

# DIGITAL PROCEEDINGS

## 17<sup>th</sup> Wind Integration Workshop

International Workshop on Large-Scale Integration of Wind Power into Power Systems as well as on Transmission Networks for Offshore Wind Power Plants



17 - 19 October 2018 | Stockholm, Sweden

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Organizer:



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## **IMPRINT**

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# 17<sup>th</sup> Wind Integration Workshop

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## Welcome to the 17<sup>th</sup> International Workshop on Large-Scale Integration of Wind Power into Power Systems as well as on Transmission Networks for Offshore Wind Power Plants

We have come a long way from the first edition of the workshop at KTH, Royal Institute of Technology, in Stockholm, Sweden in 2000 and finally, this year, we have come full circle.

17 years, with 16 Wind Integration Workshops under my belt, have been filled with many great experiences and I am looking forward to this special edition at KTH, here in Stockholm. This venue gives us the opportunity to re-visit one of our most historically significant conference cities. I am sure that this time around we will have as many exciting and eye-opening moments as we had at the first Wind Integration Workshops from 2000-2002 that also took place at KTH.

The Wind Integration Workshop itself is actually a spin off from the Stockholm located Institute. The first three editions were held by KTH until the event had become too popular and needed its own organizational structure and conference planning team. This year, we go back to the roots of the Wind Integration Workshop and again cooperate with the Royal Institute of Technology for the event's 17<sup>th</sup> edition. I would like to seize this opportunity and thank our local partners Lars Nordström and Lennart Söder of the Co-Organizer **KTH – Royal Institute of Technology** and Jonas Persson of **Vattenfall** for their great support!

As conference planning and consulting company in RE grid integration, Energynautics is well aware that in our line of work it is crucial to keep pace with the times. That is why the Energynautics workshops have always succeeded in reflecting the shifting focuses in the area of RE grid integration. Last year, we took the next step towards a comprehensive yet diverse RE conference experience and commemorated the first edition of the E-Mobility Power System Integration Symposium as we feel it necessary to discuss the impact of a larger share of EVs in transportation on the grid.

Nowadays, it is more important than ever to pool our research and combine our forces to make change happen and give our planet a fair chance. That is why we maintain last year's Workshop setup and again offer three conferences in one week that go hand in hand. **The Grid Integration Week 2018** that also features the **2<sup>nd</sup> E-Mobility Power System Integration Symposium** and the **8<sup>th</sup> Solar Integration Workshop** offers many combination opportunities for its participants to account for the inherent synergies of the conference topics.

While bringing people together has always been the workshop's purpose, it is our guests' participation, their papers and their presentations that fill the frame we set with life. In 2000, we started with 4 sessions in total – this year we received such a large number of outstanding abstracts that we can offer again a two-and-a-half day program with 23 sessions.

The programs of the Wind and Solar Workshops for example are especially designed to include sessions that are suitable for both interest groups on the shared Wednesday, like the joint session of IEA Wind Task 25 and PV Integration Task 14 "Highlights and Trends from International Collaboration on Solar and Wind Integration". Another recurring focus of this year's workshop will be ancillary services. Due to last year's great feedback, we offer the **Wind Tutorial "Ancillary Services and Wind Power Plants: Status and Experiences"** again on 16 October 2018.

We work hard at these Workshops, but it is very important to me personally to give our participants the time to mingle and network in a more casual setting as well. That is why the Wind Integration Workshop offers Accompanying Events such as the combined Solar and Wind Dinner (17 October 2018) that will take place at the spectacular Vasa Museum. It is the perfect opportunity to mingle with both solar and wind experts. On Thursday, the spotlight will be on our poster presenters. Researchers and practitioners present their projects in poster sessions during the Workshop and at the especially dedicated Poster Reception on 18 October 2018. This Networking Event is a platform for poster presenters to showcase their findings and discuss them with workshop participants in a casual get-together. This year, we offer our poster presenters the opportunity to present their research in flash talks during the evening reception. I encourage you to make good use of these unique educational and networking opportunities!

The most interesting papers from the Solar and Wind Workshops will again be published in a Special Edition of the IET Renewable Power Generation (due Jan/Feb 2020)<sup>1</sup>. Because of the high interest in the workshop proceedings, we will again submit this year's proceedings to international libraries and organizations who operate citation index systems such as the (i) FIZ – Fach Informations Zentrum Karlsruhe, (ii) Elsevier, (iii) ETDE, (iv) Reuters, (v) Compendex, (vi) Thomson Citation Index, (vii) EBSCO Information Services so that the proceedings are more easily available for academia and industry worldwide.

The 17<sup>th</sup> Wind Integration Workshop would not be possible without our sponsors and we would like to thank them for their support. Our Tera Sponsors this year are the wind turbine manufacturers **ENERCON** (Germany) and **Vestas** (Denmark), our Giga Sponsors are the consulting and software company **DigSILENT** (Germany), the energy company **Ørsted** (Denmark), the wind turbine manufacturer **Siemens Gamesa** (Denmark) and the power company **Vattenfall** (Sweden).

In addition, the workshop is supported by ENTSO-E (Belgium), ESIG – Energy Systems Integration Group (USA), the IET Digital Library (United Kingdom), Power Circle (Sweden), Renewables Grid Initiative (Germany) and Wind Europe (Belgium) as well as the media partner WindTech International (Netherlands).

I would also like to thank all those who supported the organizers of this workshop: all the members of the International Advisory Committee as well as Uta Betancourt, Ines Drewianka, Katharina Fischer and Anke Ost (all Energynautics, Germany).

**Let me seize this opportunity to announce that next year's Wind Integration Workshop will take place in October/November 2019 in Dublin, Ireland!**



Enjoy some inspiring days in Stockholm and seize the numerous networking opportunities!

**Thomas Ackermann**  
Energynautics

PS: Comments are always welcome, feel free to contact me at: [t.ackermann@energynautics.com](mailto:t.ackermann@energynautics.com)

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<sup>1</sup> The first special edition based on the 2013 Workshop was published in January 2015 (Volume 9, Issue 1), the special edition from the 2014 Berlin Workshop was published in January 2016 (Volume 10, Issue 1), the special edition from the 2015 Brussels Workshop was published in February 2017 (Volume 11, Issue 3), the special edition from the 2017 Berlin Workshop will be published in March 2019, see <http://digital-library.theiet.org/content/journals/iet-rpg>

## International Advisory Committee

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WEDNESDAY 17 OCTOBER 2018			THURSDAY 18 OCTOBER 2018			FRIDAY 19 OCTOBER 2018				
Wind Workshop Day 1			Wind Workshop Day 2			Wind Workshop Day 3				
			08:30 – 10:40	M1 SESSION 3A: ANCILLARY SERVICES I – FREQUENCY CONTROL	M2 SESSION 3B: OFFSHORE WIND ASPECTS	M3 SESSION 3C: NEDO FORECASTING PROJECTS	08:40 – 10:40	Q1 SESSION 7A: GRID CODE ASPECTS II	Hyllan SESSION 7B: MARKET AND REGULATORY ISSUES	
				10:40 – 11:00 Coffee Break				10:40 – 11:10 Coffee Break		
9:00 – 14:00	Foyer		11:00 – 13:00	M1 SESSION 4A: STORAGE ISSUES	M2 SESSION 4B: MIGRATE PROJECT	M3 SESSION 4C: MODELLING ASPECTS	11:10 – 13:10	Q1 SESSION 8A: BALANCING ISSUES	Hyllan SESSION 8B: POWER QUALITY ISSUES II	
	CHECK-IN & ON-SITE REGISTRATION			13:00 – 13:15 Group Photo // 13:15 – 14:15 Lunch				13:15 – 14:15 Lunch		
	13:00 – 14:00 Lunch									
14:00 – 15:50	M1		14:15 – 16:00	M1 SESSION 5A: DISTRIBUTED GENERATION	M2 SESSION 5B: GRID CODE ASPECTS I	M3 SESSION 5C: SECTOR COUPLING	14:15 – 15:45	Q1 SESSION 9A: INTEGRATION SOLUTIONS	Hyllan SESSION 9B: FORECASTING II	
	WELCOME & SESSION 1: KEYNOTE SESSION			16:00 – 16:30 Coffee Break				15:45 – 15:55 Short Break		
	15:50 – 16:20 Coffee Break									
16:20 – 18:30	M1 SESSION 2A: IEA TASKS 14 & 25	M2 SESSION 2B: GRID FORMING	M3 SESSION 2C: FORECASTING I	16:30 – 18:45	M1 SESSION 6A: ANCILLARY SERVICES II	M2 SESSION 6B: POWER SYSTEM STUDIES	M3 SESSION 6C: POWER QUALITY ISSUES I	15:55 – 16:55	Q1 SESSION 10: CLOSING SESSION – PODIUM DISCUSSION	
19:00	Solar & Wind Dinner		18:45	Poster Reception & Networking						



## DIGITAL PROCEEDINGS – TABLE OF CONTENTS

### WEDNESDAY, 17 OCTOBER 2018

14:10 – 15:50 SESSION 1 – KEYNOTE SESSION

> Session Chair T. Ackermann (Energynautics, Germany)

- **Next-Gen Generation System: The Symbiotic Relationship of Solar, Wind & Storage Hybrid Power Plants**  
Paulina Asbeck (Vattenfall, Germany)
- **The Path Towards a 100% Renewable Swedish Power System**  
Lennart Söder (KTH – Royal Institute of Technology, Sweden)
- **Overview of Renewables in the ERCOT System**  
Julia Matevosyan (ERCOT, USA)
- **Presentation 4**  
TBA

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

16:20 – 18:30 SESSION 2A – JOINT SESSION OF IEAWIND TASK 25 & PV INTEGRATION TASK 14:

HIGHLIGHTS AND TRENDS FROM INTERNATIONAL COLLABORATION ON SOLAR AND WIND INTEGRATION

> Session Chair Hannele Holttinen (VTT, Finland) / Roland Bründlinger (AIT, Austria)

- **Introduction: Summary of Wind and Solar Integration Study Results – IEA WIND Task 25 and IEA PVPS Task 14 Collaboration**  
H. Holttinen (OA Task 25, VTT, Finland), P. B. Eriksen, A. Orths (Energinet, Denmark), A. Estanqueiro (LNEG, Portugal), B. Mather (NREL, USA), M. Kraiczky, A. Scheidler, J. Ulfers, M. Braun, B. Ernst (Fraunhofer IEE, Germany), Y. Ueda (Tokyo University of Science, Japan)
- **Country Highlights and Trends on Solar and Wind Integration – Country experts from:**
  - USA (B.-M. Hodge, NREL)
  - Japan (Y. Ueda, Tokyo University of Science)
  - Denmark (A. Orths/P. Borre Eriksen – Energinet dk, Denmark),
  - Portugal (A. Estanqueiro – LNEG, Portugal)
- **IEA-PVPS Task 14**  
Coordination between Distribution Network and Transmission Network Operation – Relevance for Solar and Wind Integration. IEA-PVPS Task 14 Report briefing: Bernhard Ernst (Fraunhofer IEE, Germany)

16:20 – 18:30 SESSION 2B – GRID FORMING

> Session Chair Helge Urdal (Urdal Power Solutions, United Kingdom)

Co-chair: Thomas Ackermann (Energynautics, Germany)

- **Grid Forming – Introduction about the need: Essence from Europe / GB**  
H. Urdal (Urdal Power Solutions, United Kingdom) ([Submission-ID WIW-344](#))
- **E.ON Energy Distribution Microgrid in Southern Sweden – Control, Operation, Management and Power Quality within a 100% Converter, Zero-inertia Microgrid**  
M. Hirst (EON, Sweden) ([Submission-ID WIW-345](#))
- **Experience of Grid Forming Power Converter Control**  
P. Brogan, T. Knueppel, D. Elliott (Siemens Gamesa Renewable Energy, United Kingdom), N. Goldenbaum (Siemens Gamesa Renewable Energy, Denmark) ([Submission-ID WIW-343](#))
- **Requirements for Control Strategies of Grid Connected Converters in the Future Power System**  
H. Emanuel, K. Pierros (ENERCON, Germany), J. Brombach, R. Rosso (WRD, Germany) ([Submission-ID WIW18-68](#))
- **Grid Forming Control for Stable Power Systems with up to 100 % Inverter Based Generation: A Paradigm Scenario Using the IEEE 118-Bus System**  
M. Ndreko, S. Rüberg, W. Winter (TenneT TSO, Germany) ([Submission-ID WIW18-172](#))

16:20 – 18:30 SESSION 2C – FORECASTING I

> Session Chair TBA

- **IEA Wind Recommended Practices for the Implementation of Wind Power Forecasting Solutions – Part 1: Forecast solution selection process**  
C. Möhrten (WEPROG, Denmark) ([Submission-ID WIW18-133](#))
- **IEA Wind Recommended Practices for the Implementation of Wind Power Forecasting Solutions – Part 2 & 3: Designing and Executing Forecasting Benchmarks and Evaluation of Forecast Solutions**  
C. Möhrten (WEPROG, Denmark), J. Lerner (Vaisala, USA), J. W. Messner (Anemo Analytics, Denmark), J. Browell (University of Strathclyde, United Kingdom), A. Tuohy (EPRI, USA), J. Zack (UL AWS Truepower, USA), C. Collier (DNV GL, USA), G. Giebel (DTU Wind Energy, Denmark) ([Submission-ID WIW18-160](#))
- **Evaluation of Recent Advancements in Machine Learning Methods in Very Short-term Time Series Forecasts of Wind Power Production**  
J. Zack (UL AWS Truepower, USA) ([Submission-ID WIW18-184](#))
- **Considering Curtailments in Wind Power Forecasting**  
J. Koch, D. Jost, A. Braun, J. Dobschinski (Fraunhofer IEE, Germany) ([Submission-ID WIW18-93](#))
- **How to Combine State-of-the-art Multi-Scale Numerical Wind Power Forecasts and Benefits of a Human Meteorological Expertise?**  
O. Vannier, A. Ben Daoud, A. Falgon, G. Bontron (Compagnie Nationale du Rhône, France) ([Submission-ID WIW18-197](#))
- **Machine Learning Approach for Probabilistic Wind Power Forecasts with Discrete Probability Density Function**  
A. Kaifel, M. Felder, F. Sehnke, K. Ohnmeiß, L. Schröder (Center for Solar Energy and Hydrogen Research – ZSW, Germany) ([Submission-ID WIW18-292](#))



### 08:30 – 10:40 SESSION 3A – ANCILLARY SERVICES – FREQUENCY CONTROL

> Session Chair Eckehard Tröster (Energynautics, Germany)

- **Mixed Grid Forming and Grid Following Wind Power Plants for Black Start Operation**  
J. Martínez-Turégano, S. Añó-Villalba, S. Bernal-Pérez (Universitat Politècnica de Valencia, Spain), R. Peña (University of Concepción, Chile), R. Blasco-Gimenez (Universitat Politècnica de Valencia, Spain) ([Submission-ID WIW18-232](#))
- **Frequency Services for Grid Support: International Experiences from On-shore and Off-shore Wind Farms**  
S. Bolik (Senvion, United Kingdom), S. Hansen (Senvion, Germany) ([Submission-ID WIW18-83](#))
- **The Impact of Inertia Emulation on Damping of Inter-Area Power Oscillations during Under-Frequency Events in the Nordic Power System**  
T. Kujansuu, A. Harjula (Fingrid Oyj, Finland), R. Ogiewa, Y. Chompoobutrgool (ENERCON, Germany/Sweden) ([Submission-ID WIW18-5](#))
- **Potential for Provision of Ancillary Services from Wind Generation Resources in ERCOT**  
J. Matevosyan, C. Anderson (ERCOT, USA) ([Submission-ID WIW18-71](#))
- **Pen Y Cymoedd Delivery of Enhanced Frequency Response in UK by a Battery Energy Storage System**  
F. Daraiseh, J. Persson (Vattenfall R&D, Sweden), S. Gerhard (Vattenfall, Germany), N. Entwistle (Vattenfall, United Kingdom) ([Submission-ID WIW-287](#))
- **Comparison of Different Estimation Methods for the Grid Frequency Using the Example of a System Split in the Interconnected Electrical Power System**  
H. Becker, H. Sölter, L. Hofmann (Fraunhofer IEE, Germany) ([Submission-ID WIW18-119](#))
- **Sneak Preview: PowerDynamics.jl – An Open-Source Library for Analyzing Dynamic Stability in Power Grids with High Shares of Renewable Energy**  
T. Kittel, S. Auer, C. Horn (PIK – Potsdam Institute for Climate Impact Research, Germany) ([Submission-ID WIW-290](#))

### 08:30 – 10:40 SESSION 3B – OFFSHORE WIND ASPECTS

> Session Chair Michael Nørtoft Frydensbjerg (Vattenfall, Denmark)

- **Validation and Assessment of the High Definition Modular Multilevel Converter for Offshore Wind Turbines and Other Medium Voltage Applications**  
M. Smailes, C. Ng (Offshore Renewable Energy Catapult, United Kingdom), R. Torres-Olguin, S. D'Arco (SINTEF, Norway), A. Perez-Basante (Tecnalia, Spain), J. L. Dominguez (Catalonia Institute for Energy Research – IREC, Spain) ([Submission-ID WIW18-35](#))
- **Eigenvalue-based Stability Analysis of Sub-synchronous Oscillation in an Offshore Wind Power Plant**  
L. Shuai, R. Sharma, K. H. Jensen, J. N. Nielsen, D. Murcia (Siemens Gamesa Renewable Energy, Denmark), S. Pirzada, P. Brogan, P. Godridge (Siemens Gamesa Renewable Energy, United Kingdom) ([Submission-ID WIW18-148](#))
- **Kriegers Flak Combined Grid Solution – Principles of Voltage and Reactive Power Control for HVAC/HVDC Meshed Offshore Grids**  
V. Akhmatov, T. Bentzon Sørensen (Energinet, Denmark), A. K. Marten, R. Stornowski (50Hertz-Transmission, Germany) ([Submission-ID WIW18-245](#))
- **A Fault Handling Current Control Strategy for Offshore Wind Power Plants with Diode Rectifier HVDC Transmission**  
C. Neumann, H.-G. Eckel (University of Rostock, Germany), S. Achenbach (Siemens, Germany) ([Submission-ID WIW18-16](#))
- **Stability Analysis of Offshore Wind Farms with Fixed Frequency and Diode Rectifier HVDC Connection**  
C. Prignitz, H.-G. Eckel (University of Rostock, Germany), S. Achenbach (Siemens, Germany) ([Submission-ID WIW18-301](#))
- **Analysis and Mitigation of Storm and Ramping Risks from Offshore Wind Power in Belgium**  
R. Baetens, S. Declercq, A. Woyte, C. Guerrero (3E, Belgium) ([Submission-ID WIW18-125](#))

- **Japan's R&D Project of Ramp Forecasting Technology: Project Overview**  
T. Suga, Takahiro, N. Hayasaki (ITOCHU Techno-Solutions Corporation, Japan), K. Ogimoto (The University of Tokyo, Japan) (Submission-ID WIW18-168)
- **Japan's R&D Project of Ramp Forecasting Technology: Probabilistic Forecast Based on Dynamical and Statistical Ensemble Methods**  
D. Nohara, S. Kadokura, M. Ohba, T. Watanabe (Central Research Institute of Electric Power Industry, Japan) (Submission-ID WIW112)
- **Japan's R&D Project of Ramp Forecasting Technology: Deterministic Forecast with Post-processing Using Real-time Monitoring Data**  
S. Kadokura, D. Nohara, M. Ohba, A. Hashimoto, K. Nakao, Y. Hattori, T. Watanabe, H. Hirakuchi (Central Research Institute of Electric Power Industry, Japan) (Submission-ID WIW18-6)
- **Japan's R&D Project of Ramp Forecasting Technology: Meteorological Pattern Analysis Method**  
M. Okada, T. Ichizawa, Y. Nakamura, K. Yamaguchi, R. Kodama, N. Ogasawara (Japan Weather Association, Japan), H. Kato, Y. Nagano (Nihon University, Japan), R. Ikeda, V. Q. Doan, H. Kusaka, T. Araki, N. N. Ishizaki (University of Tsukuba, Japan) (Submission-ID WIW18-107)
- **Japan's R&D Project of Ramp Forecasting Technology: Correction Method with Additive Model for NWP-based Wind Speed Forecast**  
T. Araki, R. Ikeda, V. Q. Doan, N. Ishizaki, H. Kusaka (University of Tsukuba, Japan) (Submission-ID WIW18-122)
- **Japan's R&D Project of Ramp Forecasting Technology: A Machine Learning Scheme for Ramp Forecast**  
Y. Fujimoto, K. Higashiyama, Y. Hayashi (Waseda University, Japan) (Submission-ID WIW18-156)
- **Japan's R&D Project of Ramp Forecasting Technology: A Forecast Integration Method**  
T. Takeuchi, Y. Hirata, S. Horai, K. Aihara (The University of Tokyo, Japan) (Submission-ID WIW18-145)
- **Japan's R&D Project of Ramp Forecasting Technology: Metrics for Evaluating Ramp Forecast**  
K. Yoshida, N. Hayasaki, N. Ushigami (ITOCHU Techno-Solutions Corporation, Japan), N. Ogasawara, M. Okada, Y. Nakamura (Japan Weather Association, Japan) (Submission-ID WIW18-140)

- **Is Cheap Electricity Storage Essential to Build an Energy System Based on Wind and Solar Power?**  
L. Reichenberg, E. Nyholm (Chalmers University of Technology, Sweden) (Submission-ID WIW18-282)
- **Enabling 80+ Percent Share of Wind and Solar in Lithuanian Power Sector: Role of Storage Technologies**  
J. Jasiūnas, L. Söder (KTH Royal Institute of Technology, Sweden) (Submission-ID WIW18-48)
- **Role of Motor Loads and Battery Energy Storage for Active Power Controls by Wind Power**  
H. N. Villegas Pico, V. Gevorgian, P. Koralewicz, R. Wallen (NREL, USA) (Submission-ID WIW-32)
- **Balancing by Wind and Energy Storage**  
A. Linder, A. Kosareva, K. Kunz, D. McMullin (ENERCON, Germany), B. Lenz (Wobben R&D, Germany) (Submission-ID WIW18-103)
- **Utilization of Battery Energy Storage to Assist Renewable Energy Networks**  
L. O. Shobayo (University of Huddersfield, United Kingdom), N. Zhao (University College Dublin, Ireland), Y. Hu, N. Schofield (University of Huddersfield, United Kingdom) (Submission-ID WIW18-204)

11:00 – 13:00 SESSION 4B – PANEL DISCUSSION: THE MASSIVE INTEGRATION OF POWER ELECTRONIC DEVICES (MIGRATE) IN FUTURE POWER SYSTEMS – CHALLENGES AND SOLUTIONS

> Session Chair Jako Kilter (Elering/TU Tallinn, Estonia)

- **MIGRATE Project and Future Power Systems**  
J. Kilter (Elering/Tallinn University of Technology, Estonia) (Submission-ID WIW18-329)
- **Large Disturbance Rotor Angle Stability Analysis in Power Systems with High Penetration Levels of Wind Power**  
D. Wang (TU Delft, Netherlands) (Submission-ID WIW18-330)
- **Operation of Wide-Area-Controls in Iceland**  
B. Heimisson (Landsnet, Iceland) (Submission-ID WIW18-331)
- **Experimentation Results : Grid Forming Control Interoperability Tests and Current Limitation**  
T. Prevost (RTE, France) (Submission-ID WIW18-332)
- **Relay and System Protection Challenges in Future Power Systems**  
R. Andrino Gallego (REE, Spain) (Submission-ID WIW18-333)
- **Power Quality and Grid Codes in View of Massive Integration of Power Electronic Devices**  
M. Val Escudero (Eirgrid, Ireland) (Submission-ID WIW18-334)

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

11:00 – 13:00 SESSION 4C – MODELLING ASPECTS

> Session Chair TBA

- **Investment Analysis on Transmission Lines using TIMES-JMRT Grid Model under a Scenario with large amount of Renewable**  
Y. Yasuda (Kyoto University, Japan), H. Hamasaki (Fujitsu Research Institute, Japan) (Submission-ID WIW18-149)
- **Impact of Technical Parameters and Data Quality on Wind Energy Modeling in Germany**  
D. Beulertz, A. Schnettler (RWTH Aachen University, Germany) (Submission-ID WIW18-255)
- **DLR Use for Optimization of Network Design with Very Large Wind (and VRE) Penetration**  
A. Estanqueiro, J. Duque, D. Santos (LNEG, Portugal), K. Morozovska, P. Hilber, L. Söder (KTH Royal Institute of Technology, Sweden), C. Ahlrot (E.ON, Sweden), J. P. Gentle, A. W. Abboud (INL – Idaho, USA), T. Kanefendt (Fraunhofer IEE, Germany) (Submission-ID WIW18-263)
- **North Sea Offshore Grid Development: Combined Optimization of Grid and Generation Investments Towards 2050**  
M. Koivisto, P. Sørensen, J. Gea-Bermúdez (DTU, Denmark) (Submission-ID WIW18-142)
- **A Machine Learning Approach to Low System Strength Grid Identification for Large Scale Power Systems**  
A. Clark (KTH Royal Institute of Technology, Sweden | Texas A&M University, USA), Y. Zhang, S. H. Huang (ERCOT, USA), L. Xie (Texas A&M University, USA) (Submission-ID WIW18-191)

14:15 – 16:10 SESSION 5A – DISTRIBUTED GENERATION ASPECTS

> Session Chair Eckard Quitmann (ENERCON, Germany)

- **Operational Options to Integrate Decentralized Generation into Restoration Processes after Severe System Black Outs**  
H. Becker, D. Mende (Fraunhofer IEE, Germany), A. Bernhart, U. Spanel (DUtrain, Germany), J. Brombach (I4E: Innovation for Enercon, Germany) (Submission-ID WIW18-118)
- **The Impact of Renewable Energy Schemes on Electrical Power Networks.**  
P. Marinakis (HVDC Technologies, United Kingdom), N. Schofield (University of Huddersfield, United Kingdom) (Submission-ID WIW-206)
- **Optimal Provision of Frequency Containment Reserve with Hybrid Power Plants**  
C. Ionita, A. G. Raducu, N. Styliaras, J. Funkquist (Vattenfall R&D, Sweden) (Submission-ID WIW18-265)
- **Usability of Flexible Demand and Generation in the BDEW Smart Grid Traffic Light Concept**  
L. Hülsmann, J.-D. Schmidt, E. Tröster (Energynavics, Germany), M. Koch, U. Ohl (EWR Netze, Germany) (Submission-ID WIW18-327)
- **Advanced Inertial Response Control Based on Disturbance Observer in Microgrid with Wind Power**  
J. Qi, T. Tsuji (Yokohama National University, Japan) (Submission-ID WIW18-300)

14:15 – 16:00 SESSION 5B: GRID CODE ASPECTS I

> Session Chair Jens Fortmann (HTW Berlin – University of Applied Sciences, Germany)

- **Importance of Voltage-dip Knowledge for Improving Fault-ride-through of Wind Power Installations**  
A. Bagheri, M. Bollen, S. K. Rönnberg (Luleå University of Technology, Sweden), C. Chen (KTH Royal Institute of Technology, M. Bongiorno (Chalmers University of Technology, Sweden) ([Submission-ID WIW18-102](#))
- **Wind Farm Fault Ride Through – An Irish Context**  
J. Whelan, A. McDonnell, J. Kelleher, S. Hunt (ESB International, Ireland) ([Submission-ID WIW18-187](#))
- **Do we Need a Network Code on Cyber Security? How to Address Cyber Security Requirements in a Power System with High Penetration of Distributed Generation?**  
M. Doering, E. Haesen (Ecofys, Germany), M. Uslar, L. Fischer (OFFIS, Germany) ([Submission-ID WIW18-237](#))
- **FRT Test System Compact for 27 MVA with Less Grid Burdens**  
R. Klosse (WindGuard Certification, Germany) ([Submission-ID WIW18-240](#))

14:15 – 16:00 SESSION 5C – SECTOR COUPLING AND LARGE SCALE DECARBONIZATION OF POWER SUPPLY

> Session Chair TBA

- **The Impact of Sector-coupling on Transmission Reinforcement in a Highly Renewable European Energy Scenario**  
J. Hörsch, V. Hagenmeyer, T. Brown (KIT Karlsruhe Institute of Technology, Germany) ([Submission-ID WIW18-188](#))
- **Sector Coupling: Renewable Gas from Offshore Wind and Offshore Electrolysers to Decarbonise Heat and Transport**  
S. Hill, M. Jansen, I. Staffell (Imperial College London, United Kingdom) ([Submission-ID WIW18-257](#))
- **Steps to Decarbonise Power Industries Internationally – A sound method for comparing apples and pears**  
K. Burges (RE-xpertise, Germany), M. Hagemann, M. J. Kurdziel, K. Riechers, F. Röser (New Climate Institute, Germany) ([Submission-ID WIW18-215](#))
- **Modeling the Dynamics and Control of Power Systems with High Share of Renewable Energies**  
S. Auer, T. Kittel (Potsdam Institute for Climate Impact Research – PIK, Germany) ([Submission-ID WIW18-143](#))

16:30 – 18:45 SESSION 6A – ANCILLARY SERVICES II

> Session Chair Julia Matvosyan (ERCOT, USA)

- **Reactive Power in High RES-Senarios – Rethinking one of the non-frequency ancillary services**  
K. Burges (RE-xpertise, Germany), M. Döring (Ecofys, Germany) ([Submission-ID WIW18-211](#))
- **System Services by Wind Power Plants Supporting 75% Wind Penetration in Ireland**  
M. Gilsean, D. McMullin (ENERCON, Ireland), S. Engelken (WRD Wobben Research and Development, Germany) ([Submission-ID WIW18-67](#))
- **Validation using an Experimental Test-bed System for Ancillary Services of Wind Power Plants**  
L. Rezai, F. Pöschke, M. Andrejewski, M. Engel, J. Fortmann (HTW Berlin – University of Applied Sciences, Germany) ([Submission-ID WIW-196](#))
- **Frequency Response of Energy Storage Systems in Grids with High Level of Wind Power Penetration – Gotland Case Study**  
F. Daraiseh, V. Gliniewicz, E. Lidström (Vattenfall R & D, Sweden) ([Submission-ID WIW18-75](#))
- **Frequency Support Provision to Power Systems from HVDC-Based Offshore Wind Power Plants**  
A. Bidadfar, O. Saborio-Romano, M. Altin, N. A. Cutululis, P. E. Sørensen (DTU, Denmark), E. Prieto-Araujo, O. Gomis-Bellmunt (CITCEA-UPC, Spain) ([Submission-ID WIW18-81](#))
- **Active Power Control for Mitigation of Very-Short-term and Short-term Fluctuation of Wind Power**  
C. T. Urabe, T. Saitou, K. Ogimoto (The University of Tokyo, Japan) ([Submission-ID WIW-108](#))

- **Thailand Renewable Grid Integration Study**  
C. Hart, P. Vithayasrichareon and S. Mueller (IEA, France)
- **Systemic Issues of Converter-based Generation and Transmission Equipment in Power Systems**  
K. Vennemann, T. Hennig (Amprion, Germany), E. Grebe (External Advisor, Germany), W. Winter, G. Deiml (TenneT TSO, J. Lehner, H. Abele (TransnetBW, Germany), J. Weidner, R. Stornowski (50Hertz Transmission, Germany) ([Submission-ID WIW-92](#))
- **Analysis of Power System Oscillation Stability with Large Integration of Renewable Generations**  
L. Cai (University of Rostock, Germany), U. Karaagac (Hong Kong Polytechnic University, Hong Kong), J. Mahseredjian (Polytechnique Montréal, Canada) H.-G. Eckel, H. Weber ([Submission-ID WIW18-150](#))
- **Continental-Scale Grid Planning and Operations Modeling**  
G. Brinkman, A. Bloom, J. Ho, J. Novacheck (National Renewable Energy Laboratory, USA) ([Submission-ID WIW18-298](#))
- **Approach to Design and Review the System Defence Plan for Over-frequency to Ensure Frequency Stability in the ENTSO-E Continental Europe Synchronous Area**  
J. Lehner (TransnetBW, Germany), J. Weidner (50Hertz Transmission, Germany), T. Hennig (Amprion, Germany), G. Deiml (Tennet, Germany) ([Submission-ID WIW18-64](#))
- **Development of Wind Ramp Forecasting Technology in the National R&D Project (in Japan): Evaluation of Developed Forecasts by Power System Operation Simulation**  
Y. Nishitsuji, Y. Udagawa, K. Ogimoto (University of Tokyo, Japan), K. Ukegawa (Kozo Keikaku Engineering, Japan), S. Fukutome (JP Business Service Corporation, Japan) ([Submission-ID WIW-180](#))

- **How Large Wind Parks Contribute to Harmonic Waveform Distortion**  
D. Schwanz, M. H. J. Bollen, S. Rönnerberg, A. Larsson (Luleå University of Technology, Sweden) ([Submission-ID WIW18-101](#))
- **Method for Harmonic and TOV Connection Impact Assessment of Offshore Wind Power Plants – Part I: Harmonic Distortion**  
R. de Groot, F. van Erp, K. Jansen, J. van Waes (TenneT TSO, Netherlands), M. Hap, L. Thielman (Tractebel Engineering, Belgium) ([Submission-ID WIW18-124](#))
- **Method for Harmonic and TOV Connection Impact Assessment of Offshore Wind Power Plants – Part II: TOV Impact Assessment**  
K. Jansen, R. de Groot, B. van Hulst (TenneT TSO, Netherlands), K. Velitsikakis, C. Engelbrecht (DNV GL, Netherlands) ([Submission-ID WIW18-129](#))
- **Case Study: Reliability of the Summation Method to Assess the Harmonic Current due to a Wind Power Plant**  
K. Redondo, I. Azcarate, J. J. Gutierrez, P. Saiz, L. A. Leturiondo (University of the Basque Country (UPV/EHU), Spain), S. Lodetti (CIRCE University of Zaragoza, Spain) ([Submission-ID WIW18-116](#))
- **Active Filtering with Large-Scale STATCOM for the Integration of Offshore Wind Power**  
M. Lehmann, M. Pieschel (Siemens, Germany), M. Juamperez, K. Kabel, Ł. H. Kocewiak (Ørsted, Denmark), S. Sahukari (Ørsted, United Kingdom) ([Submission-ID WIW-61](#))
- **Analysis of Harmonic Summation in Wind Power Plants Based on Harmonic Phase Modelling and Measurements**  
M. Eltouki, T. W. Rasmussen (DTU, Denmark), E. Guest (DTU, Denmark | Siemens Gamesa Renewable Energy, Denmark), L. Shuai (Siemens Gamesa Renewable Energy, Denmark), Ł. Kocewiak (Ørsted, Denmark) ([Submission-ID WIW18-164](#))

08:40 – 10:40 SESSION 7A – GRID CODE ASPECTS II

> Session Chair Sigrid Bolik (Senvion, United Kingdom)

- **Wind Farm Grid Code Compliance Testing: Different Approaches, Biggest Hurdles and the Foreseeable Future**  
B. Hahn, T. Rösner, J. Fleischhauer, M. Fernandez (Nordex Energy, Germany) ([Submission-ID WIW18-96](#))
- **Use of Full-order Electro-magnetic Transient Models for Grid Compliance Assessment of Wind Turbines: Part I**  
P. Ghimire, I. Szczesny, R. Sharma, F. Martin, P. Mahat (Siemens Gamesa Renewable Energy, Denmark) ([Submission-ID WIW18-195](#))
- **Grid Code Certification in Germany – A Recipe for Europe?**  
B. Schowe-von der Brelie, C. Scheefer, C. Lütke-Lengerich, A. Hoppmann (FGH Certification Body, Germany) ([Submission-ID WIW18-87](#))
- **Comparison of Impedance Characteristics of Medium Voltage Grid Simulator with LVRT-Container during Symmetrical Voltage Dip**  
S. Azarian, T. Jersch, S.Khan (Fraunhofer IWES, Germany) ([Submission-ID WIW18-216](#))
- **Analysis of HVDC and Wind Turbine Converter Response during Offshore Asymmetrical Faults**  
Ö. Gökso, N. A. Cutululis, P. Sørensen (DTU Wind Energy, Denmark) ([Submission-ID WIW18-229](#))

08:40 – 10:40 SESSION 7B – MARKET AND REGULATORY ISSUES

> Session Chair Bri-Mathias Hodge (NREL, USA)

- **System Integration Costs – a Useful Concept that is Complicated to Quantify?**  
S. Mueller (IEA, France), H. Holttinen (VTT, Finland), E. Taibi (IRENA, Germany), J. C. Smith (ESIG, USA), D. Fraile (WindEurope, Belgium), T. K. Vrana (SINTEF, Norway) ([Submission-ID WIW-241](#))
- **Wind Generation in Adequacy Calculations and Capacity Markets in Different Power System Control Zones**  
L. Söder (KTH Royal Institute of Technology, Sweden), A. Estanqueiro (LNEG, Portugal), D. Flynn (University College Dublin, Ireland), B.-M. Hodge (NREL | University of Colorado, USA), J. Kiviluoma (VTT, Finland), M. Korpås (NTNU, Norway), E. Neau (EDF, France), A. Cuoto (LNEG, Portugal), D. Pudjianto, G. Strbac (Imperial College London, United Kingdom), D. Burke (National Grid, United Kingdom), T. Gómez (Universidad Pontificia Comillas, Spain), K. Das (DTU, Denmark) ([Submission-ID WIW18-63](#))
- **A Dispatch Methodology to Secure Power System Inertia in Future Power Systems**  
H. Thiesen, C. Jauch (Flensburg University of Applied Sciences – WETI, Germany) ([Submission-ID WIW18-146](#))
- **Negative Market Prices and Market Premium Support Schemes – Impacts on Wind Integration in the German Electricity Market**  
M. Klobasa, M. Haendel, L. Pfluger (Fraunhofer ISI, Germany) ([Submission-ID WIW18-220](#))
- **Comparison of Connection Policies for the Planning of Generation Integration into a Distribution Network**  
J. Wallace, A. Chabrol, C. Molloy (ESB Networks, Ireland) ([Submission-ID WIW18-27](#))

11:10 – 13:10 SESSION 8A: BALANCING ISSUES

> Session Chair TBA

- **Balancing Challenges for Future North Sea Offshore Network**  
K. Das, M. Koivisto, P. E. Sørensen, J. Gea-Bermúdez, (DTU, Denmark) ([Submission-ID WIW18-217](#))
- **Future Flexibility Valuation in Power Systems with High Penetration of Variable Generation**  
L. A. Hurtado, M. F. J. de Ronde, M. R. Duvoort (DNV GL, Netherlands) ([Submission-ID WIW18-304](#))
- **Finding the Limits to System Flexibility**  
E. Lannoye (EPRI International, Ireland), E. Ela, Q. Wang, A. Tuohy (EPRI, USA) ([Submission-ID WIW18-219](#))
- **Experiences in the NEM: Practical Considerations for the Successful Integration of Utility-Scale Renewable Storage Solutions**  
H. Mackenzie, J. Dyson (Dispatch Solutions, Australia) ([Submission-ID WIW18-105](#))
- **Frequency Regulation of Power System in Japan with Large-Scale Integration of Renewables by using Electrolyzers**  
T. Tsuji, J. Qi (Yokohama National University, Japan) ([Submission-ID WIW18-309](#))

**11:10 – 13:10      SESSION 8B – POWER QUALITY ISSUES II****> Session Chair      Lennart Söder (KTH – Royal Institute of Technology, Sweden)**

- **Analysis of the Flicker Estimation at PCC of a Wind Power Plant**  
K. Redondo, I. Azcarate, J. J. Gutierrez, L. A. Leturiondo, P. Saiz (University of the Basque Country (UPV/EHU), Spain) ([Submission-ID WIW18-166](#))
- **Analysis of Harmonic Resonance Stability in Power System with Renewable Generations**  
L. Cai (University of Rostock, Germany), U. Karaagac (Hong Kong Polytechnic University, Hong Kong), J. Mahseredjian (Polytechnique Montréal, Canada), H.-G. Eckel, H. Weber (University of Rostock, Germany) ([Submission-ID WIW18-26](#))
- **Type IV Wind Turbine System Impedance Modelling for Harmonic Analysis**  
L. Beloqui Larumbe, Z. Qin, P. Bauer (Delft University of Technology, Netherlands) ([Submission-ID WIW18-198](#))
- **Methods to Aggregate Turbine and Network Impedance for Wind Farm Resonance Analysis**  
H. Wang (China Electric Power Research Institute, China), C. Buchhagen, M. Greve (TenneT Offshore, Germany), J. Sun (Rensselaer Polytechnic Institute, USA) ([Submission-ID WIW18-177](#))
- **An Impedance-Based Active Filter for Harmonic Damping by Type-IV Wind Turbines**  
E. Guest, T. Rasmussen (DTU, Denmark), K. H. Jensen (Siemens Gamesa Renewable Energy, Denmark) ([Submission-ID WIW18-20](#))

**14:15– 15:45      SESSION 9A – INTEGRATION SOLUTIONS****> Session Chair      TBA**

- **Synchronous Condensers Applications in Transmission Network with Power Electronics Based Generation**  
A. Atallah (Siemens, Germany) ([Submission-ID WIW18-135](#))
- **Model-based Control of grid-side Converter: An LMI approach**  
N. Goldschmidt, H. Schulte (HTW Berlin – University of Applied Sciences Berlin, Germany) ([Submission-ID WIW-202](#))
- **A New Method for Grid Control of a Wind Turbine Facility**  
M. Engel, L. Rezai, J. Fortmann, N. Klaes (HTW Berlin – University of Applied Sciences, Germany) ([Submission-ID WIW-199](#))
- **Operational Experience with a Type 3 WPP in a Weak Power System Region with Type 2 WPPs and Synchronous Condensers**  
A. Abdellaoui, M. Asmine (Hydro-Québec TransÉnergie, Canada) ([Submission-ID WIW18-316](#))

**14:15– 15:45      SESSION 9B – FORECASTING II****> Session Chair      John Zack (UL AWS Truepower, USA)**

- **Understanding Uncertainty: the Difficult Move from a Deterministic to a Probabilistic World**  
C. Möhrlein (WEPROG, Denmark & Germany), R. Bessa (INESC TEC, Portugal) ([Submission-ID WIW18-155](#))
- **Bounded Probabilistic Wind Power Forecasting using Mixture Density Recurrent Neural Network**  
S. Haglund El Gaidi, M. Chiru (Greenlytics, Sweden) ([Submission-ID WIW-302](#))
- **Evaluation of Bi-variate Distributions of GFS and ECMWF Wind Speed Forecasts by Kullback Leibler Divergence and Wind Power Forecasting**  
M. Dione (ParisTech | ENGIE Green France, France), E. Matzner-Lober (ParisTech, France), P. Alexandre (ENGIE Green France, France) ([Submission-ID WIW18-11](#))
- **Benchmark of Spatio-temporal Shortest-Term Wind Power Forecast Models**  
S. Vogt, A. Braun, J. Koch, D. Jost, J. Dobschinski (Fraunhofer IEE, Germany) ([Submission-ID WIW18-190](#))

- **Future Requirements regarding Power System Flexibility and Markets**

**Panelists**

Peerapat Vithayasrichareon (IEA, France)

Frank Martin (Siemens Gamesa, Denmark)

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



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