind power system: large wind parks

Scaled down park

- 11 Aircon-10 wind turbines
- 10 at fixed position, 1 mobile, variable hub height
- rotor diameter 7.60 m
- hub height 7.5 m
- rated power 10 kW
- variable speed, pitch control
- active yaw
- extensively instrumented



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ECN

Nature impacts; onshore & offshore

- Sediment transport
- Birds !
- Bats
- Marine mammals !
- (Shell) fish habitat (+/-)
- Safety (navigation) !
- Visual impact (near shore)

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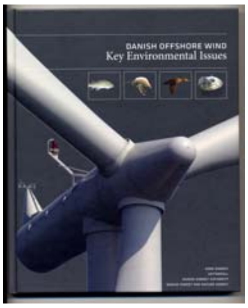
Nature impacts; birds



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Labs

- Test stations: need for more; onshore and offshore
- Blade testing: sufficient?
- Drive train testing !!!!
- Wind farms for verification control strategies!!!!
  Scaled down wind farm at ECN. Commercial farms ?
- Materials development
- Other technologies' labs: electronic industry/aerospace/…….
- Wind tunnels

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Brains

- Dramatic shortage of technical experts on all levels
- Systematic international standardised and exchangable education system needed
- Will be on EWEA's agenda soon, however:
- European approach too limited

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Issues for International co-operation (1)

- Many national and regional initiatives which are partly similar: sharing pre-competitive results ? (e.g. offshore programmes in DK, NL, UK, E, D)
- Establishment of large state-of-the-art R&D facilities: pooling?
- Serious shortage of experts in the technical domain: education and traing standards (similar approach to MEASNET?)
- R&D spending of WE sector low compared to similar industries. EU factor 10 too low: make a case also at IEA level

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Issues of International co-operation (3)

- Various initiatives to address issues. E.g.:
- TPWind
- European Academy for Wind Energy (EAWE) (Education)
- EWEA, AWEA, …..
- IEA

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Thank you !

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Summary of IEA RD&D Wind – 55th Topical Expert Meeting on

Long-Term Research Needs In the Frame of the IEA Wind Co-operative Agreement

December 2007, Berlin, Germany

Sara Hallert and Sven-Erik Thor

Aim and Objectives

The aim of the Topical Expert Meeting (TEM) was to discuss long-term research needs for the timeframe 2020. The objective of the meeting was to try to identify needed future results from R&D both in the 5 to 10 and the 10 to 20 years time frames. The strategic goal of the TEM is to give recommendations to the IEA Wind Executive Committee and to the governments involved which are based at the latest international wind technological stage. The outcome of the meeting will be used to develop a new strategic R&D plan for IEA Wind.

The objectives were also to review the latest wind energy technology and to draw conclusions for a further successful development to expand the place of wind energy in the worlds energy mix by means of R&D.

Participants / Presentations

A total of 35 persons registered for this meeting. They represented the following countries: Canada, Denmark, Germany, Italy, Korea, Norway, Portugal, Spain, Sweden, the Netherlands, the UK and the US. The participants mainly represented National Energy Administrations, Research Organizations and Universities.

The following presentations were given:

1. Introductory Note – Long-Term R&D Needs for Wind Energy
2. Evaluation of the German Renewable Energies Research Programme: Wind
3. Research Needs from a Swedish Perspective
4. R&D Needs for Large Scale Deployment a US Perspective
5. Some Key Points of the Wind Power R&D Programme in Denmark 2007
6. Wind Energy R&D in Canada
7. R&D Tasks in Norway
8. Identification of R&D Necessities in Spain
9. Netherlands LT R&D Needs
10. The UK - Offshore Wind Programm
11. Wind Power as a "base load" - R&D Needs
12. Wind Energy Activities at the University of Massachusetts
13. Long-Term R&D Needs for Wind Energy and ReKnow.net
14. Wind R&D in Vattenfall
15. Research Needs for Wind Industry
16. EP UpWind Project
17. Identifying R&D Key Issues

Summary of discussion

Below is a summary of the topics which were considered essential for the future development of the wind turbine technology and the utilization of the technology.

Turbine development

a) Use of new materials e.g. thermoplastics
b) Special offshore turbine design can be a solution for deceasing the prices
c) Design validation, current design standards are considered not to be enough in certain areas. E.g. loads and load transmission in drive trains at static and dynamic situations
d) Lighter structural design. This is not necessarily a design driver, but is a subordinate cost driver
e) Control strategies for load reduction, adapt turbines to anticipated loads in various situations
f) Optimization, smooth output as a generation unit, treat it as a power plant
g) New concept - rotors for larger diameters
h) Transition from manufacturing to automated serial production – cost reduction potential, economies of scale
i) Aerodynamics, wakes
j) Fast up scaling, ‘skip’ the first half of the blade, make it a ‘truss’
k) Combine passive built-in with multi-variable control
l) New drive train concepts

“Incremental development is important but new concept development must always be there”.

“Need to develop better technology innovative oriented research; it produces innovations on both short and long-term.” “Up scaling is a method not an objective. Developers and banks want reliable, cost effective turbines rather than JUST larger ones..”

Three levels of industrial technology development:

1) Incremental development focus on reliability
2) Change of component and subsystem concepts
3) Change of wind turbine concepts

Components

“System improvements are required to meet the necessary cost reduction, single component improvement is not enough.”

a) Adding intelligence to get smart rotors, drive train, flexibility and magnetic bearings
b) Development of new bearing structures
c) Generator - problem characterisation and transient behaviour
d) Better communication between components and grid

Tower development

“26% of the wind power cost derives from the tower, something must be done in this area”

a) Methods to decrease the share of steel in the construction is important. Wind power energy is a large steel consumer in Europe. Some manufacturers are preparing for concrete towers.
b) Everything that minimises loads on towers

Foundations

a) Mainly offshore, optimisation of traditional structure and develop new structures
b) Deeper water solutions - floating wind turbines

O&M

"Reliability is a key issue today." "Design life does not live up to production service life."

a) Component reliability, studies of rate and type of failures, life length on gear boxes approx 4-12 years.
b) Condition monitoring maintenance (a lot to learn from the oil and gas industry)
c) Availability = function of (reliability, accessibility) must be increased
d) Reliability of small turbines
e) Security of operation, ship safety
f) Reliable sensing devices (learn from other industries such as aircraft, gas and oil offshore), remote sensors with intelligent software

Logistics

a) A general improvement of logistics, i.e. optimisation of transport and installation
b) Clever and cheap transport, installation equipment and concepts dedicated for offshore
c) Access to offshore structures
d) Procedures if commissioning on quay, transport, assembly etc.

Grid system/integration - local grid (AC/DC) and national level

a) Impact and operation in power system with high wind penetration – system operation, balancing of the system when realising the ambiguous deployment plans
b) Improvement of energy production forecasting for system operation
c) Regulation of power
d) Better communication between components and grid
e) Security of supply

Wind field knowledge

a) Resource assessment and forecasting - develop forecasting tools with increased accuracy
b) Remote and satellite measuring systems
c) Offshore wind measurements needed – today very little data, important with measurements for the learning curve
d) Methods to mix new air in wake of turbines/farms
e) Knowledge of wind field in front of the turbine, for control

Deployment

a) Deployment in forest terrain – challenges: Wakes and turbulences, wind models do not comply with reality that is a problem from a financial perspective. Most of the available sites are in forestry landscape, sometimes in combination with low density of population and weak grid
b) Measurement programme is needed (see also Wind Field Knowledge)
c) Deployment in cold climate areas – challenges: Rime ice forecasting, predict when ice will occur, turbulence and snow covered blades

d) Deployment in deeper water

Financing/insurance

The warranties get shorter (from 5 to 2 years) with less content. This is not considered to be a R&D issue, but was mentioned as an observation.

Portfolio management

Control system for all the wind power plants in the portfolio.

Environmental impacts

Bird (especially eagles) and mammal behaviour have to be studied. Bats may be in the risk zone for damages if not treated properly.

Competence

Hard to find the right competences, better to educate "general engineers" in-house.

Competition on skilled people within the industry, important with education already at university level.

Knowledge transfer network.

International cooperation - establish a common state-of-the-art facility and pooling its R&D spending of wind energy?

New applications

a) Plug-in vehicles (benefits: Energy storage and transportation) - need for demonstration
b) Clean water
a) Hydrogen
b) Wind power plant in combination with hydro power station incl. pumped storage - need for demonstration
c) Combine wind and wave plant suitable for shallow water

Test facilities

"Need for test facilities for onshore and offshore wind energy"

a) Testing large blades, drive trains and new materials to verify models
b) Testing facilities and methods for cold climate are needed

Recycling

Recycling of materials is becoming more important when older turbines are exchanged to newer ones. The "cradle to cradle" concept has to be developed and implemented.

What's new compared to 2001

Operating agent Sven-Erik Thor made a comparison of the outcomes of today's meeting and of the meeting in 2001.

It was noted that there are new initiatives coming from other organisations that are looking into R&D needs. It is obvious that there are a number of new players in the R&D arena today. Examples of ongoing activities that aims at identifying R&D topics:

Structured initiatives for identifying R&D
- EU/EWEA TPWind
- REOLTEC
- MEGAWIND
- AWEA

Wind power with its application in a broader sense is now discussed. Examples are:
- wind – hydro – pump storage
- plug in hybrids

Education and Knowledge Transfer Networks are now considered to be a crucial topic for the industry and utilities. IEA Task 11 has an important role to play here. In some areas it is difficult to recruit persons with adequate knowledge within some technologies.

Reliability and Operation & Maintenance are becoming more and more important, especially when considering the number of failures that occurs in wind turbines.

Other challenges

Other challenges, (except direct research needs) that the wind industry is facing today, are:

1. Military issues involving radar and radio link issues
2. Commodities price increase; infrastructure is not in place to meet national goals
3. Offshore; cost is increasing instead of going down as expected in the 2001 long-term report
4. Compensation to fishermen; or is offshore wind a recreation area for fish (reef effects)
5. Legal aspects; protection of property offshore

Miscellaneous

It is important to keep track on other technologies and how they develop.

It was suggested that IEA IA Task 11 arranges expert meetings on how to collect statistics from turbines and radar conflicts, respectively.

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List of participants

IEA R&D Wind Task 11, Topical Expert Meeting
Long Term Research Needs – In the Frame of the IEA Wind Co-operative Agreement
Berlin, Germany
6-7 December 2007

The following persons have registered

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