

PROCEEDINGS

# 3<sup>rd</sup> Solar Integration Workshop

International Workshop on Integration  
of Solar Power into Power Systems



21 - 22 October 2013 | London, UK

Giga Sponsor:



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# PROCEEDINGS

Edited by Uta Betancourt / Thomas Ackermann

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# Welcome to...

## the 3rd International Workshop on Integration of Solar Power into Power Systems

We have the great pleasure to welcome you to the **3rd International Workshop on Integration of Solar Power into Power Systems** in London, United Kingdom.

The share of solar power in power systems is increasing in many countries very rapidly, resulting in an increasing interest in this workshop. It took some years from the initial idea before the rising interest in the topic finally led to the organisation of the first Solar Integration Workshop in Aarhus, Denmark two years ago. The feedback was much better than we anticipated, with close to 100 abstracts submitted following the call for papers, which allowed us to compile a very interesting program. This successful first edition encouraged us to stage a second edition of the Solar Integration Workshop (held in Lisbon, Portugal in 2012) and this year's third edition.

The number of submitted abstracts equalled last year's number and thus we are proud to present a challenging one-and-a-half day program. At the time of writing it looks like the number of participants will significantly exceed last year's number. This is a great sign for us as organisers that the issues discussed in this workshop are interesting for many solar integration experts.

The concept of this workshop is based on bringing together utilities, PV/CSP system developers and project developers, power systems operators and other professionals to exchange knowledge and ideas as well as experience in matters relating to the integration of solar energy into power systems.

In addition, I would like to mention that the **3rd Solar Integration Workshop** is just one of several related events such as the **Tutorials for the Solar Integration Workshop** (October 20, 2013) and the **12th International Workshop on Large-Scale Integration of Wind Power into Power Systems as well as on Transmission Networks for Offshore Wind Power Plants** (October 22-24, 2013). For the first time, the Solar Integration Workshop is organised back to back with the First European PV GRID Forum, organised by EPIA. We are very happy about this cooperation with EPIA and hope all participants will benefit from it.

This workshop would not be possible without the support of our Giga Sponsor **DigSILENT**. In addition, the workshop is supported by the European Photovoltaic Industry Association **EPIA** (Belgium), the **IET Digital Library** (United Kingdom) and the Utility Variable Generation Integration Group **UVIG** (USA), and our media partners **Bloomberg New Energy Finance** (United Kingdom), **pvtech.org** (United Kingdom), **SolarBusinessFocus** (United Kingdom) and the **Solar Power Portal** (United Kingdom). Above all, we would like to thank our Mega Sponsor the British TSO **National Grid** for its help and general support in setting up this workshop.

We would also like to thank all those who supported the organisers of this workshop: Helge Urdal (National Grid), Manoël Rekingier (EPIA), all members of the International Advisory Committee as well as Uta Betancourt, Jörg Braun and Ines Drewianka (all Energynautics, Germany).

Enjoy some inspiring days in London and seize the numerous networking possibilities!

**Thomas Ackermann**  
Energynautics

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<sup>1</sup> I would also like to mention that in order to make the contributions to this workshop more easily available for academia and industry world-wide we will submit the proceedings to international libraries and organisations who operate citation index systems such as the (i) FIZ - Fach Informations Zentrum Karlsruhe, (ii) Elsevier, (iii) ETDE, (iv) Reuters, (v) Compendex, (vi) ThomsonCitationIndex.

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09:00 – 10:50 / 21 October 2013 / Room Bartholomew&Harpley / Session chair: Thomas Ackermann  
(Energynautics, Germany)

**TBA**

TBA

**PV Positioning as a Major Player in the Electricity Sector - Market and Technology Trends**

F. Thies (EPIA, Belgium)

**PV Evolution and Coming Challenges from a German TSO Perspective**

A. J. Gesino (TenneT TSO, Germany)

**Italian Experience with PV Integration**

R. Lama (Enel Distribution, Italy)

## Session 2A: Experiences with Large-scale Integration of Solar Power into Power Systems 21

11:20 – 13:00 / 21 October 2013 / Room Bartholomew / Session chair: Charles Smith (UVIG, USA)

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M. Vandenberg, V. Helmbrecht, D. Craciun (DERlab, Germany), H. Loew (BSW, Germany), R. Lama (Enel Distribution, Italy), R. Hermes (RWE Deutschland, Germany), M. Reking, G. Concas (EPIA, Belgium), P. M. Sonvilla (Eclareon, Germany)

**Inverter-Based Voltage Control with Reactive Power: Large-Scale Deployment Results**

C. Dierckxsens, K. De Brabandere, O. Gammoh, (3E, Belgium), B. Bletterie (AIT, Austria), W. Deprez (Infrac, Belgium), Y. T. Fawzy (SMA Solar Technology, Germany), B. Uljanić, B. Blažič (University of Ljubljana, Slovenia), A. Woyte (3E, Belgium)

**Examining the Development of Non-Controllable Photovoltaic and Decentralized Generation Capacity in the Context of Balancing the German Power System**

K. Burges, M. Doering, R. Kuwahata, G. Papaefthymiou (Ecofys Germany, Germany)

**Solar Power and the Future of the Grid**

A. Galiteva (Renewables 100 Policy Institute, USA)

**Costs and Benefits of Fossil-Fueled Plant Flexibility**

D. Lew, G. Brinkman, G. Stark (NREL, USA), G. Jordan, S. Venkataraman (GE Energy, USA), N. Kumar, S. Lefton (Intertek-APTECH, USA)

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(University Carlos III, Spain)

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J.-D. Schmidt, E. Tröster (Energynautics, Germany)

**Domestic Photovoltaic Systems, Battery Storage, and the Economic Impact of Time-of-use Electricity Pricing**

E. McKenna, M. Thomson (Loughborough University, United Kingdom)

**Increasing the Share of PV by a Factor of 2-3 over the Self-use Limit Through Urban Electricity-to-thermal Conversion Schemes**

P. Lund, J. Mikkola (Aalto University, Finland)

**Modelling Concentrating Solar Power with Thermal Energy Storage for Integration Studies**

M. Hummon, P. Denholm, J. Jorgenson, M. Mehos (NREL, USA)

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14:00 – 15:40 / 21 October 2013 / Room Bartholomew / Session chair: Jens Bömer  
(TU Delft, the Netherlands)

**The Impact of Low Voltage Disconnection of Distributed PV on Bulk Electricity System Reliability**

A. Tuohy, A. Gaikwad, J. Taylor, D. Brooks (Electric Power Research Institute, USA)

**Meeting Utility Step Voltage Change Requirements by Providing Precise Voltage Control for a PV Plant on a Distribution Feeder**

J. Díaz de Leon II (AMSC, USA), B. L. Agrawal (Arizona Public Service, USA)

**Technical Assessment of On-Load Tap-Changers in Flemish LV Distribution Grids**

N. Efkarpidis, C. Gonzalez, T. Wijnhoven, D. Van Dommelen, T. De Rybel, J. Driesen (KU Leuven, Belgium)

**Probabilistic Tool Based on Smart Meters Data to Evaluate the Impact of Distributed Photovoltaic Generation on Voltage Profiles in LV Grids**

V. Klonari, F. Vallée (University of Mons, Belgium), O. Durieux (ORES, Belgium), J. Lobry (University of Mons, Belgium)

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14:00 – 15:40 / 21 October 2013 / Room Harpley / Session chair: Helge Urdal  
(National Grid, United Kingdom)

**Pool of Photovoltaic Systems Delivering Control Reserve**

M. Jansen, M. Speckmann (Fraunhofer IWES, Germany), A. von Harpe, M. Hahler (Enerparc, Germany)

**Primary Frequency Control through Grid Connected Photovoltaic Active Generator**

A. N. Azmi, M. Kolhe (University of Agder, Norway)

**PV Generation Capacity Reserve for Intermittency Mitigation and Revenue Maximization**

K. Papastergiou (Formerly ABB Corporate Research, Sweden), N. Efkarpidis (ABB Corporate Research, Sweden)

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A. Tuohy, E. Lannoye (EPRI, Ireland), C. Hansen (Sandia National Laboratories, USA), N. Troy (Electroroute Market Access, Ireland)

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**Active Distribution System Management**

J. Alvarez Fernandez (Eurelectric, Belgium), J. Tello Guijarro (Gas Natural Fenosa, Spain), P. Mandatova (Eurelectric, Belgium), D. Trebolle (Gas Natural Fenosa, Spain)

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P. Vithayasrichareon, G. Mills, I MacGill (University of New South Wales, Australia)

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A. McEachern (Power Standards Lab, USA)

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16:00 – 17:20 / 21 October 2013 / Room Harpley / Session chair: TBA

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J. D. Frank, P. Beaucage, M. C. Brower, M. Grammatico (AWS Truepower, United States)

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M. Hummon, A. Weekley, K. Searight, K. Clark (NREL, USA)

**PV Forecasting Confidence Intervals for Reserve Planning and System Operation**

P. Kreutzkamp, O. Gammoh, K. De Brabandere (3E, Belgium), M. Rekinge (EPIA, Belgium)

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L. Hirth (Vattenfall, Germany)

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J. Gilmore, B. Vanderwaal, I. Rose (ROAM Consulting, Australia)

**100% Renewables in Australia - Will a Capacity Market be Required?**

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**Optimized Residential Loads Scheduling Based on Dynamic Pricing of Electricity: A Simulation Study**

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08:00 – 09:40 / 22 October 2013 / Room Harpley / Session chair: TBA

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J. Usaola, V. Ramírez-Jusdado (Universidad Carlos III, Spain), T. Gafurov, M. Prodanovic (IMDEA Eney, Spain)

**Measurement Based PV Inverter Modelling and Verification**

Z. Fan, T. Gehlhaar (Germanischer Lloyd, Germany), J. Huang, M. Liu (CEPRI, China)

**Quasi Steady-State Modelling of Low-Voltage Connected Photovoltaic Systems for Analysing Distribution Feeder Behaviour During Faults**

B. G. Rawn (KU Leuven, Belgium), S. Torres Romo (Prolec GE, Mexico), M. Gibescu, M. van der Meijden (TU Delft, the Netherlands)

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P. Beaucage, J. D. Freedman (AWS Truepower, USA), J. Zack (MESO, USA), J. Kleissl, B. Urquhart, I. Gohari (UC San Diego, USA), A. Kankiewicz (Clean Power Research, USA)

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D. Pudjianto, P. Djapic, J. Dragovic, G. Strbac (Imperial College London, United Kingdom)

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**The contributions and discussions of this session are not part of the proceedings.**

## Poster Session Papers

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