

SEP 5 - 2006

GOLDEN, COLORADO 80401-3393



KUNGL
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Third
International Workshop on
Transmission Networks
for Offshore Wind Farms

Proceedings

Edited by Thomas Ackermann

April 11-12, 2002

Royal Institute of Technology

Electric Power Systems

Stockholm, Sweden



KUNGL. TEKNISKA HÖGSKOLAN

Royal Institute of Technology

Third International Workshop on Transmission Networks for Offshore Wind Farms

April 11 – 12, 2002

Royal Institute of Technology, Stockholm, Sweden

Final Program

(Version 1.4, 2002-04-2)

Wednesday 10 April 2002

18:00-20:00 Registration & Snack

Thursday 11 April 2002

8:00-9:00 Registration

9:00 - 9:15 Welcome and Introduction, Thomas Ackermann, KTH

9:15-10:30 Session 1: Projects and Experiences

9:15 - 10:15 Presentations:

- *Offshore Electrical System Experiences - or how to mix water and electricity safely;* by Hugh Yendole, Shell WindEnergy, UK;
- *The Swedish Experience, Utgrunden Offshore Windfarm;* Thomas Stalin, Enron Wind Sverige AB;
- *Danish offshore wind farm in The Baltic Sea;* Steen Beck Nielsen, SEAS, Denmark;

10:15 - 10:40 Discussions, Discussion leader: Thomas Ackermann

10:40 - 11:00 Coffee break

11:00-13:00 Session 2: Network Integration Issues I

11:00-12:15 Presentations:

- *Introduction to Offshore Wind,* Colin Morgan / Garrad Hassan (UK);
- *Solutions for Transmission and Interconnection of Offshore Wind Farms* by Günther Brauner, Institute of Power Systems and Energy Economics, Vienna University of Technology, Austria;
- *Network Connection Issues For Offshore Wind Farms In UK Waters* by P. Gardner, Garrad Hassan, Glasgow, UK;

12:15-13:00 Discussions, Discussion leader: Paul Gardner

13:00-14:00 Lunch

14:00-15:30 Session 3: Network Integration Issues II

14.00 - 15.00 Presentations:

- ***Topology and Governance of the United States Electricity Grid - Implications for Wind Development*** by James H. Caldwell Jr., Policy Director of the American Wind Energy Association, USA;
- ***The Impact Of Offshore Wind Farm Output Power Fluctuations On A Power Grid*** by Eduard Muljadi, National Wind Technology Center, National Renewable Energy Laboratory, Golden, USA;
- ***An Undersea Transmission Grid to Offload Offshore Wind Farms in the Irish Sea*** by Rick Watson, Dept of Electronic and Electrical Engineering, University College Dublin, Ireland;

15:00-15:25 Discussions, Discussion leader: Lennart Söder

15:25-15:40 Coffee break

15:40-17:00 Session 4

15.40-16.40 Presentations:

- ***Special Issues Concerning Wind Power Prediction for Offshore Wind Farms*** by Hans-Peter Waldl, Overspeed GmbH, Oldenburg, Germany;
- ***Wind Farm Control Software Structure*** by Jörgen Svensson, Dept. of Industrial Electrical Engineering and Automation (IEA), Lund University, Sweden;
- ***Switch For Converting AC Transmission Into DC (And Back)*** by Parviz Ali-Zada, Electronics Department, Fatih University, Istanbul, Turkey

16:40-17:00 Discussions, Discussion leader:

17.30-18.15:

A short (15 min) lecture about fuel cells and a visit to fuel cell laboratory of Applied Electrochemistry at KTH. After the lecture there will be a short discussion about possible synergetic effect of wind power and fuel cells in power systems.

After discussion there is a short tour to fuel cell laboratory of Applied Electrochemistry. A number of participants will be limited to 15 due to lack of space.

The lecture and visit is organised to participants who have a special interest on fuel cells and hydrogen. The laboratory of Applied Electrochemistry is located about 500 meters from main the workshop's seminar room.

19:30 Workshop Dinner

Friday 12 April 2002

09:00-10:30 Session 5: An Alternative for Transmission Systems: Hydrogen

9:00-10.00 Presentations:

- ***Hydrogen as a Storage and Transportation Vector for Offshore Wind Power Production***; Th. Feck, R. Steinberger-Wilckens, K. Stolzenburg; PLANET – Planungsgruppe Energie und Technik; Oldenburg, Germany;
- ***Offshore Wind Farms For Hydrogen Production Subject To Uncertainties***, Nabil Kassem, Royal Institute of Technology, Dept. of Energy Processes, Stockholm, Sweden;
- ***Offshore Wind Potential in Libya: Possibilities for Strategic Plans for Hydrogen Production*** by W. El-Osta and Y. Khalifa, Center for Solar Energy Studies, Tripoli, Libya;

10.00-10.30 Discussions, Discussion Leader: *Jari Ihonen, KTH*

10:30-10:50 Coffee break

10:50-13:00 Session 6: Transmission Issues

10:50-12.10 Presentations:

- ***AC or DC for connecting Offshore Wind Farms to the Transmission Grid?*** by Michael Haeusler, ABB Calor Emag Schaltanlagen AG, Mannheim, Germany and Fredrik Owman, ABB New Ventures GmbH, Mannheim, Germany;
- ***HVDC Transmission for Large Offshore Wind Farms***, by N.M. Kirby, W. Siepmann, L. Xu – ALSTOM T&D, UK.
- ***Transmission Networks Serving Offshore Wind Farms Based On Induction Generators*** by Rolf Grünbaum, Per Halvarsson, David Larsson, Lennart Ångquist; ABB Utilities AB, Power Systems, Vasteras, Sweden;
- ***Power Transmission Over Long Three Core Submarine AC Cables*** by Frode Rudolfson; Norwegian University Of Science And Technology, Norway;

12:10-13:00 Discussions, Discussion Leader: *Peter Christensen*

13:00-14:00 Lunch

14:00-15:40 Session 7: Power Systems Dynamics

14.00-15.40 Presentations:

- ***Introduction to Modelling for System Stability and Operation Studies*** by Lawrence Jones, Alstom EMM, USA and Juan Santos, ERCOT, USA.
- ***Dynamic Models for Modern Wind Turbine Generators and Their Application to Offshore Wind Farms*** by Steven Stapleton, Paul Hopewell, Leslie Bryans, Power Technologies International, Cheshire, UK;
- ***Modelling of Variable-Speed Wind Turbines with Double-Feed Induction Generators in Short-Term Stability Investigations*** by Vladislav Akhmatov, NESATransmission Planning, Copenhagen, Denmark;

15:00-15:20 Coffee break

- ***Stability Analysis of Grid Connected Wind Power Generation System*** by Tomonobu Senjyu, Norihide Sueyoshi, Katsumi Uezato (all University of the Ryukyus) and Toshihisa Funabashi (Meidensha Corporation);
- ***Potential Impacts of Wind Power on Power System Transient Stability*** by Han Sloopweg & Wil Kling, Electrical Power Systems Laboratory, Delft University Of Technology, Delft, The Netherlands.

16:00-16:20 Discussions, Discussion Leader: Lawrence Jones, Alstom EMM

16:20-16:30 Final Discussions, (Lawrence Jones/ Thomas Ackermann)

16:30 Closing Remarks



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Royal Institute of Technology



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Fourth
International Workshop on
Large-Scale Integration of Wind Power and
Transmission Networks for
Offshore Wind Farms.
October 20-21, 2003
in Billund, Denmark

Proceedings

Edited by:
Julija Matevosyan, Thomas Ackermann
Royal Institute of Technology
Electric Power Systems
Stockholm, Sweden



KTH

**Royal Institute of
Technology**
Stockholm, Sweden



TSO - Western Part of Denmark

**Fourth International Workshop on Large-Scale
Integration of Wind Power and Transmission Networks
for Offshore Wind farms
October 20-21, 2003
In Billund, Denmark**

Final Program
(Version 2)

Program Overview			
Sunday 19	Monday 20	Tuesday 21	Wednesday 22
	8:00 - 9:00 Registration		Eltra Day
	9:00 - 11:10 Welcome and Session 1: Danish Perspective	9:00 - 10:30 Session 5: Wind Turbine Modelling	9:00 - 13:00
	11:30 - 13:00 Session 2: Offshore Wind Power I	11:00 - 13:00 Session 6a: Grid Integration I Session 6b: System Operation	Eltra Presentations
	13:00 - 14:00 Lunch	13:00 - 14:00 Lunch	13:00 - 14:00 Lunch
	14:00 - 15:50 Session 3a: Energy Management Session 3b: Offshore Wind Power II	14:00 - 15:20 Session 7: Grid Integration II	Sightseeing Flights Horns Rev Offshore Wind Farm
	16:10 - 17:40 Session 4a: Power Quality Session 4b: Wind Prediction	15:35 - 17:15 Session 8: Modelling	
18:00 - 20:00 Registration & Snack	19:30 Dinner		

Sunday 19 October 2003

18:00-20:00 Registration & Snack

Monday 20 October 2003

8:00-9:00 Registration

9:00 - 9:10 Welcome Georg Styrbro, CEO of Eltra

9:10 - 9:20 Welcome and Introduction, Thomas Ackermann, KTH

9:20-11:10 Session 1:

9:20 - 10:40 Presentations: **The Danish Perspective**
(20 minutes each)

- *Impacts Of Large-Scale Wind Power On The Power Market*, Berit B. Kristoffersen, Bjarne Donslund, Peter Børre Eriksen, Eltra, Denmark;
- *Integration Of Wind Power In The Grid In Eastern Denmark*, C. Rasmussen, P. Jørgensen, J. Havsager Elkraft System, Denmark;
- *The Wind Farm Main Controller and the Remote Control System of the Horns Rev Offshore Wind Farm*, Peter Christiansen, Jesper R. Kristoffersen, Tech-wise A/S, Denmark.
- *Energy System Analysis of Large-Scale Integration of Wind Power*, Henrik Lund, Department of Development and Planning, Aalborg University, Denmark.

10:40 - 11:10 Discussions, Discussion leader: Anne-Marie Borbely-Bartis, U.S. DOE, Washington, USA

11:10 - 11:30 Coffee break

11:30-12:50 Session 2:

11:30-12:30 Presentations: **Offshore Wind Power I**
(20 minutes each)

- *Integration Of 6.000 MW Offshore Wind Energy In Dutch Electrical Grid*, J.W. Cleijne, C.P.J. Jansen, KEMA; J.G. Slootweg, W.L. Kling, Delft University of Technology, the Netherlands;
- *Offshore Wind Power In German Transmission Networks*, M. König, M. Luther, W. Winter, E.on, Germany;
- *Regulations To Award Concessions For Offshore Wind Power Plants*, Ole Langniss. Lund University Sweden and Poul-Erik Morthorst, Riso National Laboratory, Denmark.

12:30-13:00 Discussions, Discussion leader: *Peter Børre Eriksen, Eltra, Denmark*

13:00-14:00 Lunch

14:00-15:50 Parallel Session 3a

14.00 - 15.20 Presentations: **Energy Management**
(20 minutes each)

- ***Simulation Model Including Stochastic Behaviour Of Wind***, Jens Pedersen, Peter Børre Eriksen, Eltra, Denmark;
- ***The Effect Of Large-Scale Wind Power To A Thermal System Operation***, Hannele Holttinen, VTT Finland and Jens Pedersen, Eltra;
- ***Evaluation of Wind Energy Storage in Hydro Reservoirs in Areas with Limited Transmission Capacity***, Julija Matevosyan, Royal Institute of Technology, Stockholm, Sweden;
- ***Wind Power Plant Market and Operation Interaction – Principles for Information and Energy Management Systems***, Jörgen Svensson, Per Karlsson, Dept. of Industrial Electrical Engineering and Automation, Lund University, Sweden; Anders Johansson Vattenfall Utveckling AB, Sweden.

15:20-15:50 Discussions, Discussion leader: *Yuri V. Makarov, California Independent System Operator, USA*

14:00-15:50 Parallel Session 3b

14.00 - 15.20 Presentations: **Offshore Wind Power II**
(20 minutes each)

- ***AC Cable Versus DC Cable Transmission For Offshore Wind Farms, A Study Case***, Kent Søbrink, Eltra, Dennis Woodford, Electranix and Régine Belhomme, Eric Joncquel, EDF, France;
- ***Aspects Of Cabling In Offshore Windfarms***, Heinrich Brakelmann, University Duisburg-Essen, Germany;
- ***System Approach On Designing An Offshore Windpower Grid Connection***, K. Eriksson, ABB Power Systems, Ludvika, Sweden; P. Halvarsson, ABB Utilities Vesterås Sweden, D. Wensky, ABB Utilities, Mannheim Germany; M. Häusler, Weinheim, Germany.
- ***Engineering Design And Integration Experience From Cape Wind 420 MW Offshore Wind Farm***, Chris Bryan, CBX Energy Engineering, Waterville, ME, USA; Jeff Smith, Jason Taylor Electrotek Concepts, Knoxville, TN, USA; Bob Zavadil, Enernex, Knoxville, TN, USA;

15:20-15:50 Discussions, Discussion leader: *Julija Matevosyan, KTH, Sweden*

15:50-16:10 Coffee break

16:10-17:40 Parallel Session 4a

16.10-17.10 Presentations: **Power Quality**
(20 minutes each)

- **Measurement Methods For Calculation Of The Direction To A Flicker Source**, Peter Axelberg, Unipower AB, Sweden; Mats HJ Bollen, Chalmers University of Technology, Sweden
- **Harmonics And Interharmonics Generated By Wind Energy Converters – Measurements And A Novel Modelling Approach In The Frequency Domain**, Christoph Santer, Detlef Schulz, Rolf Hanitsch Technical University of Berlin, Institute of Energy and Automation Technology, Germany;
- **Windfarm Power Quality Monitoring And Output Comparison With EN50160**, Ivan Codd, ESB Networks, Dublin, Ireland.

17:10-17:40 Discussions, Discussion leader: *John Eli Nielsen, Eltra, Denmark*

16:10-18:00 Parallel Session 4b

16.10-17.30 Presentations: **Prediction of Wind Power**
(20 minutes each)

- **The State-of-the-Art in Short-Term Prediction of Wind Power - From a Danish Perspective**, Gregor Giebel, Risoe National Laboratory, Denmark; George Kariniotakis, Ecole des Mines des Paris; Richard Brownsword, CCLRC Rutherford Appleton Laboratory, UK;
- **Design Of A Control Algorithm For Wind Speed Prediction Purposes**, P. Flores, A. Tapia, G. Tapia, EUITI, San Sebastián, Spain;
- **Modeling, Simulation and Control of Large Wind Plants in Power Systems**, Louis Signoretty and Lawrence E. Jones, Alstrom EAI, USA & France.
- **Evolution Of Offshore Wind Power Prediction – Example Horns Rev**, U. Focken, M. Lange, J. Tembke, Carl von Ossietzky University of Oldenburg & I. Waldl, Overspeed GmbH, Oldenburg, Germany;

17:30-18:00 Discussions, Discussion leader: *Hannele Holttinen, VTT, Finland*

19:30 Dinner , sponsored by Eltra

Tuesday 21 October 2003

09:00-10:30 Session 5

9:00-10:00 Presentations: **Wind Turbine Modelling**
(20 minutes each)

- **Dynamic Phasor Modelling Of The Doubly-Fed Induction Machine In Generator Operation**, Emmanuel Delaleau, Univ. Paris-sud, France and Aleksandar M. Stankovic, Northeastern University Boston, USA;
- **Direct Drive Synchronous Machine Models For Stability Assessment Of Wind Farms**, Sebastian Achilles and Markus Pöller, DIGSILENT GmbH, Germany;
- **Validation Of DFIG Model Using 1.5 MW Turbine For The Analysis Of Its Behaviour During Voltage Drops In The 110 KV Grid**, Jens Fortmann, REpower Systems AG, Rendsburg, Germany.

10:00-10:30 Discussions, Discussion Leader: *Sigrid Bolik, Vestas, Denmark*

10:30-11:00 Coffee break

11:00-13:00 Parallel Session 6a

11:00-12:20 Presentations: **Grid Integration Issues I**
(20 minutes each)

- **Consideration Of Requirements Of TSO For Wind Farms Connection**, M.J.Lahtinen, Fingrid Oyj; A.R.Katančević, HUT, Finland;
- **Integration Of A 300 MW Wind Park At Fladen, Kattegatt, Into The Swedish 130 KV Grid**, Kjell Jonasson, Mats Carlson, Göteborg Energi AB, Sweden;
- **About Possibilities To Integrate Wind Farms Into Estonian Power System**, by Olev Liik, Mart Landsberg, Rein Oidram, Tallinn Technical University, Department of Electrical Power Engineering, Estonia;
- **The Use Of Fault Current Limiters As An Alternative To Substation Upgrade When There Is A Need To Increase The Available Short Circuit Power**, Magnus Öhrström, Lennart Söder, and Henrik Breder, Royal Institute of Technology, Stockholm, Sweden.

12:20-13:00 Discussions, Discussion Leader: *Urban Axelsson, Vattenfall, Sweden*

11:00-12:50 Parallel Session 6b

11.00-12.35 Presentations: **System Operation**
(20 minutes each)

- ***Scheduling Of Wind Generation Resources And Their Impact On Power Grid Supplemental Energy And Regulation Reserves***, Yuri V. Makarov, California Independent System Operator, USA;
- ***Analysis Of Large Scale Integration Of Wind Power In Regional HV-Grids Using Probabilistic Power Flow***, V. Diedrichs, E. Wieben, University of Applied Sciences Oldenburg/Ostfriesland/Wilhelmshaven, Power System Laboratory, Germany;
- ***Two Wind Power Prognosis Criteria And Regulating Power Costs***, C. S. Nielsen, Hans F. Ravn, Camilla Schaumburg-Müller, Informatics and Mathematical Modelling, Technical University of Denmark, Lyngby, Denmark;
- ***Integration Of Large Offshore Wind Power Into Energy Supply***, B. Ernst, M. Hoppe-Klipper, K. Rohrig, Institute für Solare Energieversorgungstechnik, Kassel, Germany;
- ***Utilization Of Wind-Diesel Systems To Provide Power Requirements Of Remote Settlements In Saudi Arabia***, Al-Shehri *et al.*, King Fahd University of Petroleum & Minerals, Dhahran, Saudi Arabi. (15 minutes)

12.35-13.00 Discussions, Discussion Leader: *Lennart Söder, KTH, Sweden*

13.00-14.00 Lunch

14:00-15:15 Session 7

14.00-15.00 Presentations: **Grid Integration Issues II**
(20 minutes each)

- ***Grid Requirements Challenges For Wind Turbines***, Sigrid Bolik, Vestas Wind Systems, Denmark;
- ***Power System Dynamic Performance Improvements From Advanced Power Control Of Wind Turbine-Generators***, Nicholas W. Miller, GE Power Systems, USA;
- ***Ride-Through Capability of ENERCON-Wind Turbines***, S. Hartge, ENERCON GmbH, Aurich, Germany; V. Diedrichs Power System Software&Swervice GmbH, Wilhelmshaven, Germany.

15.00-15.20 Discussions, Discussion Leader: *Thomas Ackermann, KTH, Sweden*

15:20-15:35 Coffee break

15:35-17:15 Session 8

15.35-16.35 Presentations: **Modelling**
(20 minutes each)

- *Voltage Stability Of Large Power Networks With A Large Amount Of Wind Power*, Vladislav Akhmatov, ELTRA, Denmark;
- *Fast Dynamic Models Of Offshore Wind Farms For Power System Studies*, Johan Morren, S.W.H. de Haan Delft University of Technology, The Netherlands; J.t.g. Pierik Wind energy research centre of the Netherlands; J. Bozelie NEG-Micon, Netherlands.
- *Aggregated Wind Park Models For Analyzing Power System Dynamics*, Markus Pöller and Sebastian Achilles, DIgSILENT GmbH, Germany.

16.35-17.00 Discussions, Discussion Leader: *Hans Knudsen, DEA, Denmark*

17:00-17.05 **Closing Remarks**

Wednesday 22 October 2003 - "Eltra Day"

9:00 – 13:00 Eltra Presentations

13:00 – 14:00 Lunch

14:00 – 16:00 Sightseeing flights to Horns Rev Offshore Wind Farm (weather depending)