DF 17: Focus Session: Alternative energies – Compensation of long- and short-term fluctuations (jointly with DY)

Organization: J. Peinke (Carl von Ossietzky Universität Oldenburg) and M. Diestelhorst (Martin-Luther-Universität Halle-Wittenberg)

Time: Thursday 15:00–18:10 Location: EB 107

Topical Talk DF 17.1 Thu 15:00 EB 107

Wind energy - Characterization and modeling of short-term fluctuations in incoming wind and power output — •Michael Hölling, Matthias Wächter, Allan Morales, Patrick Milan, and Joachim Peinke — ForWind - Center for Wind Energy Research, Institute of Physics, University of Oldenburg

One inherent characteristic of turbulent atmospheric wind fields is their correlation in time and space, which results in intermittent behavior of velocity increments on a wide range from very small to very large scales. Wind energy converters work in this highly intermittent environment and transfer these fluctuations to the generator and the power output, respectively. With a significantly increased wind power production in the future, there is a need to better understand the interaction of turbulent wind fields with wind turbines. We present methods to describe and model these intermittent characteristics of atmospheric flows and power output of wind turbines using stochastic analysis. Data from wind tunnel experiments on blade segments with respect to lift forces under turbulent wind conditions show dynamic stall like behavior with an increased maximum lift force shifted to higher angles of attack compared to laminar inflow conditions. In addition an increase in the standard deviation in the acting lift forces is observed, which leads to dynamic changes in loads, that have to be accounted for e.g. in the design process of the wind turbine. Also the power output from wind turbines shows intermittent behavior resulting from the turbulent wind fields. The presented methods can help to describe and predict power fluctuations and to make the machines last longer.

Topical Talk DF 17.2 Thu 15:30 EB 107

Fluktuationen in der Stromerzeugung aus erneuerbarer Energien: Ihre Charakterisierung und Möglichkeiten ihrer Kompensation — •Detlev Heinemann — AG Energiemeteorologie, Institut für Physik, Universität Oldenburg

Die Beitrag der erneuerbaren Energien aus Wind und Solarstrahlung an der deutschen Stromversorgung nähert sich der 20%-Marke. Damit sind erhebliche und nur teilweise vorhersagbare Schwankungen der Erzeugung verbunden und es wird z.B. zunehmend der Bedarf an Systemunterstützung z.B. durch Speicherung diskutiert. Noch wenig bekannt ist, wie weit dieser Speicherbedarf durch Ausnutzung von vorhandenen Ausgleichseffekten und durch eine intelligente Steuerung des Verhaltens der Komponenten im Stromnetz ('Smart Grid') unter Einbeziehung einer präziseren Charakterisierung der Fluktuationen reduziert werden kann.

Der Beitrag charakterisiert - ausgehend von einer Phänomenologie der beobachteten Ereignisse - die für die Energieträger Wind und Solarstrahlung wesentlichen Fluktuationen. Dabei werden die unterschiedlichen zeitlichen und räumlichen Skalen der Fluktuationen betrachtet und ebenfalls räumliche Korrelationen der zeitlichen Schwankungen untersucht. Die Beeinflussung der effektiven Stromerzeugungs-Kapazität aus Wind- und Solarenergie durch diese statistischen Effekte wird diskutiert. Abschliessend werden aktuelle Ansätze eines Ausgleichs dieser Fluktuationen sowohl durch technische Massnahmen als auch durch den Einsatz intelligenter Verfahren vorgestellt.

Topical Talk DF 17.3 Thu 16:00 EB 107

Glasses and glass ceramics as dielectrics for high power capacitors. — •Martin Letz — Schott AG, Mainz, Germany

Temperature stable, reliable and long lasting capacitors are a key component for high power electronics enabling large amount of fluctuating energy sources in the public electricity grid. Since many decades inorganic materials are known as excellent dielectrics. Among these thin foils made from alkaline free special glass are known for their very good homogeneity and excellent surface roughness. Such glass foils can reach dielectric breakdown strengths of 690 kV/mm (measured at 0.025 mm thickness) and more. Due to their excellent thermal stability they can be used for temperatures up to 500 °C as dielectrics in capacitors. A further class of materials are glass ceramics obtained via a true homogeneous glassy phase. Here it is possible to crystallize out ferroelectric phases like BaTiO3 in form of nano crystallites leading to high dielectric constants. Obtained from a true glassy phase such glass ceramics are free of pores and reach dielectric breakdown strengths of 40kV/mm (measured at 0.2 mm thickness). The current development for such glasses and glass ceramics is presented which shows the possibility for obtaining high power capacitors which exceed the energy storage capacity of todays high power capacitor solutions by more than one order of magnitude.

DF 17.4 Thu 16:30 EB 107

The dielectric AC and DC characterisation of composite capacitors for energy storage — •Sebastian Lemm[1], Wolfram Münchgesang[1], Martin Diestelhorst[1], Mandy Zenkner[2], Thomas Grossmann[2], Alexandra Buchsteiner[3], Horst Beige[1], Stefan G. Ebbinghaus[2], and Hartmut S. Leipner[3] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, D-06099 Halle, Germany — [2]Institut für Chemie, Martin-Luther-Universität Halle-Wittenberg, D-06099 Halle, Germany — [3]Interdisziplinäres Zentrum für Materialwissenschaften , Martin-Luther-Universität Halle-Wittenberg, D-06099 Halle, Germany

Today, rechargeable batteries are mostly used for energy storage. An alternative to the electrochemical storage process in batteries are capacitors with a high energy density and a long carrier storage time. For the design and development of such capacitors the default dielectric AC characterisation method for capacitors is inadequate because the energy storage process operates under DC conditions. We present a measurement procedure which includes DC and AC characterisation using the example of composite capacitors consisting of barium titanate nanoparticles embedded in a matrix material. Furthermore we show the differences between the measurement methods and the problems of analysing such capacitors.

DF 17.5 Thu 16:50 EB 107

Permittivity, energy density and carrier storage time of film composite capacitors — •Wolfram Münchgesang[1], Sebastian Lemm[1], Martin Diestelhorst[1], Claudia Ehrhardt[2], Jens Glenneberg[3], Alexandra Buchsteiner[3], Horst Beige[1], Stefan G. Ebbinghaus[2], and Hartmut S. Leipner[3] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, D-06099 Halle, Germany — [2]Institut für Chemie, Martin-Luther-Universität Halle-Wittenberg, D-06099 Halle, Germany — [3]Interdisziplinäres Zentrum für Materialwissenschaften, Martin-Luther-Universität Halle-Wittenberg, D-06099 Halle, Germany

Thin film composite capacitors are a possible alternative for batteries as energy storage. Their anticipated advantages are short charging and discharging times, a long life cycle, higher energy density and lower temperature dependency. We tested this predicted behaviour of such film composite capacitors under DC and AC conditions. The thin film composites based on nanoparticles of barium titanate which are embedded in a polymeric organic matrix and surface-modified by surfactants.

Topical Talk DF 17.6 Thu 17:10 EB 107

High Tc Superconducting Energy Storage Systems — •Frank Werfel — Adelwitz Technologiezentrum GmbH (ATZ), Arzberg-Adelwitz, Germany

Electric energy is basic to heat and light our homes, to power our businesses and to transport people and goods. Powerful storage techniques like SMES, Flywheel, Super Capacitor, and Redox - Flow batteries are needed to increase the overall efficiency, stability and quality of electrical grids. High-Tc superconductors (HTS) possess superior physical and technical properties and can contribute in reducing the dissipation and losses in electric machines as motors and generators, in electric grids and transportation. The renewable energy sources as solar, wind energy and biomass will require energy storage systems even more as a key technology. We survey the physics and the technology status of superconducting flywheel energy storage (FESS) and magnetic energy storage systems (SMES) for their potential of large-scale

commercialization. We report about a 10 kWh / 250 kW flywheel with magnetic stabilization of the rotor. The progress of HTS conductor science and technological engineering are basic for larger SMES developments. The performance of superconducting storage systems is reviewed and compared. We conclude that a broad range of intensive research and development in energy storage is urgently needed to produce technological options that can allow both climate stabilization and economic development.

Topical Talk DF 17.7 Thu 17:40 EB 107

The transmission of high-power microwaves via dielectric diamond windows: Design, qualification and first steps towards a broadband diamond window in the range of 30GHz to several THz for actual and future fusion devices — •Theo Scherer and Dirk Strauss — Karlsruhe Institute of Technology KIT; D-76021 Karlsruhe

The development of artificial diamond disks fabricated by special RF CVD processes lead to a new generation of dielectric high power millimetre wave windows with extremely low absorption and scattering losses for high power transmission. The quality of diamond as a window material is further given by its well known excellent mechanical properties and extremely high thermal conductivity. The growth process of the diamond disks is based on chemical vapour deposition (CVD) with micro/nano diamond nuclei. The transmission losses of the disk are caused by graphite formation mainly at the surface of the disk but also on the grain boundaries. RAYLEIGH scattering limits the value of loss tangent in bulk. A high quality measurement of the disk surface and bulk properties using spherical and hemispherical resonators is presented for frequencies from 90 up to 170 GHz.

The state of the art windows used in high power electron cyclotron heating and current drive (ECRH&CD) for large fusion devices such as ITER consist of a disk perpendicular to the millimetre wave beam propagation. As reflection have to be kept on a minimal level, the window thickness limits the allowed frequencies to a limited set defined by multiples of lambda/2 in the dielectric matter.