Oral presentations for Session 5.6.1 | Thursday, 27 October | Room 3911

Session Chair:
Raymond HUDSON (DNV GL, USA)
Wilfred WALSH (SERIS, Singapore)

5.6.1a Invited Talk (14:00 - 14:15)
Prof Andrew Blakers
Australian National University, Australia

Pumped Hydro Energy Storage and the Renewable Energy Revolution

A. BLAKERS[1]
[1] Australian National University, Australia

Abstract
In Australia and around the world a combination of photovoltaics, wind and pumped hydro energy storage (PHES) can largely eliminate fossil fuel generation within 15 years.

Biography
Andrew Blakers is Professor of Engineering at the Australian National University. He has held a Humboldt Fellowship, and the Queen Elizabeth II and Senior Research Fellowships of the Australian Research Council. He is a Fellow of the Australian Academy of Technological Sciences and Engineering, the Australian Institute of Physics and the Australian Institute of Energy, and is a Life Member of the International Solar Energy Society and the Australian Conservation Foundation. He has published more than 400 papers and patents. He was lead inventor of PERC silicon solar cell technology and Sliver solar cell technology. He has extensive project management experience, and has procured more than $100 million in externally-sourced research-related funding.

5.6.1b (14:15 - 14:30)
Mr Hadrien Verbois
Solar Energy Research Institute of Singapore (SERIS), Singapore

Forecasting day-ahead solar irradiance for Singapore using Numerical Weather Prediction Model with Post-processing

H. VERBOIS[1], R. HUVA[1], W. WALSH[1] et al.
[1] Solar Energy Research Institute of Singapore (SERIS), Singapore

Abstract
Increasing penetration of distributed renewable power means that reliable generation forecasts are required for grid operation. For day-ahead predictions Numerical Weather Prediction (NWP) performs best for solar power applications. However, at high spatial and temporal resolution, local terrain complexity, uncertain cloud formation physics and imperfect observational data conspire to introduce random and systematic errors in numerical forecasts. Hence NWP models are combined in ensembles and the outputs analysed with post-processing algorithms. Neural Networks, Kalman Filters and Model Output Statistics (MOS) are popular techniques. We apply Weather Research and Forecasting Model (WRF) with a MOS algorithm to implement high resolution day-ahead hourly forecasts for Singapore. We use stepwise regression to select the combination of WRF outputs that best explain measured clear sky index. This combination of techniques currently provides the most accurate forecast of day-ahead irradiance for Singapore, and guides our future work which shall explore additional post-processing techniques.

Biography
Hadrien is a NUS PhD student in the Solar Potential and Energy Meteorology at SERIS since August 2015. His background is in electrical and computer engineering and in astrophysics.

Oral presentations for Session 5.6.1 | Thursday, 27 October | Room 3911

5.6.1c (14:30 - 14:45)
Dr Robert Huva
Solar Energy Research Institute of Singapore (SERIS), Singapore

Influence of Data Assimilation on Solar Irradiance Forecasting for Singapore using the WRF Model (WRFDA)

R. HUVA[1], H. VERBOIS[1], K. WINTER[1] et al.
[1] Solar Energy Research Institute of Singapore (SERIS), Singapore

Abstract
Operational forecasting of solar irradiance at time horizons of day-ahead, or longer, can only be achieved using Numerical Weather Prediction (NWP) models. NWP models simulate the time evolution of atmospheric processes that are important for the prediction of solar irradiance. We use the Weather and Research Forecasting model (WRF) to simulate the atmosphere over Singapore. However, NWP models suffer from incomplete knowledge of atmospheric initial conditions. The process of Data Assimilation (DA) minimises this source of error by incorporating observations from GPS receivers, radar, satellites and ground/ship-based/aircraft measurements. DA utilises such observations to constrain the state of the model either at initialization (3DVAR) or at forecast time steps (4DVAR). We utilise 3DVAR with observations from the SERIS network of meteorological stations, as well as satellite data and GPS observations of precipitable water vapour content. Results show improved forecasts of solar irradiance for Singapore using WRF with Data Assimilation and post-processing

Biography
Robert did his Bachelor of Science with Honours at the University of Melbourne before also completing his PhD in Meteorology at the University of Melbourne. His PhD focused on optimal combinations of wind and solar for the Australian National Electricity Market (NEM), as well as influential weather types for an high penetration renewable NEM. As a Research Fellow at the Solar Energy Research Institute of Singapore (SERIS) Robert's more recent work now focuses on forecasting solar irradiance for Singapore using numerical weather models. Robert is part of a team of researchers at SERIS who are developing a sophisticated solar irradiance forecasting product for Singapore, with focus on timescales from minutes to days ahead.

5.6.1d (14:45 - 15:00)
Miss Alison Hightman
Waseda University, Japan

Computational Modelling of Photovoltaic Systems with Battery Management and Demand Response for Smoother Grid Integration

A. HIGHTMAN[1], S. WAKAO[1]
[1] Waseda University, Japan

Abstract
A computational model is built to simulate the operation of Photovoltaic (PV) systems in a residential community. This paper uses PV/load data collected each hour of every day for the year of 2007 from a 553 house community (each with a PV panel and battery) in Gunma-ken Ota-shi, Japan. The model in this paper simulates battery management and demand response (DR), specifically four different scenarios are analyzed: no management techniques, battery management, demand response, and both battery management and demand response combined. The design variables are: battery state of charge and capacity. The optimization functions: cost payback time and CO2 payback time. The design variables are optimized and several algorithms are performed to calculate the Pareto Optimal solutions for the objective functions. The aim is to determine the ideal combination of battery management and DR for the best payback times and to define the relationship between battery capacity and DR.

Biography
Alison Hightman graduated with a B.S. in Electrical Engineering and B.A. in Asian Studies from Rice University in Houston, Texas in 2013. After graduation she moved to Tokyo where she worked for one year in the IT/Telecommunications industry before deciding to go back to graduate school to pursue her interests in renewable energy. She is currently a second year graduate student in Electrical Engineering at Waseda University and is working towards pursuing a career in renewable energy and related technologies.

Oral presentations for Session 5.6.1 | Thursday, 27 October | Room 3911

5.6.1e (15:00 - 15:15)
Mr Yuichiro Yanai
Waseda University, Japan

Battery Group Control with Predictive Information in Area of Massive PV Introduction

Y. YANAI[1], S. WAKAO[1]
[1] Waseda University, Japan

Abstract
Output of photovoltaic (PV) systems depends on weather conditions. Therefore, if there is a large introduction of PV systems, the power quality in the distribution system will be affected. One effective solution is to introduce batteries into the distribution system. Additionally, the use of next day load prediction information is considered effective in determining the optimal battery operation. Drastic variations in the load characteristics of each consumer make accurate prediction difficult. By summing the load of various consumers into clusters, thus smoothing the load characteristics, the load prediction accuracy can be improved. On the other hand, storage battery operation is more efficient when individually controlled for each consumer. In this paper, we carry out battery group control with load prediction in an area of massive PV introduction. Finally, we examine the most suitable number of residences for the battery group control.

Biography
Yuichiro Yanai was received the B. E degrees from Waseda University, Tokyo Japan, in 2015. He is now a master course student of Waseda University. His research interest focused on the battery control system.

5.6.1f (15:15 – 15:30)
Mr Roland Bründlinger
AIT Austrian Institute of Technology, Austria

The Role of Grid Codes in the Sustainable Grid Integration of PV - Latest Developments in Europe and World-Wide

R. BRUENDLINGER[1]
[1] AIT Austrian Institute of Technology, Austria

Abstract
The crucial role Grid Codes play for the effective integration of PV systems in the electric power system has long been recognized in Europe, facing the rising share of RES. In the years from 2008, the first basic grid supporting functions such as reactive power (Q) provision and active power (P) frequency response were introduced in national grid codes. While these capabilities were widely sufficient to accommodate the first phase of PV deployment, it has been recognized recently that additional features will be required to cope with power system-wide issues as frequency and voltage stability. The presentation will highlight the latest developments in National Grid Codes as well as the introduce the European „Requirements for Generators“ Network Code, published in 2016. New functions and control schemes, which go beyond the established grid support features of distributed PV will be described. Finally, recommendations for the implementation of requirements will be given.

Biography
Roland Bründlinger studied at the Technical University, Graz, Austria and the Royal Institute of Technology (KTH) in Stockholm and received his M. Sc. degree in Power Engineering in 2000. Since 2001 he has been with the Business Unit Electric Energy Systems at the Austrian Institute of Technology in Vienna, Austria. As Senior Research Engineer he is responsible for laboratory activities on qualification testing and conformity assessment of Grid Connected Power Converters at the AIT SmartEST laboratory. Roland Bründlinger is member of national and international Technical Committees working on PV standardisation and is member of the Board of DERlab e.V., the Association of the European Laboratories for Distributed Energy Resources. As Operating Agent of IEA-PVPS Task 14, he is coordinating the international research activities in the framework of the “High Penetration PV in Electricity Grids” task within the Photovoltaic Power Systems Programme of the International Energy Agency.https://www.researchgate.net/profile/Roland_Bruendlinger