HELMHOLTZ ZENTRUM FÜR UMWELTFORSCHUNG UFZ

EnergyLandUse

Book of Abstracts

UFZ EnergyDays 2017

15-16 March 2017, KUBUS Leipzig

UFZ EnergyDays 2017

The workshop has been initiated to provide a platform to debate challenges and recent progress in research on renewable energies and on the transition towards decarbonisation and the bioeconomy. Scientists, stakeholders and experts of the authorities discuss technological and socio-environmental implications of using renewable resources for energy and material supply. Technological and institutional options are looked at in their systemic interplay to foster sustainability.

In 2017 there will be workshops on various topics, such as subsurface energy systems, the technological use of microbes for energy and material supply, the sustainable deployment of wind energy, and on the perception and acceptance of new energy infrastructures. Each session will include topical introductory notes held by scientists from UFZ and other research institutes, experts from the authorities, and stakeholders.

The UFZ EnergyDays are organised by the IP EnergyLandUse. Please visit our Homepage for further information.

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Workshop Programme

Wednesday, 15 March 2017				
12:00	**Registration**			*Foyer*
13:00	**Welcome: Karin Frank** (UFZ) and **Daniela Thrän** (UFZ) A short presentation of the environmental energy research at UFZ			*Hall 1A*
13:30	**Keynotes:** ***Energy Systems 2030 – Transformation completed?*** **Uwe Leprich,** Umweltbundesamt UBA (Federal Environment Agency) and **Boris Schucht**, 50Hertz Transmission GmbH			*Hall 1A*
14:30	***Coffee break***			*Foyer*
15:00	**Session A1**[1] ***Hall 2AB*** ***Die künftige Rolle von Bioenergie und Stromspeicher im Energiesystem*** **Speakers:** - *Martin Dotzauer, Katja Oehmichen* (Deutsches Biomasseforschungszentrum) - *Annedore Kanngießer, Anna Grevé, Benedikt Meyer* (Fraunhofer UMSICHT) - *Sabine Schulte-Beckhausen* (White&Case LLP) - *Annette Keil* (energy2market GmbH) - *Philip Tafarte, Markus Millinger* (UFZ)	**Session B1** ***Hall 1B*** ***Experimental and numerical analysis of subsurface energy systems managed for storage operation*** **Speakers:** - *Ralf Köber* (CAU Kiel) - *Anke Bucher* (HTWK Leipzig) - *Christian Griebler* (Helmholtz Zentrum München) - *Xing-Yuan Miao, Thomas Nagel, Carsten Vogt, Detlef Lazik* (UFZ)	**Session C1** ***Hall 1CD*** ***The beauty and exploitation of surface associated microbes*** **Speakers:** - *Rainer Krull* (TU Braunschweig) - *Harald Horn, Michael Wagner, Johannes Gescher* (Karlsruher Institut für Technologie) - *Thomas Maskow, Markus Weitere, Benjamin Korth* (UFZ)	
18:30	***Dinner at the KUBUS and get together***			*Foyer*
Thursday, 16 March 2017				
9:00	**Session A2**[1] ***Hall 1CD*** ***"Wohin mit den Anlagen?" – Wege zu einer nachhaltigen Ausnutzung des Windkraft-Potentials in der Fläche*** **Speakers:** - *Jana Bovet, Marcus Eichhorn, Frank Masurowski* (UFZ)	**Session B2** ***Hall 2AB*** ***"Can you feel the energy?" – The 'Sensory Governance' of energy technologies and systems*** **Speakers:** - *Johannes Pohl, Gundula Hübner* (MLU Halle) - *Thomas Vienken* (UFZ) - *Stefan Majer* (Deutsches Biomasseforschungszentrum) - *Jochen Wendel. Roman Zorn* (European Institute for Energy Research)		
12:00	***Lunch (individually)***			*Canteen*

[1] Vortrag und Diskussion auf Deutsch/ Presentation and discussion in German

Abstracts

Session A1: Die künftige Rolle von Bioenergie und Stromspeicher im Energiesystem

SessionkoordinatorInnen und Chairs: ***Markus Millinger[1], Daniela Thrän[2]***

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Das deutsche Energiesystem wird künftig von fluktuierender erneuerbarer Stromerzeugung geprägt sein - vor allem von Solar-PV und Windenergie. Um Stromnachfrage und Dargebot jederzeit auszugleichen erscheinen neue Ausgleichsoptionen zunehmend wichtig. Flexible Bioenergie und Stromspeicher sind zwei wichtige Ausgleichsoptionen, welche die Systemintegration der fluktuieren Erneuerbaren ermöglichen um die angestrebte Stromversorgung mit erneuerbarer Energie in Zukunft zu ermöglichen. Flexible Bioenergie und Stromspeicher können sowohl miteinander konkurrieren als auch Synergieeffekte aufweisen und haben unterschiedliche technische Ausprägungen, Umwelteffekte und Kosten, die mit in Betracht genommen werden müssen.

In diese Session werden die Ausgleichsoptionen aus technischer, rechtlicher und wirtschaftlicher Sicht beleuchtet und die Ergebnisse anschließend gemeinsam diskutiert.

Ort: *Saal 2AB*

Zeitplan:

Zeit	Vortrag	Referierende
15:00 – 16:15	*Die künftige Rolle von Bioenergie und Stromspeicher im deutschen Energiesystem - Ergebnisse aus dem Projekt BalanceE*	Markus Millinger, Philip Tafarte (UFZ), Martin Dotzauer, Katja Oehmichen (DBFZ), Annedore Kanngießer, Anna Grevé, Benedikt Meyer (Fraunhofer UMSICHT)
16:15 – 16:45	*Diskussion*	
16:45 – 16:55	*Pause*	
16:55 – 17:15	*Bioenergie und Stromspeicher als Ausgleichsoptionen im Energiesystem – Chancen und Risiken für ein Stromhandelsunternehmen*	Annette Keil (energy2market GmbH)
17:15 – 17:45	*Rechtliche Aspekte der Nutzung von Bioenergie und Stromspeichern zum Energieausgleich*	Sabine Schulte-Beckhausen (White & Case LLP)
17:45 – 18:30	*Diskussion*	

Die künftige Rolle von Bioenergie und Stromspeicher im deutschen Energiesystem - Ergebnisse aus dem Projekt BalanceE

Referierende: ***Markus Millinger[1], Philip Tafarte[2], Martin Dotzauer[3], Katja Oehmichen[4], Annedore Kanngießer[5], Anna Grevé[6], Benedikt Meyer[7]***

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Im Projekt BalanceE hat ein Team von Wissenschaftlern am UFZ, DBFZ und Fraunhofer UMSICHT Szenarien für die Integration fluktuierender Erneuerbarer Energien und der benötigten Ausgleichsoptionen in Deutschland bis 2050 untersucht. Die folgenden Zielstellungen wurden untersucht und werden in der Session vorgestellt:

• Welche Rolle können Bioenergie und Stromspeichertechnologien bei der Systemintegration fluktuierender erneuerbarer Energien spielen?

• Wie entwickeln sich die technischen Möglichkeiten im Zeitverlauf und unter unterschiedlichen regionalen Gegebenheiten?

• Wann und wo ergeben sich Synergien, wo sind Konkurrenzen zu erwarten?

Bioenergie und Stromspeicher als Ausgleichsoptionen im Energiesystem – Chancen und Risiken für ein Stromhandelsunternehmen

Referentin: ***Annette Keil***

Energy2market GmbH, Leipzig, Deutschland

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Abstract folgt.

Rechtliche Aspekte der Nutzung von Bioenergie und Stromspeichern zum Energieausgleich

Referentin: ***Sabine Schulte-Beckhausen***

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Bioenergie kann auf verschiedene Weise einen Beitrag zur Flexibilisierung der Energieversorgung und damit zur Systemintegration der Erneuerbaren Energien leisten. Der Vortrag gibt einen Überblick über die rechtlichen Rahmenbedingungen ausgewählter Flexibilisierungsoptionen auf verschiedenen Ebenen der Wertschöpfung, insbesondere mit Blick auf die Nutzung von Stromspeichern.

Im Rahmen der energetischen Nutzung von Bioenergieträgern als elektrische Energie, Heizenergie oder Kraftstoff kann sich die Flexibilität auf die Zeit (zeitlich verschobene Energieumwandlung oder Einspeisung) oder auf die Menge (z.B. Anpassung an den Bedarf in einer bestimmten Zeitscheibe) beziehen. Daneben sind Bioenergieträger, anders als die dargebotsabhängigen Energieträger Sonne und Wind, auch selbst speicherbar. Darüber hinaus bestehen auf der Ebene des Outputs (Strom, Wärme, Kraftstoffe) Möglichkeiten der Speicherung. Darüber hinaus bestehen Speicheroptionen durch Verknüpfung von Strom, Wärme und auch Mobilität (Sektorenkopplung).

Der Beitrag beleuchtet die rechtlichen Rahmenbedingungen, die die Anforderungen an die Bereitstellung von Flexibilität und Energiespeichern regeln. Hierbei wird der Einsatz von Speichern im Zusammenhang mit der Erzeugung, aber auch mit dem Großhandel betrachtet. Dies umfasst auch diejenigen Regelungen, die finanzielle Auswirkungen auf den Speichereinsatz haben (Stichworte: EEG-Umlage, Netzentgelte, Stromsteuer). Die Neuregelungen des EEG 2016 zum Speichereinsatz werden dargestellt. Ein Schwerpunkt wird auf den Rechtsrahmen für die Erbringung von Regelenergie durch Bioenergie-Anlagen gelegt. Hierzu werden die gesetzlichen Regelungen der StromNZV durch regulierungsbehördliche Vorgaben konkretisiert; in Zukunft wird dies durch sog. Europäischen Netzkodizes weiter detailliert werden. Ergänzend wird dargestellt, wie Power-to-Gas und Power-to-Heat-Modelle sowie Geschäftsmodelle, die Schwarmspeicher aggregieren, in den Ordnungsrahmen eingebettet sind.

Session B1: Experimental and numerical analysis of subsurface energy systems managed for storage operations

Session coordinators and chairpersons ***Thomas Nagel[1], Birgit Daus[2]***

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As a key factor for the substantial reduction of greenhouse gas emissions, German policy and economy started the process of a fundamental transformation of the energy system towards a more intense exploitation of renewable sources for power and heat generation.

The individual as well as the national energy demand represent cyclic processes with quite stable daily and seasonal cycles. Using a substantial higher amount of fluctuating energy sources like wind and solar power, it stays increasingly more difficult to harmonize cyclic processes of power supply and power demand. One of the key factors for managing this dilemma will be energy storage on large scales. The subsurface provides several options for the short- and long-term storage of energy carriers and thermal energy of a substantial order. Moreover, geological storage of waste products of energy generation processes (like CO_2) based on classical but recently attracted to criticism technologies, e.g., focusing on fossil fuels provides additional opportunities to foster the reduction of greenhouse gas emissions.

This session addresses several scientific questions of large-scale geological storage of energy carriers (e.g., hydrogen storage in salt caverns), waste (e.g., aquifer storage of carbon dioxide), and thermal energy. Contributions are focused on exploration and monitoring techniques, site characterization, computational process analysis, and the evaluation of environmental impacts of the considered geotechnologies.

Venue: *Hall 1B*

Schedule:

Time	Presentation	Speakers
15:00 – 15:30	*Near surface heat storage in urban conurbations - climate protection potential and impact on groundwater*	Robert Köber (CAU Kiel)
15:30 – 15:50	*Shallow geothermal energy systems: Current technical design practice and suggestions for its improvement*	Anke Bucher (HTWK Leipzig)
15:50 – 16:10	*Design, operation and environmental impact assessment of modular sensible heat storage solutions using numerical simulations*	Xing-Yuan Miao (UFZ)
16:10 – 16:30	*Potential impacts of geothermal energy use and storage of heat on groundwater quality, biodiversity and ecosystem processes*	Christian Griebler (Helmholtz-Zentrum München)
16:30 – 16:40	*Break*	
16:40 – 17:00	*Thermo-mechanical investigation of salt caverns for short-term hydrogen storage*	Thomas Nagel (UFZ)
17:00 – 17:20	*Underground gas storage: microbial processes and concepts for monitoring them*	Carsten Vogt (UFZ)
17:20 – 17:40	*Non-iterative description of CO2-brine equilibria for efficient numerical CCS-modelling*	Norbert Böttcher (BGR)
17:40 – 18:00	*Characteristic length measurement of a subsurface gas anomaly - an integrating monitoring approach over heterogeneous distributed gas flow paths*	Detlef Lazik (UFZ)

Near surface heat storage in urban conurbations - climate protection potential and impact on groundwater

*Speaker: **Ralf Köber***

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Since the transformation of the energy supply for the heat market towards renewable resources using primarily electricity-based technologies would lead to a not wanted multiplication of already installed systems (wind power, PV, etc), it is essential to use solar thermal energy, geothermal energy and underground thermal heat storage to a much greater extent than today. Despite the prominent role near surface heat storage can play, only isolated applications are realized so far. This is also linked with knowledge gaps concerning possible hydraulic, geochemical, microbial and mechanical impacts.

Therefore the aim of the presented ANGUS+ project was to develop basics for predictability and assessment of such impacts. An overview of the most relevant temperature-induced geochemical processes, including mineral precipitation and dissolution, gas phase formation and behavior of organic and inorganic contaminants is given within the presentation. Different experimental set-ups with various sediments for a temperature range between 5 and 70°C and numerical approaches were tested to identify and quantify general and site-specific effects.

The results illustrate that a more differentiated consideration of boundary conditions frequently seen as obstacles like e.g. existing organic contaminants or temperature increases above 10 Kelvin, can lead to more positive assessment of application options under specific site conditions. Compared to the current authorisation practice which is precautionarily kept restrictive, this means that near surface heat storage can play a more important role to cover the national heat demand, to use industrial waste heat and surplus energy from renewables, to reduce CO2 emissions, and to increase the independence from future international availability of fossil fuels. This work is part of the ANGUS+ project, funded by the German Ministry of Education and Research (BMBF,03EK3022A) as part of the research initiative “Förderinitiative Energiespeicher”.

Shallow geothermal energy systems: Current technical design and suggestions for its improvement

Speaker: ***Anke Bucher***

Faculty of Mechanical and Energy Engineering, Leipzig University of Applied Sciences, Leipzig, Germany

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Co-authors: P. Hein, T. Vienken, H. Shao, U.-J. Görke, O. Kolditz

Geothermal energy systems have base load capacities. Therefore shallow geothermal energy systems can become more and more important as a decentralized energy supply for heating and cooling of buildings. Sustainability and efficiency of the installed supply systems are desired results of their design procedure as well as reasonable investment costs. Therefore reliable technical design procedures play a significant role for the functionality of the systems.

We present a short overview about the current technical design procedures for borehole heat exchangers installations in Germany. Thereby we analyze different regulatory conditions of the German federal states. Differences in available information and related parameters of the subsurface are presented as well. Finally we pay attention to the underlying assumptions within the technical design framework and their impact on the design.

We discuss the specific heat extraction as the most important quantity, defining the length of the borehole heat exchanger. To realize a sustainable use of the shallow geothermal energy we propose a new, more informative quantity for an easier evaluation of the exploitability of geothermal resources. This quantity is called exploitable shallow geothermal energy and takes into account already installed geothermal plants in the neighborhood.

Other effects, which are influencing the functionality of the energy system, as for example groundwater flow or already installed systems in the neighborhood, are discussed.

Based on the outlined problems we propose a modified workflow for the technical design of shallow geothermal energy systems. This workflow should help on the one hand decisions-makers as well as the consulting and designing engineers to realize reliable and efficient geothermal systems.

Design, operation and environmental impact assessment of modular sensible heat storage solutions using numerical simulations

Speaker: ***Xing-Yuan Miao***

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Co-authors: C. Beyer, T. Vienken, S. Bauer, F. Wuttke, A. Dahmke, U.-J. Görke, T. Nagel

The IGLU project aims at developing an environmentally neutral and economically viable solar collector-supplied energy storage system featuring a modular design for integration into heating systems of domestic or industrial buildings. Here, we present aspects of model development and application for numerical thermo-hydro-mechanical simulations in the context of optimizing design and operation protocols of the IGLU energy storage system. Numerical sensitivity analyses are used to select thermally, hydraulically and mechanically sutiable materials and heat exchanger geometries of the heat storage system. Besides dimensioning a laboratory test setup and a real-scale prototype, the model is being used for the prognosis of possible environmental impacts on both soil and groundwater in the vicinity of the storage system, as the intention is to install it in the shallow subsurface. Results of these studies will serve as a basis for the development of guidelines for environmental compatibility.

Potential impacts of geothermal energy use and storage of heat on groundwater quality, biodiversity and ecosystem processes

Speaker: ***Christian Griebler***

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Co-authors: H.Brielmann, C.M. Haberer, C. Stumpp, D. Kuntz, S. Walker-Hertkorn, T. Lueders

Geothermal energy plays an important role as a renewable energy source. However, it may induce temperature changes in natural thermally static groundwater ecosystems. Temperature impacts can considerably alter the groundwater chemical composition and quality, the metabolism of organisms, and, consequently, biogeochemical processes and ecosystem functions. We show that a moderate increase in groundwater/aquifer temperature (+5 to 10 Kelvin (K)) generally causes only minor changes in water chemistry, microbial biodiversity, and ecosystem functions in non-contaminated and energy-poor (oligotrophic) groundwater systems. In aquifers that are contaminated with organics, nutrients, and heavy metals – typical in urban areas and at sites with intensive land use (e.g., agriculture) – and particularly at temperatures ≥30°C as regularly reached when heat is actively stored in aquifers, significant changes in water quality and ecological patterns can result. Here most critical are the heat-related mobilization of organic matter and contaminants (e.g., arsenic), the reduction and depletion of dissolved oxygen, and consequently the consecutive shift to anaerobic redox processes that may produce toxic and corrosive products (e.g., hydrogen sulfide) and greenhouse gases (e.g., methane and carbon dioxide). Severe temperature alterations lead to a reduced biodiversity of the aquifer's microbial community with the establishment of atypical thermophilic assemblages. Groundwater fauna, which is specifically adapted to the cold groundwater habitat, may be sensitive to thermal changes at temperature increases of only 5 K with long-term emigration or direct lethal effects. From an ecological point of view, long-lasting or reoccurring temperature alterations need to be carefully evaluated and regulated in the future. We suggest developing local and regional vulnerability concepts for the sustainable and ecologically sound use of subterranean heat and cold.

Thermo-mechanical investigation of salt caverns for short-term hydrogen storage

Speaker: ***Thomas Nagel***

Department of Environmental Informatics, Helmholtz-Centre for Environmental Research – UFZ, Leipzig, Germany

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Co-authors: N. Böttcher, U.-J. Görke, O. Kolditz

To investigate the temperature influence on the cavern capacity, a numerical model was developed in order to simulate the thermo-mechanical behaviour of salt caverns during cyclic hydrogen storage. The model considers the thermodynamic characteristics of the storage medium as well as the heat transport and the temperature-dependent material properties of the host rock. Therefore, a well-known constitutive thermo-visco-elastic constitutive model was modified to describe temperature effects of rock salt and implemented into the freely available simulator OpenGeoSys. Thermal and mechanical processes are solved using a finite element approach, connected via a staggered coupling scheme. Numerical analyses were performed and evaluated using basic criteria for cavern safety and convergence. The results show that large temperature amplitudes in the working gas may lead to tensile stresses at the cavern boundary. Reducing the frequency of the cyclic loading is a way to reduce temperature variations and to avoid tensile failure. Furthermore, the influence of cavern shape was investigated. Narrow cylindrical caverns converge faster than spherical ones of the same volume and are subjected to a higher risk of structural failure.

Underground gas storage: microbial processes and concepts for monitoring them

Speaker: ***Carsten Vogt***

Department of Isotope Biogeochemistry, Helmholtz-Centre for Environmental Research – UFZ, Leipzig, Germany

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Co-authors: P. Bombach, H. Richnow

Underground storage of natural gas is widespread using former gas reservoirs, caverns or porous lime or sand stone layers. New interest in large-scale underground storage of energy has been sparked by the expanding renewable energy production worldwide. As hydrogen is a promising energy carrier produced from renewable energy production, the storage of hydrogen in such underground chambers may become economically important in future; hence, information regarding the risk assessment of underground hydrogen storage is needed. Generally, the underground storage of hydrogen can be negatively affected by its physical properties and (bio)chemical reactivity. Oxidation of hydrogen by microorganisms might be the most critical issue related to underground storage; hydrogen can be used by several ecophysiological different chemolithotrophic bacteria and archaea as electron donor, leading to hydrogen loss and production of e.g. methane, reduced sulfur compounds or acetic acid. The assessment and monitoring of potential reactions leading to loss of hydrogen during underground storage will be highly important for the social acceptance and technical safety of hydrogen underground storage. We will introduce and discuss the pros and cons of possible monitoring methods for detecting microbial processes related to hydrogen consumption at underground storage sites.

Non-iterative description of CO2-brine equilibria for efficient numerical CCS-modelling

Speaker: ***Norbert Böttcher***

Department for Geotechnical Safety Analyses, Federal Institute for Geosciences and Natural Resources (BGR), Hannover, Germany

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Co-authors: J. Maßmann, T. Nagel

We introduce the development of a numerical model, suitable for simulating geological storage applications of carbon dioxide. The governing equations cover twophase flow of immiscible fluids, strongly coupled with heat transport and solid deformation.

Although immiscible, component-based phase transitions between the fluids are considered, governed by thermodynamic relations. This choice of processes allows the description of CO2 propagation in the reservoir, reservoir temperature evolution, the safety assessment of rock integrity, and the quantification of structural, residual and solubility trapping mechanisms in geological CCS applications.

For the description of the vapour-liquid and solution equilibria, a non-iterative method was developed, following well-known and established thermodynamic relations and empirical models. By avoiding iterative computations, this method is very efficient and thus well-suited for simulations exhibiting many degrees of freedom.

Characteristic length measurement of a subsurface gas anomaly - an integrating monitoring approach over heterogeneous distributed gas flow paths

Speaker: ***Detlef Lazik***

Department of Soil Physics, Helmholtz-Centre for Environmental Research – UFZ, Leipzig, Germany

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Co-authors: S. Ebert, P.P. Neumann, M. Bartholmai

Geogenic gases such as CH4 or CO2 from natural sources, gases (CCS-CO2, H2, Natural gas, City gas …) from a geological repository, or a leaking gas pipeline can present serious risks in industrial and urban areas where the density of infrastructural elements increases as well as above and below ground. To extend the lead time for risk treatment in such critical regions, reliable detection of gases within the shallow subsurface is required to observe critical gas accumulations before degassing into the atmosphere.

A near real-time monitoring approach is introduced to determine the volumetric expansion of such a gas escaping from a leak in the subsurface. Considering the pressure relaxation with the ambient air pressure, the approach enables the forecasting of the final size of a pressurized gas body in terms of characteristic lengths. According to theoretical basics, such a characteristic length, which allows to perform a gas (safety) measurement based on a purely geometrical measure, behaves independently of subsurface properties, i.e., it enables a reliable quantification of the escaping gas, irrespective of its heterogeneous flow path distribution. A field test for a 10 l/min pinhole leakage of CO2 injected in an unsaturated Chernozemic soil (agricultural test field Bad Lauchstädt) that was equipped with linear gas sensors demonstrates the lateral-vertical volumetric gas expansion along the environment of these gas sensors, and confirms the applicability of the new characteristic length approach.

Session C1: The beauty and exploitation of surface associated microbes

Session coordinators and chairpersons: ***Katja Bühler[1], Falk Harnisch[2]***

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This session is devoted to the characterization, modelling and application potential of surface associated microbes. It will span from the role of these microbial aggregates and biofilms in natural systems to biotechnological applications allowing the development of continuous processes for material and energy production.

Although widely accepted as a potent alternative to planktonically growing cell cultures in biotechnology, there are still a number of challenges to be addressed before biofilm-process really break through. These comprise fundamental questions of, e.g. mass transfer, metabolic and other kinds of interactions in biofilms. For elucidating these processes as well as structure-function-relationships in biofilms composed of different microbial species a plethora of tools and approaches exists. These range from ecological measures up to engineering performance indicators.

From the engineers perspective biofilms represent a microbial catalyst format which in principle exhibits an infinite turn-over number (TN) due to the fact that they are constituted of naturally immobilized cells continuously regenerating themselves. Their natural, intrinsic ability of tolerating different kind of stresses, natural (desiccation, starvation, predators) or process related (toxic compounds, pH shifts, high salt) make biofilms an ideal system for continuous bioprocess development. Developing novel reactor concepts, technical solutions for mass transfer limitations, highly diluted bleed streams and low specific activities are as important as designing novel biofilm catalysts and understanding biofilm regulation and development.

Also new developments as multispecies biofilms, multistep catalysis and activities in the field of electrobiotechnology are highly exciting and open up new areas in biofilm research.

Starting from natural systems and highlighting different approaches and tools of research and development, this session will discuss various aspects in biofilm research, resources include sugars and plant oils (first generation), cellulose and lignin (second generation), as well as carbon dioxide and waste products in the sense of a circular economy as it is aimed at in future bioeconomy concepts. Biological and technical challenges and approaches based on hetero- as well as autotrophic organisms will be discussed.

Venue: *Hall 1CD*

Schedule:

Time	Presentation	Speakers
15:00 – 15:05	*Welcome address*	Katja Bühler, Falk Harnisch (UFZ)
15:05 – 15:35	*The funtional role of biofilms in aquatic ecosystems*	Markus Weitere (UFZ)
15:35 – 16:05	*Microbe-Electrode-Interactions*	Johannes Gescher (KIT)
16:05 – 16:35	*Morphology engineering of bio-agglomerates and surface associated populations – a suitable tool for electrobiotechnological applications*	Rainer Krull (TU Braunschweig)
16:35 – 16:50	*Break and Discussion*	
16:50 – 17:20	*Real time information about biofilm processes via metabolic heat*	Thomas Maskow (UFZ)
17:20 – 17:50	*Modeling in microbial electrochemistry: Challenging the complexity*	Benjamin Korth (UFZ)
17:50 – 18:20	*The mesoscale of biofilm*	Harald Horn (KIT)
18:20 – 18:25	*Closing remarks*	Katja Bühler, Falk Harnisch (UFZ)

The functional role of biofilms in aquatic ecosystems

Speaker: ***Markus Weitere***

Department of River Ecology, Helmholtz-Centre for Environmental Research – UFZ, Leipzig, Germany

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Environmental biofilms are complex, surface-associated communities of microbiota (bacteria, algae, fungi, protists, small metazoans) and their extracellular polymeric substances (EPS). The densities of active organisms within biofilms are often several orders of magnitude higher than in planktonic systems and, correspondingly, the contribution of biofilms to microorganism-mediated ecosystem processes is high. Furthermore, biofilms create their own microenvironment with steep gradients (e.g. redox gradients) allowing different transformation processes in close proximity. Besides chemical transformation processes, biofilm biomass alters hydraulic processes, e.g. within hyporheic or deep aquifer habitats. Taking the fact that central biogeochemical and hydraulic processes are regulated by these complex biological systems, which in turn are controlled by their chemical and physical environment, the understanding of the mutual interactions between biofilms and their abiotic environment is essential. Behind this background, three topics are, among others, in the focus of current environmental biofilms. These are (i) the role of biofilm community complexity for total biofilm processes, (ii) the scaling of biofilm processes to ecosystem-wide processes and (iii) the control of biofilm structure and functioning in the environment. The presentation will summarize present knowledge on the functional role of biofilms within aquatic ecosystems with special focus on these three research topics.

Microbe-Electrode-Interactions

Speaker: ***Johannes Gescher***

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Microbe electrode electron transfer reactions are key to a number of novel research directions within basic and applied science. Regarding the transfer of electrons from microorganisms to electrodes we know at least for a small number of model organisms how the electron transfer is conducted on a molecular level. Since genetic systems have been developed for these organisms, we are moreover able to engineer production strains that can catalyze novel anoxic fermentation routines. These routines are characterized by the higher oxidation state of the product compared to the substrate and the concomitant production of an electrical current as a fermentation side product. In the reverse direction, evidence was provided that some organisms might be able to import electrons directly from a cathode surface. Coupling this process to an autotrophic lifestyle would enable sustainable biotechnology with carbon dioxide as carbon source and electricity as sustainable energy source. In this talk I will highlight what we know about electron transfer from and to electrodes and what typical applications of these electron transfer interactions could be.

Morphology engineering of bio-agglomerates and surface associated populations – a suitable tool for electrobiotechnological applications

Speaker: ***Rainer Krull***

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Co-authors: A. Fröhlich, C. Engel, K. Dohnt

Electrobiotechnological systems have gained great importance over the last decade. The reactions in these anaerobic systems are carried out by electrochemically active bacteria which have the ability to transfer electrons onto an extracellular acceptor (in this case an electrode). A close connection of the biological system to the electrode is necessary which is ensured by immobilization on the electrode surface or by brief randomized contact. The biofilm causes a considerable transport resistance. Therefore, it is important to study biofilm and agglomerate structure and to characterize its influence and optimize the efficiency of electron transfer.

In recent years, considerable progress has been made influencing the structure, stability and vitality of biofilms and fluidized filamentous bio-agglomerates under varying process conditions, leading to lower mass transfer resistance and thus conducting the morphology in the direction of increased targeted product yields. Morphology influencing methods (morphology engineering) are the variation of flow conditions and substrate concentration, flow-induced mechanical stress, osmolality of the cultivation medium and the addition of micro- (e.g. talc) or macro-particles (e.g. glass). Also, a broad spectrum for quantitative detection of the morphology with analysis by CLSM, laser diffraction, microscopy, automated image analysis and conversion into dimensionless morphology data can be used. Most of these methods could also be transferred to plane electrode associated biofilms.

The presentation will show how morphology engineering methods could be used to investigate and influence the morphology of electrochemically active consortia in such a way that the current density as targeted product can be increased for energy conversion. The first results of the investigations are reported here and will show that these methods are suitable tools to increase the performance of electrobiotechnological systems.

Real time information about biofilm processes via metabolic heat

Speaker: ***Thomas Maskow***

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The biotechnological transformation of renewable raw materials into valuable substances in a bio-refinery concept requires stable and reliable biocatalysts. As an alternative to planktonic growth in liquid media, biofilms represent a particular stable microbial catalyst format due to the fact, that they are constituted of naturally immobilized cells continuously regenerating themselves in the biofilm. However, the development of such continuous biofilm reactor format needs a direct, easy, cheap and non-invasive method to analyze overall reactor performance.

Dissipation of the assimilated Gibbs energy in the form of heat is a general feature of all microbial processes. This all metabolic processes driving Gibbs energy can be derived from renewable raw materials, industrial and agricultural residues, but also from photons (solar energy) or electrons (excess current). We suggest using the part of energy that cannot be used for metabolism and synthesis (i.e. the heat) for on-line analysis and control of biofilm performances. This approach has been chosen because: i) the heat reflects metabolic changes in real time, ii) metabolic heat is measurable with high precision, iii) the measurement of heat works differently to other methods, even with optically opaque media or with biocatalysts embedded in closed modules, and iv) heat contains information about the metabolic fluxes via law of Hess. However, for the technical application of this principle, instruments are needed which, deviating from conventional calorimeters, can be flexibly integrated into existing systems or instruments which permit high measuring throughputs and are inexpensive to manufacture. Corresponding developments and concepts are presented and discussed with the respective advantages and weaknesses.

Modeling in microbial electrochemistry: Challenging the complexity

Speaker: ***Benjamin Korth***

Department of Environmental Microbiology, Helmholtz-Centre for Environmental Research – UFZ, Leipzig, Germany

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For fully describing complex systems like microbial biofilms numerous scientific disciplines have to be integrated including e.g., biology, chemistry, and physics. An overarching approach combining these various disciplines and pooling the obtained phenomena and processes is mathematical modeling. Modeling allows describing and connecting the different phenomena and processes using appropriate mathematical equations. Thereby, biofilms can be analyzed across temporal and local scales with the latter ranging from microscale level to macroscale level.

This complexity is even accelerated in the case of electroactive biofilms as another branch of natural sciences comes into play: (microbial) electrochemistry. This science of studying interactions between microorganisms and solid electron conductors (e.g., electrodes) introduces new phenomena and challenges into biofilm research and modeling: At biofilm anodes, microorganisms transfer catabolically generated electrons beyond the cell membrane via extracellular electron transfer (EET). By using EET they conduct electrons between exterior biofilm layers and to an electrode over distances of several tens of micrometers. Although the research on microbial electrochemistry and electroactive microorganisms significantly flourished the last two decades, many knowledge gaps remained, including for instance: How is the long-range electron transport within biofilms facilitated? What are the mechanisms for energy harvest and energy conservation in electroactive microorganisms?

By integrating mathematical descriptions of fundamental electrochemical processes (e.g., Nernst-Planck equation, Ohm’s law) into established frameworks allowing describing biofilm growth and maintenance, modeling can allow shading light on these open questions. This is demonstrated on the basis of a developed model framework for microbial electrodes yielding information on microscale and macroscale parameters for static and dynamic potential conditions.

The mesoscale of biofilms

Speakers: ***Harald Horn[1], Michael Wagner[2]***

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Imaging of biofilm systems is a prerequisite for a better understanding of both structure and its function. The presentation will give a very short overview on common and established imaging techniques for biofilms such as scanning electron microscopy (SEM), confocal laser scanning microscopy (CLSM), Raman microscopy (RM), magnetic resonance imaging (MRI), and optical coherence tomography (OCT). The latter provides exceptional imaging capabilities paving the way to the mesoscale of biofilms. The mesoscale has been proposed to cover several mm large biofilm structures. It was further suggested that the mesoscale provides a representative view since it contains repeating structural units. In biofilm research typically a special focus is paid to the micro- and mesoscale, because mass transport and transfer processes as well as fluid-structure interactions are occurring at these scales.

The mesoscale most suitable investigated by means of OCT. Principle, resolution, imaging velocity, and limitations of OCT are thus presented and discussed in the context of biofilm applications. Examples are provided showing the strength of this technique with respect to the visualization of the mesoscopic biofilm structure as well as the estimation of flow profiles and shear rates. Finally, the implementation of multi-dimensional OCT datasets in biofilm modeling is shown aiming on an improved understanding of mass transfer at the bulk-biofilm interface and the mechanical characteristics of biofilms.

Session A2: "Wohin mit den Anlagen?" - Wege zu einer nachhaltigen Ausnutzung des Windkraft-Potentials in der Fläche

SessionkoordinatorInnen und Chairs: ***Jana Bovet[1], Marcus Eichhorn[2], Karen Görner[3], Frank Masurowski[4]***

[1] Department Umwelt- und Planungsrecht, Helmholtz-Zentrum für Umweltforschung – UFZ, Leipzig, Deutschland

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Deutschland hat mit dem Übergang von den traditionellen Energiequellen hin zu erneuerbaren Energien begonnen. Dieser Übergang erfordert eine Berücksichtigung der räumlichen Verfügbarkeit, der ortsspezifischen Einflussfaktoren sowie des Rechts- und Planungsrahmens. Die Onshore-Windenergie stemmte in der Vergangenheit den größten Teil der Bruttostromerzeugung aller erneuerbaren Energien. Gründe dafür waren die frühe technologische Reife, der schnelle techno-ökonomische Fortschritt und die hohe Energieeffizienz. Diese vorteilhaften Aspekte dürften auch in Zukunft dazu beitragen, dass die Windenergie an Land weiterhin eine tragende Säule der deutschen Energiewende sein wird.

Die techno-ökonomische und räumliche Integration von Windenergie in die bestehende (Energie-) Landschaft erfordert die Identifikation von geeigneten Flächen und Standorten, die mit Hilfe einer Potenzialanalyse (Energie-Mapping) durchgeführt wird. Diese Methode umfasst alle innerhalb des gesetzlichen Rahmens notwendigen Bewertungsverfahren, um die geeigneten Flächen für die Errichtung von Windenergieanalgen zu identifizieren. Im nächsten Schritt werden diese Flächenpotenziale in Energiepotenziale übersetzt, um energetische und ökonomische Parameter der potenziellen Standorte zu bestimmen. Dies kann mit Hilfe der Planungssoftware "MaxPlace" realisiert werden, die am UFZ entwickelt wurde. Die Software ermittelt die maximale Anzahl potenzieller Anlagenstandorte innerhalb der identifizierten Potenzialflächen, wodurch das maximale Energiepotential in Bezug auf den jeweiligen Windenergieanlagentyp und die regionalen Windverhältnisse berechnet werden kann. In einem letzten Schritt werden dann die Standorte noch einmal hinsichtlich möglicher ökologischer und soziologischer Auswirkungen im Verhältnis zum Energieertrag bewertet.

Vor diesem Hintergrund werden Experten juristische und planerische Anforderungen für die Ermittlung nachhaltiger Standorte sowie Bewertungsansätze anhand von Fallstudien vorstellen. Die Teilnehmer werden eingeladen, die Chancen und Herausforderungen dieser Ansätze und das Potenzial von "MaxPlace" zu diskutieren.

Ort: *Saal 1CD*

Zeitplan:

Zeit	Vortrag	Referierende
09:00 – 09:05	*Begrüßung*	Karen Görner (UFZ)
09:05 – 09:35	*Rechtsrahmen für Planung und Genehmigung von Windenergieanlagen*	Jana Bovet (UFZ)
09:35 – 10:10	*MaxPlace – ein Tool für Planung und Genehmigung von Windenergieanlagen*	Frank Masurowski (UFZ)
10:10 – 10:40	*Pause*	
10:40 – 11:00	*FIND - Analyse und Beschreibung der Zielkonflikte bei der Verortung von Windenergieanlagen*	Marcus Eichhorn (UFZ)
11:00 – 12:00	*Keynote Statements mit anschließender Diskussion*	Jens Uhlig (Planungsverband Region Chemnitz), Wolfgang Daniels (Sachsenkraft GmbH)

Rechtsrahmen für Planung und Genehmigung von Windenergieanlagen

Referentin: ***Jana Bovet***

Department Umwelt- und Planungsrecht, Helmholtz-Zentrum für Umweltforschung – UFZ, Leipzig, Deutschland

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Das Rechtsregime für die Steuerung von Windenergieanlagen ist komplex: Eine gebietliche Steuerung erfolgt über die Regional- und Flächennutzungsplanung, für die anlagenspezifische Zulassung ist eine Genehmigung erforderlich. Die Präsentation wird diese beiden Verfahren darstellen, die der Rahmen sind, die der Rahmen sind, in denen die Tools „MaxPlace“ und FIND zum Einsatz kommen könnten.

Ausgangspunkt für die planerische Steuerung der Windenergie ist § 35 BauGB, wonach Windenergieanlagen im Außenbereich zulässig sind, wenn öffentliche Belange nicht entgegenstehen. Zu letzteren zählen z.B. Belange des Naturschutzes und der Landschaftspflege, des Boden- oder des Hochwasserschutzes. Öffentliche Belange stehen einer Windenergieanlage aber in der Regel auch entgegen, soweit hierfür durch Darstellungen im Flächennutzungsplan oder als Ziele der Raumordnung eine Ausweisung an anderer Stelle erfolgt ist. Wenn also in einem Flächennutzungs- oder Raumordnungsplan eine gebietliche Letztentscheidung zu Windkraftanlagen getroffen wurde, müssen die Anlagen in den festgelegten Gebieten realisiert werden und können nicht außerhalb dieser Gebiete errichtet werden. Die Planung hat von dieser Steuerungsoption – Planvorbehalt genannt – vielfach Gebrauch gemacht und in kommunalen Flächennutzungsplänen sowie auf der Ebene der Regionalplanung entsprechende Gebietsfestlegungen getroffen. Die Planungsträger (Gemeinden bzw. Regionalplanung) müssen dabei eine Vielzahl an rechtlichen und tatsächlichen Vorgaben und Rahmenbedingungen beachten.

Windenergieanlagen ab einer Höhe von 50 m bedürfen zu ihrer Errichtung einer immissionsschutzrechtlichen Genehmigung. Abhängig von Leistung, Größe und ihrer nachteiligen Umweltauswirkungen wird festgelegt, ob ein vereinfachtes, ein förmliches oder ein förmliches Verfahren inkl. Umweltverträglichkeitsprüfung durchgeführt werden muss. Die immissionsschutzrechtliche Genehmigung ist eine gebundene Entscheidung, d.h. wenn die vom Gesetzgeber in § 6 BImSchG abschließend vorgegebenen Genehmigungsvoraussetzungen vorliegen, muss die Genehmigung erteilt werden. Der Antragssteller hat in diesem Fall also einen Anspruch auf die Genehmigung. Aspekten des Natur- und Artenschutzes wird dabei häufig in Form von Monitoring- und Vermeidungsmaßnahmen (z.B. Abschaltzeiten) Rechnung getragen.

MaxPlace – ein Tool für Planung und Genehmigung von Windenergieanlagen

Referent: ***Frank Masurowski***

Department Naturschutzforschung, Helmholtz-Zentrum für Umweltforschung – UFZ, Leipzig, Deutschland

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Windenergie ist eine der tragenden Säulen der Energiewende in Deutschland. Physikalisch und planungsrechtlich geeignete Flächen (Eignungsflächen) werden meist mit Geographischen Informationssystemen (GIS) ermittelt. Sie erlauben jedoch keine Aussage über die bestmögliche Allokation/Energieeffizienz der Windenergieanlagen (WEA) auf den Eignungsflächen, sodass die Planung in der Praxis mit spezieller, sehr kostenintensiver Software oder per Hand durchgeführt wird.

„MaxPlace“ ist eine am UFZ entwickelte eigenständige Softwarelösung, die mittels verschiedenster Algorithmen unter Annahme flexibler Mindestabstandsparameter die optimalen Standorte der Onshore-WEA in Bezug auf die maximale Flächeneffizienz berechnet. Über eine GIS-Schnittstelle können Eignungsflächen und Allokationsergebnisse unkompliziert mit jedem gängigen GIS ausgetauscht werden. Darüber hinaus können pro Eignungsfläche unterschiedliche WEA-Typen in Abhängigkeit von ihren Abmaßen zugewiesen und standortspezifische Parameter wie z.B. Hauptwindrichtung oder die sich daraus ableitende WEA-Verschattung (Park-Effekt) berücksichtigt werden.

Die Innovation von „MaxPlace“ liegt darin begründet, dass „MaxPlace“ innerhalb einer Eignungsfläche die WEA-Allokation nicht bzgl. Kostenminimierung optimiert, sondern nach der Maximierung des Energieertrags (bei gegebenen Kosten). Dadurch wird eine umfangreiche Auswahl von WEA-Standorten pro Eignungsfläche generiert, welche in einer nachfolgenden energetischen Optimierung unter Berücksichtigung regionaler Windbedingungen selektiert wird. In diesem Vortrag werden das Tool MaxPlace, seine technologischen Vorteile sowie Einsatzmöglichkeiten in der Planungs- und Genehmigungspraxis vorgestellt.

FIND – Analyse und Beschreibung der Zielkonflikte bei der Verortung von Windenergieanlagen

Referent: ***Marcus Eichhorn***

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Bei der Suche nach geeigneten Standorten für Windenergieanlagen, sowohl auf Ebene der Region, des Landes oder Bundes, ergeben sich, auch unter Berücksichtigung des Rechtsrahmens für Planung und Genehmigung von Windenergieanlagen, eine Vielzahl an Potenzialflächen für selbige. Mit Hilfe von MaxPlace können auf diesen Flächen individuelle Standorte für Windenergieanlagen identifiziert werden. Dadurch können unter anderem die möglichen Energieerträge von Potenzialflächen besser abgeschätzt werden. Hier zeigt sich zumindest bei Analysen auf Landes- und Bundesebene, dass grundsätzlich mehr Flächen und damit potenzielle Standorte identifiziert werden konnten als zur Erfüllung der Energieziele notwendig wären. Somit stellt sich die Frage welche Flächen, beziehungsweise Standorte aus diesem Pool gewählt werden sollten.

Der am UFZ entwickelte FIND Ansatz (**Fi**nding sustainable Wi**nd** turbine sites) kann zur Entscheidungsfindung für oder gegen eine Eignungsfläche/ Standort durch Sichtbarmachung möglicher Konsequenzen beitragen. Dazu werden die drei Kriterien „Energieertrag am Standort (in Abhängigkeit der gewählten Technologie)“, „Beeinträchtigung des menschlichen Wohlergehens (gemessen als Abstand zwischen dem potenziellen Standort und der nächstgelegenen Siedlungsfläche)“ und „Auswirkungen auf Ziele des Naturschutzes (gemessen als Abstand zwischen dem potenziellen Standort und der nächstgelegenen Schutzgebieten)“ als Bestandteile des Energiepolitischen Zieldreiecks analysiert und die entstehenden Zielkonflikte bewertet. Der Ansatz erlaubt einen Vergleich der Konsequenzen, wenn unter der Prämisse eines bestimmten Energieziels unterschiedliche Zielfunktionen gewählt werden. So führt ein Szenario, bei dem Anlagenstandorte gewählt werden, die weit von den Siedlungsflächen entfernt stehen, dazu, dass insgesamt mehr Anlagen gebaut werden und mit stärkeren Auswirkungen auf die Ziele des Natur- und Artenschutzes gerechnet werden müsste als beispielsweise bei einer Gleichgewichtung aller drei Kriterien.

Der FIND-Ansatz hat nicht zum Ziel, optimale Allokationsmuster zu generieren. Vielmehr ist er als Entscheidungsunterstützungswerkzeug gedacht, das die Konsequenzen unterschiedlicher Präferenzen visualisiert. Der Ansatz ist GIS-basiert und kann in der jetzigen Form mit den frei verfügbaren Daten auf jeder räumlichen Skala angewendet werden.

Session B2: "Can you feel the energy?" – The 'Sensory Governance' of energy technologies and systems

Session coordinators and chairpersons: ***Nona Schulte-Römer[1], Alena Bleicher[2], Matthias Groß[3]***

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This session assembles empirical evidence on perception-related controversies that occur in the course of energy transition projects. Based on this evidence we will discuss what we call 'sensory governance': policies, evidence production and regulatory efforts designed to resolve controversies over im/perceptible and anticipated 'sensible issues'.

The presentations will introduce how sensory experiences and sensor-based evidence become controversial in energy transition projects and cause public protest or expert debate. Examples include wind energy projects that are accompanied by complaints about the disfigurement of scenic landscapes, light pollution or infrasound. Other examples of annoyance are smells caused by bioenergy plants. In response, innovators aim to reduce such stress factors by defining minimum distances or seeking technological solutions. On the other hand, the imperceptibility of energy systems can also become a critical issue, e.g. when experts or citizens rely on sensors to render visible the otherwise imperceptible impacts of geothermal energy systems, notably groundwater temperature or seismic activity.

The aim of the interdisciplinary session is to develop a better understanding of the commonalities and differences of the observed controversies and mediation processes and to explore the challenges of 'sensory governance' in the context of energy transition.

Venue: *Hall 2AB*

Schedule:

Time	Presentation	Speakers
09:00 – 11:00	*Stress effects of wind turbine noise: The role of psychological factors*	Johannes Pohl (MLU Halle)
	When energy smells funny. The sensual aspect of Bioenergy	Stefan Majer (DBFZ)
	A matter of degrees - Prediction, monitoring, and evaluation of subsurface temperatures for the sustainable use of shallow geothermal energy	Thomas Vienken (UFZ)
	Participatory monitoring for energetic and environmental phenomena	Jochen Wendel
11:00 – 12:00	*Discussion*	

Stress effects of wind turbine noise: The role of psychological factors

Speaker: ***Johannes Pohl***

Psychology Department, Martin Luther University of Halle-Wittenberg, Halle (Saale), Germany

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Co-author: G. Hübner

As with other sources of noise, annoyance induced by wind turbine noise depends not only on physical factors but psychological factors. International studies show that noise level explains a maximum of only 26 % of the variance of wind turbine noise annoyance. Therefore it is useful to explore the influence of other factors, e. g. psychological factors. In the context of wind energy discussed psychological factors are: noise sensitivity, attitudes towards wind energy, stress due to the planning process, financial participation and positive and negative expectations, for example. The impact of these factors will be explained by examples based on our own and further international empirical research.

The knowledge of the impact of these factors can be used to shape a fair planning process for the residents and thereby reduce the incidence of annoyance.

When energy smells funny. The sensual aspect of Bioenergy

Speaker: ***Stefan Majer***

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The german energy transition will be accompanied by substantial changes in the structure of the overall energy system. This might affect the types of energy carriers used and also the diversity of technologies, their locations as well as the quantity of the necessary installations. Consequently, the character of the overall energy system might change from large-scale and, mostly centralized production systems to smaller, decentralized units. In some cases, this might as well have an impact on the public perception of the energy production.

Bioenergy technologies can be an option to utilize locally sourced waste or residue streams to produce electricity, heat or liquid fuels. However, depending on the type of the used substrates or the actual conversion process, bioenergy systems can be associated with several sensory nuisances. These sensual perceptions may directly influence the public perception and acceptance of the concerned bioenergy projects.

During our input to workshop B2 we will present a number of examples for bioenergy projects which can, because of their inherent properties, be subject to public controversies and intense discussions between interested citizens, project developers and/or policy makers.

A matter of degrees – Prediction, monitoring, and evaluation of subsurface temperatures for the sustainable use of shallow geothermal energy

Speaker: ***Thomas Vienken***

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The thermal use of the shallow subsurface for heat generation, cooling, and thermal energy storage is increasingly gaining importance for the future low emission energy supply. The exploitation of shallow geothermal energy is often promoted as being of little costs during operation, while simultaneously being environmentally friendly. However, the thermal use of the shallow subsurface directly impacts soil and ground water temperatures. Resulting conflicts of an intensive use may arise between individual users or between different subsurface utilizations, e.g. energy and ground water provision. Therefore, an understanding of the subsurface temperature regime and induced changes is in the interest of all involved actors to facilitate a sustainable ecological and economic intensive thermal use of the shallow subsurface. Although computer-based simulations strongly support impact assessment, the overall problem is that processes in the subsurface are in many cases only accessible by drillings and sensor-based monitoring. This in turn is generally associated with large efforts and costs. To reveal potential conflicts in interest as well as resulting ecological and economic trade-offs, this presentation will give an insight in subsurface temperature monitoring and its relevance from the different perspectives of regulators, planers, and end-users.

Participatory monitoring for energetic and environmental phenomena

Speaker: ***Jochen Wendel***

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Co-author: R. Zorn

Participatory monitoring can be described as the practice of monitoring environments through low-cost and do-it yourself digital technologies by non-professional scientists. Recent advancements in information technology such as Internet of Things (IoT) and availability of broadband cellular networks spiked the application of participatory monitoring approaches. Monitoring environmental phenomena through a people-centered observation web using low cost sensors instead of expensive and hard to maintain public owned monitoring networks is now possible. While traditional measurement stations have higher accuracy in their measurements, they lack the spatial coverage required to monitor environmental phenomena in detail. Because of this fact they are mainly used for calibration of simulated data. Through the deployment of a large number of sensors the lower accuracy of measurements can be compensated by an increase in spatial coverage.

Early applications that incorporated sensors for measuring environmental phenomena were mainly focused on data gathering and data visualization. Open-source web services developed by the OGC (Open Geospatial Consortium) make the exchange of such data now possible and allow communities to communicate efficiently bi-directionally with citizens. Furthermore, recent applications of participatory monitoring make use of data analytics for informed decision making through the introduction of indicators based on ISO standards.

In the energy domain, participatory monitoring approaches have been used successfully for example in monitoring of air quality, noise emissions and mobility. This presentation will cover three examples of participatory monitoring of environmental phenomena and its linkages to energy. Examples include a sensory framework for monitoring impacts of seismic geothermal activities, the usage of mobile air pollution sensors on a tram across the city of Karlsruhe and the usage of open sensor APIs for smart cities applications.