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**IEEE POWER ENGINEERING SOCIETY  
ENERGY DEVELOPMENT AND POWER GENERATION COMMITTEE**

**PANEL SESSION: Impact of Dispersed and Renewable Generation on System Structure  
Including Impact of Enlarged Community on Energy Development, Power Generation,  
International Interconnections, Transmission and Distribution**

**(Tom Hammons and Zbigniew Styczynski)**

**IEEE 2006 General Meeting, Montreal, Canada, 18-22 June 2006  
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Room 512a**

**Sponsored by: International Practices for Energy Development and Power Generation<sup>#</sup>**

Chairs: Tom Hammons, University of Glasgow, Scotland, UK  
Zbigniew Styczynski, University of Magdeburg, Germany

**Topic: Integrating New Sources of Energy in Power Systems**

## **INTRODUCTION**

On behalf of the Energy Development and Power Generation Committee, welcome to this Panel Session on Impact of Dispersed and Renewable Generation on System Structure Including Impact of Enlarged Community on Energy Development, Power Generation, International Interconnections, Transmission and Distribution.

In Europe the dependency on imported primary energy increases from year to year. As a countermeasure against this growing dependency, national programs inside the European Community are directed to increase the share of renewable energy sources and the efficiency of power generation by cogeneration of heat and power (CHP). Targets are set by the European Commission for each country to gain a sustainable electricity supply in the future.

Generally, the share of renewable energy sources has to be increased until 2010 from 14% to 22% and the share of CHP has to be doubled from 9% to 18%.

Assuming that the wind power will grow initially by way of large wind farms feeding into the transmission grids with additional 35 GW installed power by 2010 (today approximately 36 GW are operated in Europe and about 50 % of these are located in Germany), the dispersed generation based on CHP and small renewable sources shall achieve an additional growth of 300 TWh/a to meet the mentioned goals.

The question arises, how can the power system be operated with such a large share of mostly not dispatched power sources? How can the reserve power be limited, which is required for

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<sup>#</sup> Document prepared and edited by T J Hammons

compensation of power fluctuations and ensuring a safe network operation?

In this context, a vision sees the power system of the future consisting of a number of self-balancing distribution network areas. In each of these areas a significant share of the power demand will be covered by renewable and CHP generation. However, the power balance of these areas shall be plan-able and dispatch-able in such a way that the import or export of power from or into the higher-level network has to follow a schedule which can be predicted with high level of accuracy in advance.

The distribution networks will become active and have to provide contributions to such system services like active power balancing, reactive power control, islanded operation and black-start capability. These services have to be coordinated with the transmission system operators where the responsibility for system stability will be allocated in the future as well.

This Panel Session panel fits very well with the scope of the advisory council of the European Commission "Platform of the Electricity Network of the Future".

Some of the key persons of the advisory council will participate with technical presentations.

The Panelists and Titles of their Presentations are:

1. Johan Driesen and Ronnie Belmans, KU Leuven, Leuven, Belgium. Distributed Generation: Challenges and Possible Solutions (paper 06GM0404)
2. Pier Nabuurs, Chief Executive Officer, and Peter Vaessen, KEMA, Arnhem, The Netherlands. Dispersed Generation and System Structure - The Crucial Exchange Layer between Transmission and Distribution (06GM1038)
3. Bernd Michael Buchholz, Director, PTD Services, Power Technologies, Siemens AG, Erlangen, Germany and Zbigniew Antoni Styczynski, Dean of Faculty of Electrical Engineering and Information Technology, Otto-von-Guericke University, Magdeburg, Germany. New Tasks Create New Solutions for Communication in Distribution Systems (paper 06GM0435)
4. Peter Børre Eriksen, Antje Orths and Vladislav Akhmatov, Energinet.Dk, Analysis and Methods, Fredericia, Denmark. Integrating Dispersed Generation into the Danish Power System - Present Situation and Future Prospects (paper 06GM0520)
5. Christian Sasse, General Manager, AREVA T&D, Stafford, UK. Electricity Networks of the Future (paper 06GM0339)
6. Bruno Meyer, Director 'Power Systems Technology & Economics', EDF R&D, Clamart, France, Yves Bamberger, Executive Vice President, Head of Corporate EDF R&D, EDF R&D, Clamart, France and I. Bel, Research Engineer, EDF R&D, Clamart, France. Electricité de France and Integration of Distributed Energy Sources (paper 06GM0475)
7. J. Kabouris, Hellenic Transmission Operator, Greece and Nikos D. Hatziaargyriou, National Technical University Athens, Athens, Greece. Wind Power in Greece—Current Situation, Future Developments and Prospects (paper 06GM1335)
8. Kurt Rohrig and Bernhard Lange, ISET Kassel, Germany. Application of Wind Power Prediction Tools for Power System Operations (paper 06GM0523)
9. Livio Gallo, Eugenio Di Marino, Christian D'Adamo and Simone Bottom, ENEL Distribuzione, Italy. Integration of New Sources of Energy in the Italian Distribution Network (paper 06GM0373)
10. Invited Discussers..

Each Panelist will speak for approximately 20 minutes. Each presentation will be discussed immediately following the respective presentation. There will be a further opportunity for discussion of the presentations following the final presentation.

The Panel Session has been organized by Tom Hammons (Chair of International Practices for Energy Development and Power Generation IEEE, University of Glasgow, UK) in consultation with Bernd Michael Buchholz (Director, PTD Services, Power Technologies, Siemens AG, Erlangen, Germany).

Tom Hammons and Zbigniew Styczynski (University of Magdeburg, Germany) will moderate the Panel Session.

The first presentation will be given by Johan Driesen and Ronnie Belmans, KU Leuven, Leuven, Belgium. It is entitled: Distributed Generation--Challenges and Possible Solutions.

The contribution starts from the observation that there is a renewed interest in small-scale electricity generation. The authors start with a discussion of the drivers behind this evolution indicating the major benefits and issues of small-scale electricity generation. Attention is paid to the impact of a massive penetration of distributed generation in the grid on the system safety and protection. An overview of the impact on voltage quality and stability is given, both static and dynamic. A practical example is discussed to show the problems and indicate solutions. Different types of generators and grid interfaces are treated.

**Johan Driesen** is an associate professor at the K.U.Leuven and teaches power electronics and drives. In 2000-2001 he was a visiting researcher in the Imperial College of Science, Technology and Medicine, London, UK. In 2002 he was working at the University of California, Berkeley, USA. Currently he conducts research on distributed generation, including renewable energy systems, power electronics and its applications, for instance in drives and power quality.

**Ronnie Belmans** is a full professor with K.U.Leuven, teaching electrical machines and variable speed drives. He is an appointed visiting professor at Imperial College in London.

He was with the Laboratory for Electrical Machines of the RWTH, Aachen, Germany (Von Humboldt Fellow, Oct.'88-Sept.'89). From October 1989-September 1990, he was visiting associate professor at Mc Master University, Hamilton, Ont., Canada. During the academic year 1995-1996 he occupied the Chair at London University, offered by the Anglo-Belgian Society. Dr.Belmans is a Fellow of the IEE (United Kingdom) and a Fellow of IEEE. He is also Chair of the Board of Elia, the Belgian TSO.

The second presentation has been prepared by Pier Nabuurs, Chief Executive Officer and Peter Vaessen, KEMA, Arnhem, The Netherlands. It is entitled: Dispersed Generation and System Structure--The Crucial Exchange Layer between Transmission and Distribution. Peter Vaessen will present it.

The transition from the present power system with a high share of large-scale generation towards a network that is able to accommodate a large amount of dispersed and intermittent

generation has started. This presentation considers the effects of dispersed generation on system structure. The power exchange layer between the future transmission and distribution system is essential, as is the developing shared public-private responsibility for Power Quality and reliability. The Need for new experiments with distributed systems, test- and certification procedures and analyzing tools, spanning the technical, economic and regulatory levels in the power systems, becomes clear. This will be discussed.

**Pier Nabuurs** held jobs in de management of R&D at Philips and Océ during many years. For Océ he became responsible for managing global purchasing en the supply chain. After that he was CEO of Océ-Belgium and Executive Director of the Strategic Business Unit Document Printing, including the responsibility for the product development program. In January 2002 he became CEO of KEMA, an international company specialized in high-grade technical energy consultancy and R&D , inspection, testing and certification.

**Peter Vaessen** joined KEMA and has held several research positions in the field of large power transformers and measurements in high-voltage networks. From 1991 to 1996, he managed several realization projects, among them construction of Dutch 400 kV substations. As a consultant he has experience in the conceptual design of integrated electrical systems and innovative techniques and tools for transforming existing large-scale hierarchical systems into flexible dynamic structures, allowing economic utilization, competition and integration of RES and DG.

The third presentation has been prepared by Bernd Michael Buchholz, Director, PTD Services, Power Technologies, Siemens AG, Erlangen, Germany and Zbigniew Antoni Styczynski, Dean of Faculty of Electrical Engineering and Information Technology, Otto-von-Guericke University, Magdeburg, Germany. It is entitled: New Tasks Create New Solutions for Communication in Distribution Systems

New communication facilities are required to provide a decentralized energy management and to ensure the provision of system services by D&RES. In a case study, it is analyzed how the existing infrastructure can be used to build a communication network with different physical communication channels. Furthermore, the application of communication standards is investigated and in the result the use of the data models and the services of the communication standard IEC 61850 (for substation communication) is recommended. In the presentation, it is shown that the advantageous application of this standard and its subsequent standards IEC 61400-25 for wind power plants and IEC 62350 for dispersed generation requires consistency of all described models. It becomes clear that the implementation of more communication in the distribution level helps to improve the distribution system management

**Bernd Michael Buchholz** is director of the business unit “Power Technologies” in the “Service” division of the Power Transmission and Distribution group in Erlangen. Between 1995 and 2000 he worked as editor for the parts 4 and 7 of IEC 61850. He is the German member of the SC C6 of CIGRE “Dispersed generation in distribution systems”.

**Zbigniew Antoni Styczynski** became in 1999 the Head and the Chair of Electric Power Networks and Renewable Energy Sources of the Faculty of Electrical Engineering and Information

Technology at the Otto-von-Guericke University, Magdeburg, Germany. Since 2002 he is also the dean of the Faculty. His special field of interest includes electric power networks and systems, expert systems and optimization problems. He is senior member of IEEE PES, member of CIGRE SC C6, VDE ETG und IBN and fellow of the Conrad Adenauer Foundation.

The next presentation is entitled *Integrating Dispersed Generation into the Danish Power System - Present Situation and Future Prospect*. It has been prepared by Peter B. Eriksen, Antje G. Orths and Vladislav Akhmatov , all from Energinet.dk, Fredericia, Denmark.

Since the early 1980s a huge amount of dispersed generation has been implemented into the Danish power systems. Today the Danish system has a share of 18,5% electricity consumption produced by wind turbines and 26,5% produced by combined heat and power units (CHP), of which the biggest part is installed in the western part of Denmark. The presentation shows the technical measures as well as utilization of market mechanisms applied by the Danish system operator, Energinet.dk, to handle the challenging situation of safe and reliable system operation. Future prospects with respect to the internationally growing wind power capacity and respective need for a market for ancillary services will be discussed.

**Peter Børre Eriksen** is head of *Analysis and Methods* of Energinet.dk, the Danish Transmission System Operator for Electricity and Gas. After a career in system planning for the Danish utility ELSAM he joined Eltra, the former Western Danish TSO in 1998, where he was leading the Development Department from 2000 until 2005. In 2005 the two regional TSOs on power (Eltra and Elkraft) and the TSO on natural gas (Gastrå) merged forming the new national TSO Energinet.dk, which bears overall responsibility for power and natural gas systems in Denmark. Peter Børre Eriksen is author of numerous technical papers on system modeling.

**Antje G. Orths** joined the Planning Department (*Analysis and Methods*) of Energinet.dk, the Danish TSO for Electricity and Gas in 2005. Before she was researcher at the OvG-University Magdeburg, Germany and also head of the group Critical Infrastructures at the Fraunhofer Institute for Factory Operation and Automation IFF in Magdeburg. Her special fields of interests include electric power networks and systems, modeling of dispersed energy resources, distribution network planning and optimization problems. She is member of the IEEE-PES, VDE-ETG and CRIS.

**Vladislav Akhmatov** is since 2003 with the Planning Department (*Analysis and Methods*) of Energinet.dk, the Danish TSO for Electricity and Gas. Before he worked for the Danish electric power company NESA A/S, investigating power system stability of the eastern Danish power system with incorporation of large offshore wind farms. He has developed detailed wind turbine models for different power system simulation tools and carried out a lot of respective analyses. His special interests are power system analysis, wind power and simulation tools.

The fifth presentation will discuss Electricity Networks of the Future and will be given by Christian Sasse, General Manager, AREVA T&D Technology Center, Stafford, UK. He is Chairman of Advisory Council - EU "Technology Platform for the Electricity Networks of the Future

In May 2005 the European Commission Research Directorate-General defined an initial scope for the creation of a "Technology Platform for the Electricity Networks of the Future. This was namely to increase the efficiency, safety and reliability of European electricity transmission and distribution systems and to remove obstacles to the large-scale integration of distributed and renewable energy sources. It is in line with the proposed priority for "Smart Energy Networks" in the Research Directorate-General's Framework Program 7 (FP7). In January 2006, the Platform's Vision Paper was published. This presentation gives an overview of the initial issues raised.

**Christian Sasse** joined Areva T&D (former ALSTOM T&D) in 2000 where he was appointed as Program Manager for solid oxide fuel cells. Within this program, he formulated a fuel cell strategy and initiated a European partnership with several companies with the objective of designing low cost planar solid oxide fuel cell systems. He is now General Manager for the Areva T&D Technology Center in Stafford, UK. His recent focus has been on active power networks where he coordinated activities within Areva and initiated new UK DTI and EC FP6 proposals in this area. In May 2005 he was invited to join the EC Technical Platform for Electricity Networks for the Future in preparation for Framework 7.

The next presentation has been prepared by Bruno Meyer, Director "Power Systems Technology & Economics", EDF R&D, France, Yves Bamberger, Executive Vice President, Head of Corporate EDF R&D, France and I. Bel, Research Engineer, EDF R&D, France. It is entitled: Electricité de France and Integration of Distributed Energy Sources. Bruno Meyer will present it.

It underlines technical challenges that arise from this expansion, taking into account the regulatory and technical background in France and Europe.

**Bruno Meyer** holds degrees in physics from Unicamp (B.Sc.), Sao Paulo (M.Sc.) and Edinburgh (Ph.D.). He is director of Power Systems Technology and Economics at EDF R&D. He joined EDF in 1985 where he has held several positions in the R&D Division as well as in the Marketing and Commerce Divisions. He is a Senior Member of IEEE, and is Region 8 Representative for IEEE PES. He is also Eminent Member of Cigré.

**Yves Bamberger** is a graduate from Ecole Polytechnique and Ecole Nationale des Ponts et Chaussées. He is Senior Vice-President at EDF R&D.

**Ivan Bel** holds a degree in mechanical engineering from ESTP. He is research engineer at EDF R&D.

The seventh presentation is entitled: Wind Power in Greece, Current Situation, Future Developments and Prospects and has been prepared by J. Kabouris, Hellenic Transmission Operator, Greece and Nikos D. Hatziargyriou, National Technical University of Athens, Athens, Greece. It will be presented by Nikos D. Hatziargyriou.

It describes the current status of wind power in wind Greece focusing on the future developments and prospects. Most of the applications for new wind farm installations refer to three specific areas of high wind potential in the Greek mainland. Due to the geographical distribution and the size of wind farms (10 to 40 MW installed capacity), wind integration in these areas will be highly concentrated and the wind farms will be connected mainly to the high voltage network. The expected impact of the large wind penetration will impact significantly on the ESI and the new challenges that arise will be discussed.

**John Kabouris** is assistant Director in the System Expansion Studies Department of the HTSO. His research interests include power system analysis, generation simulation and renewable energy sources.

**Nikos D. Hatziargyriou** is Professor at the Power Division of the School of Electrical and Computer Engineering of NTUA. His research interests include dispersed and renewable generation, artificial intelligence techniques in power systems and power system dynamic analysis and control. He is a senior IEEE member, member of CIGRE SCC6 and the Technical Chamber of Greece.

The pen-ultimate presentation will be given by Kurt Rohrig, ISET Kassel, Germany. It is entitled: Application of Wind Power Prediction Tools for Power System Operations.

The significant amount of installed wind power in the German power system (currently more than 18 GW) make the traditional scheduling of power generation for the day ahead very unsure. Consequently, the costs of power system operation are high because of large-scale provision of spinning reserve from the traditional power plants. The decisive rule in decreasing these costs in the wind energy transformation modeling process starts with the forecast of wind speed.

In Germany for more than ten years the knowledge on how to solve this problem has been available. Based on more than 100 representative wind farm power measurements all over Germany very exact models for determination of current and expected wind power have been developed. The models are in operation at the control stations of the Transmission System Operators. This will be discussed.

**Kurt Rohrig** is head of ISET's Program Area Information and Energy Economy. He has worked with ISET since 1991 and has been the scientist-in-charge for projects handling the online monitoring and prediction of wind power for large supply areas – operated in co-operation with large power transmission utilities. The computer models and approaches, developed in his work are in operation at all German transmission system operators with high wind power penetration.

**Bernhard Lange** is head of Information and Prediction Systems of the Program Area Information and Energy Economy at ISET. After graduating he worked in Denmark with Risø National Laboratory and Wind World A/S. His main research interests for the last 10 years are wind power meteorology and wind farm modelling.

The final presentation is by Livio Gallo, Eugenio Di Marino, Christian D'Adamo and Simone Bottom, ENEL Distribuzione, Italy. It is entitled: Integration of New Sources of Energy in the Italian Distribution Network. Livio Gallo will present it.

#### **PANELISTS:**

1. Prof Ronnie Belmans  
J. Driesen  
KU Leuven  
Kasteelpark Arenberg 10  
B-3001 Leuven  
Belgium  
E-mail: [ronnie.belmans@esat.kuleuven.be](mailto:ronnie.belmans@esat.kuleuven.be)
  
2. Mr Pier Nabuurs  
CEO  
KEMA  
PO Box 9035  
6800ET Arnhem  
The Netherlands  
Tel: +31 26 356 3511  
Fax: +31 26 443 4025  
[Pier.Nabuurs@kema.com](mailto:Pier.Nabuurs@kema.com)  
[www.kema.com](http://www.kema.com)
  
3. Bernd Michael Buchholz  
Director,  
PTD Services,  
Power Technologies  
Siemens AG PTD SE NC,  
Paul-Gossen- Str. 100,  
91052 Erlangen,  
Germany  
E-mail: [bernd.buchholz@siemens.com](mailto:bernd.buchholz@siemens.com)  
Tel: +49 91317 34443,  
Fax: +49 91317 34445

Prof. Zbigniew Antoni Styczynski  
Dean of Faculty of Electrical Engineering and Information Technology  
Otto-von-Guericke-University  
Magdeburg  
Universitaetsplatz 2  
D-39106 Magdeburg  
Germany  
E-mail: [sty@e-technik.uni-magdeburg.de](mailto:sty@e-technik.uni-magdeburg.de)  
Tel.: +49 391 6718866  
Fax.: +49 391 6712408

4. Antje Orths, Dr.-Ing.  
Vladislav Akhmatov  
Analysis and Methods  
Energinet.Dk  
Fjordvejen 1-11  
DK-7000 Fredericia  
Telefon: +45 7622 4426/4000  
Fax: +45 7624 5180  
E-mail: [ANO@energinet.dk](mailto:ANO@energinet.dk)

Peter Børre Eriksen  
Head of Analysis and Methods  
Energinet.dk  
Fjordvejen 1-11  
DK-7000 Fredericia  
Denmark  
E-mail: [pbe@energinet.dk](mailto:pbe@energinet.dk)  
Energinet.dk  
Tel.: +45 7622 4000  
Fax: +45 7624 5180  
[www.energinet.dk](http://www.energinet.dk)

5. Mr Christian Sasse  
General Manager  
AREVA T&D  
AREVA T&D Technology Centre  
St Leonards Ave  
Stafford ST17 4LX  
UK  
Tel: +44 1785 78 6490  
Fax: +44 1785 78 6499  
[Christian.sasse@areva-td.com](mailto:Christian.sasse@areva-td.com)  
[www.areva.com](http://www.areva.com)

6. Bruno Meyer  
Director "Power Systems Technology & Economics"  
EDF R&D

1, Ave. du General De Gaulle  
92141 Clamart  
France  
Tel: +33 1 47 65 43 21  
Fax: +33 1 47 45 42 06  
E-mail: [bruno.meyer@edf.fr](mailto:bruno.meyer@edf.fr)

Mr Yves Bamberger  
Executive Vice President  
Head of Corporate EDF R&D  
EDF R&D  
Ave. du General De Gaulle  
92141 Clamart CEDEX  
France  
Tel: +33 1 47 65 58 40  
Fax: +33 1 45 29 92 41  
[Yves.Bamberger@edf.fr](mailto:Yves.Bamberger@edf.fr)  
<http://www.edf.fr/>

I. Bel  
Research Engineer

EDF R&D  
Ave. du General De Gaulle  
92141 Clamart CEDEX  
France

7. Prof Nickolas Hatziargyriou  
National Technical University Athens  
9 Heron Polytechniou Str  
157 73 Zografou  
Athens  
Greece  
Tel: +30 210 772 3661  
Fax: +30 210 772 3968  
[Nh@power.ece.ntua.gr](mailto:Nh@power.ece.ntua.gr)  
[www.ntua.gr](http://www.ntua.gr)

J. Kabouris  
Hellenic Transmission Operator  
Amfitheas 11  
N. Smyrni  
Greece  
[kabouris@desmie.gr](mailto:kabouris@desmie.gr)

8. Kurt Rohrig

Head of Division Information and Energy Economy  
Institut für Solare Energieversorgungstechnik  
Königstor 59  
D-34119 Kassel  
Germany  
[k.rohrig@iset.uni-kassel.de](mailto:k.rohrig@iset.uni-kassel.de)  
Tel: +495617294330  
Fax: +495617294260

Bernhard Lange  
Head of Department Information and Prediction Systems  
Institut für Solare Energieversorgungstechnik  
Königstor 59  
D-34119 Kassel  
Germany  
[blange@iset.uni-kassel.de](mailto:blange@iset.uni-kassel.de)  
Tel: +495617294358  
Fax: +495617294260

9. Livio Gallo  
Chief Operating Officer  
Infrastructures and Network Division  
Enel SpA  
Italy  
E-mail: [livio.gallo@enel.it](mailto:livio.gallo@enel.it)

Eugenio Di Marino  
Infrastructures and Network Division  
Enel SpA  
Italy  
E-mail: [eugenio.diemarino@enel.it](mailto:eugenio.diemarino@enel.it)

Christian D'Adamo  
Infrastructures and Network Division  
Enel SpA  
Italy  
Enel Distribuzione  
Italy  
E-mail: [Christian.d'adamo@enel.it](mailto:Christian.d'adamo@enel.it)

Simone Bottom  
Infrastructures and Network Division  
Enel SpA  
Italy  
Italy  
E-mail: [simone.botton@enel.it](mailto:simone.botton@enel.it)

## 10. Invited Discussers

### **PANEL SESSION CHAIRS**

Tom Hammons  
Chair International Practices for Energy Development and Power Generation  
University of Glasgow  
11C Winton Drive  
Glasgow G12 0PZ  
UK  
E-mail: [T.Hammons@ieee.org](mailto:T.Hammons@ieee.org)  
Tel: +44 141 339 7770

Zbigniew Antoni Styczynski  
Dean of Faculty of Electrical Engineering and Information Technology  
Otto-von-Guericke-University  
Magdeburg  
Universitaetsplatz 2  
D-39106 Magdeburg  
Germany  
E-mail: [sty@e-technik.uni-magdeburg.de](mailto:sty@e-technik.uni-magdeburg.de)  
Tel.: +49 391 6718866  
Fax.: +49 391 6712408

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