

# New generation types in Europe versus Future Power Quality Needs

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IEEE POWER ENGINEERING SOCIETY  
ENERGY DEVELOPMENT AND POWER GENERATION COMMITTEE

## New Generation Types in Europe versus Future Power Quality Needs

Wil L. Kling and Antje Orths

*Working Group European Electricity Infrastructure*

2010 IEEE PES General Meeting, July 25-29 2010, Minneapolis, Minnesota, USA  
**Wednesday, July 28, 2010, 8:00 a.m~12:00 a.m. (Tentative)**

**Sponsored by: International Practices for Energy Development and Power Generation**

Chairs: Wil Kling, University of technology, Eindhoven, the Netherlands  
Antje Orths, Energinet.dk, Fredericia, Denmark

**Track: Wind and Solar Energy: Challenges in Furthering its Penetration**

### I. INTRODUCTION

For many decades there has been an electricity system with generation from large centralized power plants. The main advantages of these conventional power generation plants are the price and the controllability of their output. The main disadvantages are the future availability of their primary energy sources (natural gas, coal, oil) and their environmental consequences.

Therefore in the last decades there has been an increase in the development and use of renewable energy sources. The connection of the new types of generation is often through power electronics.

Regulations set requirements on the power quality in the network, whose indicators have to be within specified limits.

Some of the problems are:

- Distributed generation can increase the slow voltage variations in the network.
- Electronic equipment increases the harmonic current injections in the network, resulting in higher harmonic voltages.
- Dips are influenced by the protection philosophy of the renewable energy sources.
- Selective switching can have negative impact on dips.

The use of dispersed generation could on the other hand improve the quality of the service, but additional control and protection strategies are needed to take full advantage of distributed generation.

The session starts with an overview on power quality requirements and addresses the aspects of costs of inadequate power quality. Insufficient compatibility may result in stoppage of the production activity, equipment malfunction or incorrect operation. Equipment may also operate outside its normal functionality at reduced efficiency or in such a way that its operating life is reduced. The situation is further complicated by the fact that many PQ issues are caused by the operation (or miss-operation) of end-use equipment that is connected to the network. Better certification of such equipment will be discussed.

Harmonic and interharmonic distortion in the network because of for instance a wind park and how much harmonics can be expected in future low voltage networks and how this is influenced by harmonic load conditions is the next topic in the session.

The session ends with presentations on ancillary services of grid inverters and the need to supervise the new types of distributed generation.

## II. LIST OF PAPERS

1. **Overview on PQ development in Europe**  
**A. Baggini** (Bergamo University, Italy), **F. Bua** (ECD, Italy); (invited panel paper 2010GM1691)
2. **Evaluating cost of inadequate Quality of Supply**  
**R. Targosz** (European Copper Institute, Poland); (invited panel paper 2010GM0271)
3. **Contribution of Dispersed Power Generation to Power Quality by Advanced Electrical Characteristics in German Grid Codes – Certification based on Validated WEC Models and Simulation of Wind Farms**  
**B. Schowe-von der Brellie** (FGH, Germany), **H. Vennegeerts** (FGH, Germany), **M. Brennecke** (FGH, Germany); (invited panel paper 2010GM1010)
4. **Harmonic Current Pollution in a Low Voltage Network**  
**S. Bhattacharya** (Eindhoven University of Technology, the Netherlands), **J.F.G. Cobben** (Eindhoven University of Technology, the Netherlands), **W.L. Kling** (Eindhoven University of Technology, the Netherlands); (invited panel paper 2010GM0411)
5. **Harmonic and Interharmonic Distortion due to a windpark**  
**M. H.J. Bollen** (STRI AB, Sweden), **L. Yao** (Areva T&D, UK), **S.K. Rönnberg** (Luleå University of Technology, Sweden), **M. Wahlberg** (Luleå University of Technology, Sweden); (invited panel paper 2010GM0498)
6. **Power injection by distributed generation and the influence of harmonic load conditions**  
**J. M. Desmet** (Howest, Belgium), **C. Debruyne** (Howest, Belgium), **J. Vanalme** (Howest, Belgium), **L. Vandeveld** (Ghent University, Belgium); (invited panel paper 2010GM1109)
7. **Harmonic Distortion and Oscillatory Voltages and the Role of Negative Impedance**  
**P.J.M. Heskes** (ECN, the Netherlands), **J.M.A. Myrzik** (Technical University of Dortmund, Germany), **W.L. Kling** (Eindhoven University of Technology, the Netherlands); (invited panel paper 2010GM0413)
8. **Grid Inverter Ancillary Services**  
**Z. Hanzelka** (AGH- University of Science and Technology, Poland), **I. Wasiak** (Technical University of Lodz, Poland); (invited panel paper 2010GM1431)
9. **Supervision of renewable energy for its integration in the electrical system**  
**B. Robyns** (University of Lille, France), **J. Sprooten** (University of Lille, France), **A. Vergnol** (University of Lille, France); (invited panel paper 2010GM1076)

Each Panelist will speak for approximately 15 minutes. Each presentation will shortly 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 Antje Orths (Chair of WG Europe, IPSC, Energy Development and Power Generation Committee, IEEE and Energinet.dk, Denmark) and Wil Kling (Chair of Electrical Power Systems group of Eindhoven University of Technology, the Netherlands).

Wil Kling and Antje Orths will moderate the Panel Session.

## III. TITLES, AUTHORS ABSTRACTS AND BIOGRAPHIES

### *Overview on PQ development in Europe*

#### 1) Authors:

**Angelo Baggini** (Bergamo University, Italy); **Franco Bua** (ECD – Engineering Consulting and Design, Italy).

#### 2) Abstract

This paper aims to give an overview on main PQ development in Europe. It focuses basically on recent legislative, regulatory, standardization, voltage quality monitoring and education initiatives summarizing the latest outcomes.



#### 3) Biographies

**Angelo Baggini** is currently aggregate professor of Electrical Engineering at University of Bergamo and international consultant in the energy sector (energy efficiency, power quality, renewables).

He received his degree in Electrical Engineering cum laude from University of Pavia in 1993; his thesis research work in CESI Metrological Lab, was awarded with the "AEI Stefano e Flora Badoni" prize by AEI (Associazione Elettrotecnica Italiana). From 1993 to 1994 he prosecuted his research work both in CESI Metrological Lab in Milan and in Electrical Engineering Department of University of Pavia focusing on EMC and PQ aspects of electrical measurements and electrical machinery construction.

He received his PhD in Electrical Engineering from University of Pavia in 1997.

Since 1997 he is a member of CEI TC14 and from 2007 he is secretary of CENELEC TC14, member of IEC-SMB Study Group 1 "Energy Efficiency and Renewables".

Author of over 200 technical and scientific papers both on magazines and in national and international conferences either in the industry or at University. Author of PQ Handbook published by Wiley in 2008.



**Franco Bua** received his degree in Electrical Engineering from University of Pavia in 1995. Immediately after degree, he was involved in research activity relevant to electromagnetic compatibility and energy

efficiency.

Currently he is technical director of ECD, an engineering company active in the field of design and consultancy in the electrical sector. He is member of various TC at Italian NSB (CEI) and is member of IEC-SMB Study Group 1 “Energy Efficiency and Renewables” and CEI representative at the European Sector Forum on Energy Management.

### *Evaluating cost of inadequate Quality of Supply*

#### *1) Authors:*

**Roman Targosz** (European Copper Institute, Poland).

#### *2) Abstract*

Electricity has the increasing role in energy supply chain. Electricity supply has to satisfy user requirements also in quality terms and good compatibility is necessary, including supply voltage level, voltage stability, waveform distortion due to harmonics and interharmonics, voltage unbalance but also long and short-term availability of the supply.

One social concern is to keep electricity prices low enough not to slow down economic growth. At the same time electricity has to be increasingly green and functional. There is a risk that the quality of supply may deteriorate.

Cost of insufficient quality may result in stoppage of the production, equipment malfunction, incorrect or reduced rate operation or equipment lifetime reduction. These costs has to be properly assessed to help in selection of preventing measures. These cost are also necessary to set up regulatory measures. The regulation incentive or penalty has to balance the cost of problems mitigation versus cost of consequences in as much as possible social dimension. PQ contracts should work in similar way but are limited to particular consumers for whom such balance is easier to quantify and integrate with risk assessment.

The power quality cost evaluation methods, historical examples and application of results will be presented in the paper.

#### *3) Biographies*



**Roman Targosz** is born January 7, 1962. He graduated from Wroclaw Technical University in 1986 with M.Sc. in power engineering. He has experience in marketing and sales as well as in project management from ABB where he worked between 1991 and 1999 for large synchronous generator company. He moved than to open pit mining equipment company, Famago where he managed Sales & Marketing as the Member of the Board. From June, 2000 he is in European Copper Institute, based in Polish Copper Promotion Centre. He post graduated from ABB Executive Management MBA program. He supports ECI activities in Energy projects and local activities in Central Europe.

His special interests cover power quality and its economics, energy efficiency particularly in transformers, rational use of energy in general and energy policy.

### *Certification*

#### *1) Authors:*

**Bernhard Schowe-von der Brelie** (FGH Research Association for Power Systems and Power Economics, Germany); **Hendrik Vennegeerts** (FGH Research Association for Power Systems and Power Economics, Germany); **Martin Brennecke** (FGH Research Association for Power Systems and Power Economics, Germany).

#### *2) Abstract*

This paper describes the German regulation on the integration of dispersed power generation into the medium and high voltage grid in terms of the latest grid codes. A special consideration is given to the advanced requirement on frequency control and dynamic voltage support.. An overview on the status quo of certification regulations and implementation approaches in selected countries both on single WEC types and on wind farms is provided.

Furthermore, the model validation and subsequent certification procedure FGH Certification Office has developed and applied to first wind farm certifications will be presented. A focus will be given to the validation of the WEC model and the simulation of the wind farm’s LVRT behaviour.

Finally, potentials for harmonisation of the certification and, subsequently, on the underlying testing and validation schemes will be sketched.

#### *3) Biographies*



**Bernhard Schowe-von der Brelie** (1971) graduated in physics at Philipps-Universität Marburg in 1997. Since 2006 he is responsible for the business development at the Institute for High Voltage Engineering at RWTH Aachen University and for the Research Association for Power Systems and Power Economics (FGH) e.V. in terms of acquisition and project management. Since 2008 he is the deputy Head of FGH Certification Office. He is active in German national working groups on certification schemes for proofing the conformity of single wind energy converters and entire wind farms with respect to the new German grid codes.



**Dr. Hendrik Vennegeerts** (1973) is with Research Association for Power Systems and Power Economics (FGH) e.V. since August 2004, first as consultant in and then head of the system technique section. Since August 2006 he is head of the department system studies / software development / training. Here, among other things, various studies and research projects on the electric power supply networks are performed and the software product INTEGRAL, a network calculation tool, is further developed. He is actively involved in many national and international advisory and steering bodies. He is heading the institutes’ studies of WEC model implementation and validation.

**Martin Brennecke** (1973) graduated in Electrical Engineering (diploma) at RWTH Aachen University in 2008. He has been involved in several projects at the Research Group of Asset Management at the Institute of High Voltage Engineering at RWTH Aachen University before he joined Research Association for Power Systems and Power Economics (FGH) e.V. in 2009. Here, he is engaged in the new validation schemes for WEC models and respective certification process within FGH's Certification Office. He is highly engaged in the ongoing consultations on the recent technical guidelines for implementing the compliance testing schemes as required by the new German grid codes.

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### *Harmonic Current Pollution in a Low Voltage Network*

#### 1) Authors:

**Sharmistha Bhattacharyya** (Eindhoven University of Technology, the Netherlands); **Sjef Cobben** (Eindhoven University of Technology, the Netherlands); **Wil Kling** (Eindhoven University of Technology, the Netherlands).

#### 2) Abstract

Modern household customers use many power electronic based devices for their daily usage. Those devices emit harmonic current pollution in the network and eventually increase harmonic voltage distortion level in the power system. When the supply voltage is distorted, the devices produce even more harmonic currents and pollute the network.

In this paper, a number of household devices are measured in the laboratory to find out their harmonic current spectrums for clean as well as polluted grid conditions. Those harmonic spectrums are later used in the simulation. Next, three house models are made with different combinations of above measured devices and simulations are done to estimate total harmonic current distortion levels at the point of connection (POC) of each house. Moreover, each of these house models is also individually tested in the laboratory to find out the harmonic current spectrum at the POC of a house.

Further, harmonic simulation is done on a typical low voltage network in which several household customers are connected, using the measured harmonic spectrums. Harmonic current emission levels at different points of the network are noted. The simulation results are verified with practical field measurements. This analysis gives an overview of harmonic current emission level in a typical low voltage network. Furthermore, based on the simulation results, a suggestion is given to improve the existing standards on harmonics.

#### 3) Biographies



**Sharmistha Bhattacharyya** received her B.E degree (1994) in electrical engineering from Jadavpur University, India. During 1994-2005, she worked for various consultancy companies in India and the Netherlands in the

direction of Power System Analysis. In 2006, she received her master degree in Sustainable Energy Technology from Technical University of Eindhoven (TU/e), the Netherlands. At present, she is pursuing her PhD research in the Electrical Power Systems group (EPS) at TU/e. Her main area of research is the power quality aspects of the future electricity infrastructure in the Netherlands.



**Sjef Cobben** was born in Nuth, Netherlands, in 1956. He received the Bachelors degree in Electrical Engineering from the Technical University of Heerlen in 1979. In 2002 he received the Masters degree in Electrical Engineering from Eindhoven, University of Technology (TU/e).

In 1979 he joined NUON, one of the largest energy organizations in the Netherlands. Since 2000 he is working for the Dutch grid operator Liander, where he is engaged in Power Quality problems and safety requirements. From 2003 to 2007 he worked part time on a Ph.D. project about "intelligent grids" with as special topic Power Quality problems. Sjef Cobben is member of several national and international standardization commissions about requirements for low and high voltage installations and characteristics of the supply voltage.

He is author of several books about power quality and low voltage installations. Since 2007 he is working as assistant professor at the University of Technology in Eindhoven, Netherlands.



**Wil Kling** received his M.Sc. degree in Electrical Engineering from the Eindhoven University of Technology, Eindhoven, the Netherlands, in 1978. Since 1993, he has been a part-time Professor with the Delft University of Technology, the Netherlands in the field of Electrical Power Systems. Up till the end of 2008 he was also with TenneT, the Dutch Transmission System Operator, as senior engineer for network planning and strategy. Since Dec. 2008, he has been appointed Chair of the Electrical Energy Systems group, Eindhoven University of Technology. He is leading research programs on distributed generation, integration of wind power, network concepts and reliability issues.

Prof. Kling is involved in scientific organizations such as CIGRE and the IEEE. As Netherlands' representative, he is a member of CIGRE Study Committee C6 on Distribution Systems and Dispersed Generation, and the Administrative Council of CIGRE.

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### *Harmonic and Interharmonic Distortion due to a wind park*

#### 1) Authors:

**Math Bollen** (Luleå University of Technology and STRI AB, Sweden); **Liang-Zhong Yao** (Areva T&D, UK); **Sarah Rönnberg** (Luleå University of Technology, Sweden); **Mats Wahlberg** (Luleå University of Technology and Skellefteå



Kraft, Sweden).

### 2) Abstract

This paper discusses two aspects of the impact of windparks on the waveform distortion in the power system: emission and resonances. The paper gives a general overview of the emission and shows measurements results from a small but modern windpark connected to a 10-kV feeder.

The paper also gives a general overview of harmonic resonances associated with windparks and illustrates this by means of two numerical examples. Important conclusions from this paper are that harmonic resonances are more likely to be a concern that the emission from windparks, and that the interharmonic emission is more prominent than with existing installations.

### 3) Biographies



**Math Bollen** received his M.Sc. and Ph.D. degrees from Eindhoven University of Technology, Eindhoven, the Netherlands, in 1985 and 1989, respectively.

He is guest professor at EMC-on-site, Luleå University of Technology, Skellefteå, Sweden and the technical manager for power quality and distributed generation at STRI AB, Ludvika, Sweden and. Math Bollen was a research associate at Eindhoven University of Technology from 1989 to 1993; lecturer at the University of Manchester, Institute of Science and Technology between 1993 and 1996; and professor in electric power systems at Chalmers University of Technology, Gothenburg, Sweden, between 1997 and 2003.

His research interests cover a wide range of power-system issues, with special emphasis on power quality and reliability. He has published a number of fundamental papers on voltage dip analysis and two textbooks on power quality. Math Bollen is Fellow IEEE and active in several IEEE, CIGRE and IEC working groups on power quality.



**Liangzhong Yao** received his MSc degree in 1989 and PhD degree in 1993 all in electrical power system engineering from Tsinghua University, Beijing, China. He is currently a Program Manager for Network Solutions, Renewables and Emerging Technologies and also a Technology Consultant and Senior Expert at the AREVA T&D Technology Centre, Stafford, UK.

Prior to AREVA T&D, he was an Associate Professor at Tsinghua University until 1995, and was a Post Doctoral Research Associate in the Manchester Centre for Electrical Energy at University of Manchester (former UMIST), UK from 1995 to 1999, and was a Senior Power System Analyst in the network consulting group at ABB UK Ltd from 1999 to 2004. Dr Yao is a Chartered Engineer and a member of both IET and Cigré, and Guest Professor at Shanghai Jiao Tong University, China.



**Sarah Rönnerberg** received the BSc degree from Luleå University of technology, Skellefteå, Sweden in 2006. Between 2006 and

2009 she was involved in several R&D projects for Skellefteå Kraft and for Luleå University of Technology. Currently she is PhD student at the same university. Her main interests are power quality issues and power line communication in the frequency range between 3 and 148.5 kHz.



**Mats Wahlberg** is currently working at Skellefteå Kraft Elnät. He has been with the company for about 30 years. He has a long and broad experience obtained from involvement in a wide range of tasks. Some examples are calculations of constructions, losses and protection relays. In the last 15 years the main focus of his work has been with power quality issues and different kinds of communications. He is also senior research engineer at Luleå University of technology, Skellefteå

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### *Power injection by distributed generation and the influence of harmonic load conditions*

#### 1) Authors:

**Jan Desmet** (Howest and Ghent University, Belgium);  
**Colin Debruyne** (Howest and Ghent University, Belgium);  
**Johan Vanalme** (Howest and Ghent University, Belgium);  
**Lieven Vandeveld** (Ghent University, Belgium)

#### 2) Abstract

The number of installed distributed generation (DG) in residential areas rapidly increases, specifically in the form of photovoltaics (PV), causing some undesired side effects such as voltage rise. Overvoltage can damage critical loads, but is also disadvantageous for the owner because inverters switch off in case of overvoltage, resulting in output loss.

Since grid connected inverters essentially exhibit nonlinear behavior, harmonic interactions between large numbers of DG systems and the distribution network may occur. Also nonlinear loads inject harmonic currents and induce increased voltage drops over both phase and neutral conductors. This extra supply voltage drop can lead to an even more pronounced production loss of grid coupled inverters.

This contribution gives some guidelines for the maximum power acceptance in a residential grid and the estimation of PV production losses due to overvoltage and discusses the influence of harmonic voltage drops.

#### 3) Biographies

**Jan Desmet** (M '04 – SM '10) received the polytechnical engineer degree from the polytechnic in Kortrijk Belgium in 1983, the M.S degree in electrical engineering in 1993 from the V.U.Brussels Belgium and in 2008 his PhD degree at the KULeuven, Belgium. Since 1984 he is member of the staff of the University College Howest Dept. GKG. Currently he is full professor at the University College Howest teaching power quality, renewables and industrial electric measurement techniques.



His research interests include energy efficiency, renewable, power quality and their mutual interactions. He is also IASTED and IEEE member, member of SC77A (IEC) and TC210 (CENELEC).

**Colin Debruyne** received the Ma. Industrial Engineering Degree (with honors) in Electrotechnical Engineering from Howest, the University College of West Flanders, Kortrijk, Belgium, in 2004. For five years he has been a research assistant at Howest, Kortrijk, mainly in the field of power quality and general electrotechnical engineering. Since '09 he is a Ph.D. student at the University of Gent, Ghent, Belgium, where he is working on improving the magnetization of permanent magnet synchronous motors by supplying a non sinusoidal wave shape. His research interests include low voltage grid analysis, general power quality issues and electrical machines.



**Johan Vanalme** received the M.Sc. degree in Electronics Engineering from the University of Gent, Gent, Belgium, in 1990, and post-graduated in Business Administration at K.U.Leuven, Kortrijk, Belgium, in 1996.

He was with Barco, Kuurne, Belgium, as Electronic Development Engineer, where he designed high end electronics and embedded software for the professional image projection market. Since 2006, he is a research assistant at Howest, the University College of West Flanders, Department of Electromechanical, Electrical and Automation Engineering, Kortrijk, Belgium, and associate researcher at the University of Gent, Engineering Faculty, Department of Electrical Energy, Systems and Automation, Laboratory of Electrical Energy, Ghent, Belgium. He worked on electric motor drive systems and is currently involved in distributed generation and power quality.



**Lieven Vandeveld** (M '05 - SM '07) was born in Eeklo, Belgium in 1968. He graduated in electromechanical engineering at Ghent University in 1992 and is since then with the Electrical Energy Laboratory (EELAB). He received the Ph.D. degree from Ghent University in 1997.

Since 2004, he is professor in electrical power engineering. His research and teaching activities are in the field of electrical power systems, electrical machines and (computational) electromagnetics.

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*Harmonic Distortion and Oscillatory Voltages and the Role of Negative Impedance*

*1) Authors:*

**Peter Heskes** (ECN, the Netherlands); **Johanna Myrzik** (Technical University of Dortmund, Germany); **Wil Kling** (Technische Universiteit Eindhoven, the Netherlands).

*2) Abstract*

This paper focuses on two power quality effects that are noticed with power electronic appliances. One effect is a sub-harmonic oscillation due to the negative differential impedance of constant power loads and the other one a harmonic oscillation by inverters for photo voltaic systems due to a high parallel capacitance and a negative absolute impedance.

This paper focuses on both effects and proposes counter measures to control these effects. For the sub-harmonic oscillatory voltages due to appliances with negative differential impedances, a solution can be found in the voltage control systems of the network power generators. For harmonic oscillations due to photo voltaic inverters, an ancillary service for these inverters is discussed.

*3) Biographies*



**Peter Heskes** received the Electronic Engineer degree from the HTS, The Hague, The Netherlands, in 1980. From 1980 to 1999, he was with a large Dutch electronic-product manufacturer for the military and professional market. He started there as a Product Designer and became a Product Manager of the power-electronic department. His work was related to power electronic converters. In 2000, he started as a Project Coordinator with Intelligent Energy Management at the Energy Research Centre of the Netherlands (ECN), Petten, the Netherlands. His current work is related to power electronic converter technology in grid connected distributed energy systems.

From the beginning of 2007 he combines his work at ECN with a position as a Ph.D. student at the Electrical Power Systems group of the Eindhoven University of Technology. His research interests are power quality issues with the coupling of power electronic converters of distributed energy systems to the electricity network.



**Johanna Myrzik** was born in Darmstadt, Germany in 1966. She received her MSc. in Electrical Engineering from the Darmstadt University of Technology, Germany in 1992. From 1993 to 1995 she worked as a researcher at the Institute for Solar Energy Supply Technology (ISET e.V.) in Kassel, Germany. In 1995 Mrs. Myrzik joined the Kassel University, where she finished her PhD thesis in the field of solar inverter topologies in 2000. From 2000, Mrs. Myrzik has been with the Eindhoven University of Technology, the Netherlands. In 2002 she became an assistant professor and in 2008 associate professor in the field of residential electrical infrastructure.

In 2009 Johanna Myrzik joined the Technical University of Dortmund where she holds a professorship on energy efficiency. Her fields of interests are: power electronics, renewable energy, distributed generation, electrical power supply.

**Wil Kling** received his M.Sc. degree in Electrical Engineering from the Eindhoven University of Technology, Eindhoven, the Netherlands, in 1978. Since 1993, he has been

a part-time Professor with the Delft University of Technology, the Netherlands in the field of Electrical Power Systems. Up till the end of 2008 he was also with TenneT, the Dutch Transmission System Operator, as senior engineer for network planning and strategy. Since Dec. 2008, he has been appointed Chair of the Electrical Energy Systems group, Eindhoven University of Technology. He is leading research programs on distributed generation, integration of wind power, network concepts and reliability issues.

Prof. Kling is involved in scientific organizations such as CIGRE and the IEEE. As Netherlands' representative, he is a member of CIGRE Study Committee C6 on Distribution Systems and Dispersed Generation, and the Administrative Council of CIGRE

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### *Grid inverter ancillary services*

#### 1) Authors:

**Zbigniew Hanzelka** (AGH-University of Science and Technology, Poland); **Irena Wasiak** (Technical University of Lodz, Poland).

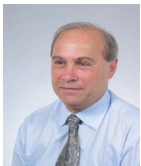
#### 2) Abstract

In this paper the meaning of the term "ancillary services" applies to all additional functions of converters, connected to the supply network, beyond their basic task, i.e. transferring active power/energy in the form suitable to be converted into other forms of energy, adequate for intended purposes.

No limits have been set on the converter power (from kW to MWs), or on the voltage level at which they are connected to the supply network, both the single-phase and three-phase. The only condition is their co-operation with AC power networks.

For the purposes of this paper the converter is considered to be a black box connected to the power system. The objective is to define; (a) new tasks, resulting from the needs of energy sources, transmission and distribution systems operators and end users, which designers of converter can/should undertake and (b) the standardization gap with respect to the converters that perform ancillary services.

#### 3) Biographies



**Zbigniew Hanzelka** is professor in the Institute of Electrical Drive and Industrial Equipment Control of the University of Science and Technology – AGH. He is author and co-author of more than 200 technical and scientific papers. Editor-in-chief of the periodicals: *Electrical Power Quality and Utilization* and *Power Engineering and Electronics*. His area of interest includes electrical power quality, particularly methods of reducing the influence of power converters on supply network. Member of scientific committees of national and international conferences, several national and international committees, among other IEC, UIE, CIGRE and member of Power Electronics - Electric Drives and Electromagnetic Compatibility Committees in Polish Academy of Science.

He is chairman of the Electrical Power Quality Committee (Association of Polish Electrical Engineers SEP).

**Irena WASIAK** graduated from the Technical University of Lodz (TULodz), Poland, where she received Ph.D. and D.Sc. degrees in electrical power engineering. Presently she is an associate professor at the TULodz and the Head of Division of Electrical Power Microsystems and Consumer Networks at the Institute of Electrical Power Engineering. Her research work concerns distributed generation, microsystems, power supply quality and modeling and simulation of power systems operation.




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### *Supervision of renewable energy for its integration in the electrical system*

#### 1) Authors:

**Benoit Robyns** (University of Lille and Ecole des Hautes Etudes d'Ingénieur, France); **Jonathan Sprooten** (University of Lille and Ecole des Hautes Etudes d'Ingénieur, France); **Arnaud Vergnol** (University of Lille and Ecole des Hautes Etudes d'Ingénieur, France).

#### 2) Abstract

As renewable electricity generation is increasing, several concerns are addressed by the Transmission System Operators (TSO) towards the management and the security of the electrical grid. This paper reviews solutions to ease the integration of renewable energy in the electrical systems through enhanced supervision of renewable generation as well as utilisation of short term or medium term storage system. Among these solutions, supervision and storage allow to smooth output power, avoid congestion and participate in primary frequency control. Dynamic power system simulations are shown to illustrate the efficiency of the supervision methods.

#### 3) Biographies

**Benoit Robyns** received the "Ingénieur Civil Electricien" and the "Docteur en Sciences Appliquées" degrees from the Université Catholique de Louvain (UCL), Louvain-la-Neuve, Belgium, in 1987 and 1993, respectively.



He received the "Habilitation à Diriger des Recherches" degrees from the Université des Sciences et Technologies de Lille (USTL), Lille, France, in 2000.

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### V. PANEL SESSION CHAIRS



**Wil L. Kling** (M'95) received the M.Sc. degree in electrical engineering from the Eindhoven University of Technology, the Netherlands, in 1978.

From 1978 to 1983 he worked with Kema, from 1983 to 1998 with Sep and since then up till the end of 2008 he was with TenneT, the Dutch Transmission System Operator, as senior engineer for network planning and network strategy. Since 1993 he is a part-time Professor at the Delft University of Technology and since 2000 also at the Eindhoven University of Technology, the Netherlands. From December 2008 he is appointed as a full Professor and chair of Electrical Energy Systems group at the Eindhoven University of Technology.

He is leading research programs on distributed generation, integration of wind power, network concepts and reliability issues.



**Antje G. Orths** (M'2001) joined the Development Department (Systems Analysis) of Energinet.dk in 2005. Before, she graduated at the Technical University of Berlin, Germany was researcher at the OvG-University Magdeburg, Germany where she received her PhD and then was 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, network planning and optimization problems. Beside her job at Energinet.dk she is adjunct professor at the Otto-von-Guericke University in Magdeburg, Germany. She is member of the IEEE-PES, VDE-ETG and CRIS.