Surface energy and work function of elemental metals

We have performed an ab initio study of the surface energy and the work function for six close-packed surfaces of 40 elemental metals by means of a Green's-function technique, based on the linear-muffin-tin-orbitals method within the tight-binding and atomic-sphere approximations. The results are in excellent agreement with a recent full-potential, all-electron, slab-supercell calculation of surface energies and work functions for the 4d metals. The present calculations explain the trend exhibited by the surface energies of the alkali, alkaline earth, divalent rare-earth, 3d, 4d, and 5d transition and noble metals, as derived from the surface tension of liquid metals. In addition, they give work functions which agree with the limited experimental data obtained from single crystals to within 15%, and explain the smooth behavior of the experimental work functions of polycrystalline samples as a function of atomic number. It is argued that the surface energies and work functions calculated by present day ab initio methods are at least as accurate as the experimental values.
Recycling CO2 Into Sustainable Hydrocarbon Fuels: Electrolysis of CO2 and H2O

**General information**
State: Published
Organisations: Electrochemistry, Fuel Cells and Solid State Chemistry Division, Risø National Laboratory for Sustainable Energy
Authors: Graves, C. R. (Intern)
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Solid Oxide Fuel Cells, Fuel Cells and Hydrogen
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Strategic Management: The theory and practice of strategy in (business) organizations.
This work is the result of an ongoing study on the patterns and trends on both the theory and practice in the field of strategic management carried out at the Section of Innovation Systems and Foresight. The report focuses on different issues regarding the broad topic of strategy in organizations, but special attention is given to three relevant issues regarding the current diversification and fragmentation in the field of strategic management: • The lack of a universally accepted definition of what strategy is, • The multi-disciplinary nature of the field, and • The development and evolution of our knowledge on human cognition and organizations’ behaviour. These issues are addressed from the perspective of influential scholars and practitioners of different disciplines, yet they are discussed from the angle of business organizations.

**General information**
State: Published
Organisations: Innovation Systems and Foresight, Department of Management Engineering
Authors: Jofre, S. (Intern)
Number of pages: 87
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Original language: English
Series: DTU Management 2011
Number: 1
Main Research Area: Technical/natural sciences
Strategy Process, Strategic Management, Strategy, Organizational Theory
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On the Design of Tilting-Pad Thrust Bearings

Pockets are often machined in the surfaces of tilting-pad thrust bearings to allow for hydrostatic jacking in the start-up phase. Pockets and other recesses in the surfaces of bearing pads influence the pressure distribution and thereby the position of the pivot resulting in the most advantageous pad convergence ratio. In this thesis, a theoretical approach is applied in the attempt to quantify the influence of recesses in the pad surfaces. The recesses may be relatively deep and enclosed as is the case with pockets designed for hydrostatic jacking. Such recesses are characterized by low friction and a small pressure build-up. As in parallel-step bearings the recesses may also have a depth of the same order of magnitude as the oil film thickness. Such recesses are characterized by a strong pressure build-up caused by the reduction of the flow area at the end of the recess. Numerical models based on the Reynolds equation are used. They include the effects of variations of viscosity with temperature and the deformation of the bearing pads due to pressure and thermal gradients. The models are validated using measurements. Tilting-pad bearings of standard design are studied and the influences of the bearing length-to-width ratio, pad deformation and injection pocket size are quantified. Suggestions for the design of energy efficient bearings are given. The results show that correctly dimensioned, bearings with oil injection pockets have smaller friction coefficients than bearings with plain pads. Placing the pockets in the high-pressure zones close to the trailing edges of the bearing pads causes a substantial reduction in the friction coefficient. The design of the recess sizes and positions leading to the largest improvements is studied and design suggestions for various pad geometries are given. Parallel-step bearings theoretically have smaller friction coefficients than tilting-pad bearings. A design of a tilting-pad bearing is suggested which combines the benefits of the two types of bearings in a tilting-pad bearing with inlet pockets. This design results in a substantial reduction of the friction loss. Both this bearing and the bearing design with enclosed recesses in the high-pressure regions of the pads suffer from a higher sensitivity to the position of the pivot. The design of such bearing is therefore no trivial task.

General information
State: Published
Organisations: Solid Mechanics, Department of Mechanical Engineering
Authors: Heinrichson, N. (Intern), Santos, I. (Intern)
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Main Research Area: Technical/natural sciences
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FPGA Acceleration by Dynamically-Loaded Hardware Libraries

Hardware acceleration is a viable solution to obtain energy efficiency in data intensive computation.

In this work, we present a hardware framework to dynamically load hardware libraries, HLL, on reconfigurable platforms (FPGAs). Provided a library of application-specific processors, we load on-the-fly the specific processor in the FPGA, and we transfer the execution from the CPU to the FPGA-based accelerator.

Results show that significant speed-up and energy efficiency can be obtained by HLL acceleration on system-on-chips where reconfigurable fabric is placed next to the CPUs.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science , Embedded Systems Engineering, Technical University of Denmark, University of Roma ‘Tor Vergata’
Authors: Lomuscio, A. (Ekstern), Nannarelli, A. (Intern), Re, M. (Ekstern)
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Publisher: Technical University of Denmark (DTU)
Original language: English
Clinker Burning Kinetics and Mechanism

The industrial cement process is subject to several changes in order to reduce the high energy consumption and thereby increase the profitability of cement production. These changes also affect the core of the entire cement producing process: the clinker formation in the rotary kiln. Thus, in order to maintain or even improve clinker quality (and output), we need a better understanding of the development of clinker properties inside the kiln to react upon the impact of process changes. Clinker formation in industrial rotary kilns is very complex due to a vast number of interacting parameters: kiln dimensions, rotation velocity, temperature, gas composition, heat transfer phenomena, etc. These conditions can only be partly simulated in ordinary lab-scale experiments. Thus, the objectives of this project have been to establish test equipment to simulate the industrial clinker burning process on a laboratory scale and to conduct clinker formation experiments in order to derive knowledge on gradual clinker property development, as a function of different process parameters.

A new lab-scale setup rotary kiln simulator (RKS) was designed and built for this purpose. It is assembled of two parts: an ordinary lab-scale heating furnace and a sample motion system. The motion system consists of a SiC tube, which moves the sample, placed in a Pt/Rh-crucible, at a chosen velocity through the heating furnace. Simultaneously, the sample is rotated around its horizontal axis with a chosen rotation velocity. The heating furnace consists of five individual heating zones, which are set to obtain a temperature ramp from ~900-1540 °C. Furthermore, the atmosphere in the system can be set to any mixture of N2, O2 and CO2. Thus, the rotary kiln simulator features most important parameters of the industrial cement rotary kiln (ICRK): gradual temperature increase, rotation velocity and gas phase composition.

An investigation of clinker formation vs. heating profile and rotational velocity were conducted, and the influence on the clinker phase composition and clinker agglomeration was deduced. Independent of the raw meal used, the different clinker phases were formed in three stages: 1. C2S, C3A and C4AF formation at ~900-1350 °C; 2. Clinker melt formation at ~1350-1400 °C; and 3. C3S formation at >1350 °C. The first temperature of clinker melt occurrence varied slightly depending on the type of raw meal used.

The influence of different heating profiles on clinker formation was studied, and it was observed that C3S formation was more complete, the faster the sample was heated to a temperature >1400 °C. However, only with relative long residence times above this temperature clinker phase formation similar to industrial clinker, i.e. with high C3S concentration and low CaO concentration, were obtained. It was concluded, that the maximum temperature of 1540 °C in the RKS does not simulate the maximum temperature in the ICRK. Thus, the maximum temperature of 1450 °C, as is often stated in literature, is likely often not applicable.

Agglomeration of the raw meal was observed to start already at 900 °C. The agglomerates formed are first rather weak, but increase in hardness with increasing temperature. The size of the agglomerates as well as the amount formed was found to be dependent on the rotation velocity: the higher the rotation velocity, the higher was the amount of agglomerates < 1mm. The higher rotation velocity also resulted in a decrease of the total amount of agglomerates, whereas the amount of material lining on the reactor walls increased.

The establishment of the RKS setup will allow more realistic clinker formation studies in future and thus potentially an experimental lab-scale access to the understanding of important parameters in the ICRK. The obtained qualitative and quantitative data on clinker phase composition and on agglomerate formation depended on operational parameters are essential for the development/improvement of models for bed material process in the ICRK, and for the development steps to improve the reactor technology.
The Development of an Online Grading System for Distributed Grading in a Large First Year Project-Based Design Course

AC 2012-3467: This paper presents an online grading system that was developed to collect, process, and return the grades produced by juries using a series of rubrics in a first year project-based design course. It discusses the design requirements, features, and implementation of the online grading system, as well as reactions from course faculty and staff members. It is shown that this system has a number of advantages over analog grading methods, including scalability, real-time feedback on the status of grading, the reduced potential for human error in compiling grades, the ability for jury members to grade remotely and to revise their grades after submission, the ability for course administrators to easily review grading results and remove statistical outliers from the score set, the ability to return both provisional and final grades to the course faculty, staff, and students in a timely manner, and the ability to archive and export grading data for future use. Although the online system is a clear improvement over paper-based rubrics, it is also shown that small details can interfere with usability and thus user satisfaction and that compatibility with mobile devices is a necessary, but still unaddressed, requirement.

High Efficiency Power Converter for Low Voltage High Power Applications

The topic of this thesis is the design of high efficiency power electronic dc-to-dc converters for high-power, low-input-voltage to high-output-voltage applications. These converters are increasingly required for emerging sustainable energy systems such as fuel cell, battery or photo voltaic based energy systems. Applications include systems for emergency power back-up (UPS), de-centralized combined heat and power systems, traction applications such as hybrid electrical vehicles, forklift trucks and special applications such as low emission power generation for truck and ship containers, and remote power generation for light towers, camper vans, boats, beacons, and buoys etc. A review of current state-of-the-art is presented. The best performing converters achieve moderately high peak efficiencies at high input voltage and medium power level. However, system dimensioning and cost are often determined by the performance at the system worst case operating point which is usually at minimum input voltage and maximum power. Except for the non-regulating V6 converters, all published solutions exhibit a very significant drop in conversion efficiency at minimum input voltage and maximum output power. A detailed analysis of dominant loss factors in high power converters for low voltage applications is presented. The analysis concludes that: • Power transformers for low voltage high power, if properly designed, will have extremely low leakage inductance. • If optimally designed, boost converters will be much more efficient than comparable buck type converters for high power low voltage applications. • The use of voltage clamp circuits to protect primary switches in boost converters is no longer needed for device protection. On the other hand, they will dramatically increase power losses. Moreover, if a converter is properly designed, primary side voltage clamp circuits will not even work in low voltage high power converters. • Very high conversion efficiency can be achieved. Peak efficiency of 98% and worst case minimum efficiency of 96.8% are demonstrated on a 1.5 kW converter. The ability to - and challenges involved in - scaling...
of power converters for low voltage applications in the power range of 1-10 kW are analyzed. The analysis concludes that power MOSFETs needs to be paralleled extensively to scale power level to 10 kW. Maintaining fast current switching and reliable current sharing is essential. Further, the high ac-current carrying loop on the converter primary side will become increasingly difficult to scale due to fundamental issues such as physical size of components and penetration depth in copper. Finally a new method for partial paralleling of multiple primary power stages in isolated boost converters is presented. Maximum benefit of scaling in terms of higher efficiency and lower cost is preserved by only paralleling primary switches and the critical high ac-current loop. Dynamic current sharing is inherently guaranteed between parallel power stages. The principle can be applied to all isolated boost type converters and, in principle, an unlimited number of power stages can be paralleled. Feasibility and operation of the new topology are demonstrated on a dual 3 kW and a quad 10 kW prototype converter. Measured peak efficiency is 98.2% and worst case minimum efficiency is between 96.5% and 96.9%.

General information
State: Published
Organisations: Electronics, Department of Electrical Engineering
Authors: Nymand, M. (Intern), Andersen, M. A. E. (Intern)
Number of pages: 164
Publication date: 2010

Call Center Capacity Planning
The main topics of the thesis are theoretical and applied queueing theory within a call center setting. Call centers have in recent years become the main means of communication between customers and companies, and between citizens and public institutions. The extensively computerized infrastructure in modern call centers allows for a high level of customization, but also induces complicated operational processes. The size of the industry together with the complex and labor intensive nature of large call centers motivates the research carried out to understand the underlying processes. The customizable infrastructure allows customers to be divided into classes depending on their requests or their value to the call center operator. The agents working in call centers can in the same way be split into groups based on their skills. The discipline of matching calls from different customer classes to agent groups is known as skills-based routing. It involves
designing the routing policies in a way that results in customers receiving a desired service level such as the waiting time they experience. The emphasis of this thesis is on the design of these policies. The first paper, Queues with waiting time dependent service, introduces a novel approach to analyzing queueing systems. This involves using the waiting time of the first customer in line as the primary variable on which the analysis is based. The legacy approach has been to use the number of customers in queue. The new approach facilitates exact analysis of systems where service depends on the waiting time. Two such systems are analyzed, one where a server can adapt its service speed according to the waiting time of the first customer in line. The other deals with a two-server setup where one of the servers is only allowed to take customers who have waited a certain fixed amount of time. The latter case is based on a commonly used rule in call centers to control overflow between agent groups. Realistic call center models require multi-server setups to be analyzed. For this reason, an approximation based on the waiting time of the first in line approach is developed in the paper Waiting time dependent multi-server priority queues, which is able to deal with multi-server setups. It is used to analyze a setup with two customer classes and two agent groups, with overflow between them controlled by a fixed threshold. Waiting time distributions are obtained in order to relate the results to the service levels used in call centers. Furthermore, the generic nature of the approximation is demonstrated by applying it to a system incorporating a dynamic priority scheme. In the last paper Optimization of overflow policies in call centers, overflows between agent groups are further analyzed. The design of the overflow policies is optimized using Markov Decision Processes and a gain with regard to service levels is obtained. Also, the fixed threshold policy is investigated and found to be appropriate when one class is given high priority and when it is desired that calls are answered by the designated agent class and not by other groups through overflow.

**General information**

State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Networks Technology and Service Platforms, Department of Photonics Engineering
Authors: Nielsen, T. B. (Intern), Nielsen, B. F. (Intern), Iversen, V. B. (Intern)
Publication date: Mar 2010

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Source: orbit
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**Stress concentrations in keyways and optimization of keyway design**

Keys and keyways are one of the most common shaft–hub connections. Despite this fact very little numerical analysis has been reported. The design is often regulated by standards that are almost half a century old, and most results reported in the literature are based on experimental photoelastic analysis. The present paper shows how numerical finite element (FE) analysis can improve the prediction of stress concentration in the keyway. Using shape optimization and the simple super elliptical shape, it is shown that the fatigue life of a keyway can be greatly improved with up to a 50 per cent reduction in the maximum stress level. The design changes are simple and therefore practical to realize with only two active design parameters.

**General information**

State: Published
Organisations: Solid Mechanics, Department of Mechanical Engineering
Authors: Pedersen, N. L. (Intern)
Pages: 593-604
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Main Research Area: Technical/natural sciences

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BFI (2016): BFI-level 1
As Architectural Research is in the process of re-establishing itself as a research discipline according to university standards, it may appear as if the pool of knowledge generated by more than three millennia of experimental research and its internal systems of evaluation are being grossly devalued and colonized by attitudes to research that are imported or even imposed from the outside. Does architectural research have to rely on imported theory from philosophy, the social or the natural sciences in order to meet societal acceptance of its relevance? What constitutes architectural research as a particular research discipline, what are its main characteristics and how can its paradigms, methodologies, strategies and tactics be described? What should be essential aspects of doctoral curriculae in architecture? Discussing Groat and Wang’s Architectural Research Methods in the light of Reflected Practice, and Organizational Knowledge Creation, a framework is presented that includes evolving paradigms and art in architectural research, and demonstrate how this framework allows one to describe the paradigmatic
shifts that happened during the course of a PhD research project involving cross-disciplinary teamwork.

Efficiency of Compressed Air Energy Storage

The simplest type of a Compressed Air Energy Storage (CAES) facility would be an adiabatic process consisting only of a compressor, a storage and a turbine, compressing air into a container when storing and expanding when producing. This type of CAES would be adiabatic and would if the machines were reversible have a storage efficiency of 100%. However, due to the specific capacity of the storage and the construction materials the air is cooled during and after compression in practice, making the CAES process diabatic. The cooling involves exergy losses and thus lowers the efficiency of the storage significantly. The efficiency of CAES as an electricity storage may be defined in several ways, we discuss these and find that the exergetic efficiency of compression, storage and production together determine the efficiency of CAES. In the paper we find that the efficiency of the practical CAES electricity storage is 25-45% and thus has a quite low efficiency, which is close to the efficiency of the simple diabatic CAES-process. Adiabatic CAES would reach significantly higher storage efficiency about 70-80%.

Caractérisation de l'acier inoxydable après trempe superficielle à basse température
The Multivariate Gaussian Probability Distribution

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Authors: Ahrendt, P. (Intern)
Publication date: 2005

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http://www2.imm.dtu.dk/pubdb/p.php?3312

Numerical Modelling of Welding Induced Stresses

General information
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Organisations: Department of Management Engineering
Authors: Hansen, J. L. (Intern)
Number of pages: 180
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Very High Frequency Switch-Mode Power Supplies.: Miniaturization of Power Electronics.
The importance of technology and electronics in our daily life is constantly increasing. At the same time portability and energy efficiency are currently some of the hottest topics. This creates a huge need for power converters in a compact form factor and with high efficiency, which can supply these electronic devices. This calls for new technologies in order to miniaturize the power electronics of today. One way to do this is by increasing the switching frequency dramatically and develop very high frequency switch mode power supplies. If these converters can be designed to operate efficiently, a huge size, weight and cost reduction can be achieved due to the smaller energy storing elements needed at these frequencies. The research presented in this thesis focuses on exactly this. First various technologies for miniaturization of power supplies are studied, e.g. piezo electric transformers, wide band gap semiconductors and integrated power supplies. Afterwards a wide range of topologies suited for operation at very high frequencies is investigated and the most promising ones are tested experimentally. Through a comparison of these topologies the class DE inverter is found to be superior to the other alternatives, at least for converters with hundreds of volts as input and a few tens of watts output power. A class DE inverter does however require a high side gate drive, which have never been presented before for these frequencies and voltages. This thesis presents the worlds first high side gate drive capable of operating at these frequencies and voltage levels. Two control methods are also investigated, namely burst mode and outphasing. It is shown that a very flat efficiency curve can be achieved with burst mode. A 89.5% efficient
converter is implemented and the efficiency only drops 5% at 10% load. This is some of the highest efficiencies presented for converters operating at these frequencies. Burst mode control does however have two major drawbacks, ii/xvi introductions of low frequency harmonics and decreased control bandwidth. Outphasing is therefore investigated as an alternative, which does not introduce these drawbacks. In the last chapter the conducted and radiated electromagnetic interference from two prototypes are investigated, one running with constant output and one with burst mode control implemented. By the end of the thesis it is shown, that a size reduction of 70%, weight reduction of 81%, cost reduction of 56% and efficiency gain of 4.5%-points can be achieved with a very high frequency class DE converter, compared to a commercial product.

Digital Signal Processing for Optical Coherent Communication Systems
In this thesis, digital signal processing (DSP) algorithms are studied to compensate for physical layer impairments in fiber optic coherent communication systems. The physical layer impairments investigated in this thesis include fiber chromatic dispersion, polarization demultiplexing, light sources frequency and phase offset and phase noise. The studied DSP algorithms are considered as key building blocks in digital coherent receivers for the next generation of optical communication systems such as 112-Gb/s dual polarization (DP) quadrature phase shift keying (QPSK) optical transmission links.

Highlight results presented in this PhD thesis include three areas. First, we present an experimental demonstration of enhanced tolerance to phase noise using pilot-tone-aided phase noise mitigation DSP algorithms. To the best of our knowledge, it is the first experimental demonstration of high phase noise tolerance of 40-Gb/s coherent DP-QPSK systems using vertical cavity surface emitting lasers (VCSELs) as transmitter and local oscillator lasers. Second, in order to fulfill the strict constrains of spectral efficiency, this thesis shows the pioneering experimental demonstration of high spectrum narrowing tolerance 112-Gb/s DP-QPSK optical coherent systems using digital adaptive equalizer. The demonstrated results show that off-line DSP algorithms are able to reduce the bit error rate (BER) penalty induced by signal spectrum narrowing. Third, we also investigate bi-directional transmission of carrierless amplitude and phase (CAP) modulation format signal. In this thesis we focus on the experimental demonstration of DSP channel estimation implementations with CAP signal in the bi-directional optical transmission system.

Furthermore this thesis proposes recongurable and ultra dense wavelength division multiplex (U-DWDM) optical coherent systems based on 10-Gbaud QPSK. We report U-DWDM 1.2-Tb/s QPSK coherent system achieving spectral efficiency of 4.0-bit/s/Hz. In the experimental demonstration, digital decision feed back equalizer (DFE) algorithms and a finite impulse response (FIR) equalizer algorithms are implemented to reduce the inter channel interference (ICI). This PhD thesis also investigates a parallel block-divided overlapped chromatic dispersion DSP compensation algorithm. The essential benefit of using a parallel chromatic dispersion compensation algorithm is that it demands less hardware requirements than a conventional serial chromatic dispersion compensation algorithm.

In conclusion, the digital signal processing algorithms presented in this thesis have shown to improve the performance of digital assisted coherent receivers for the next generation of optical fiber transmission links.
**Introduction to computed tomography**

**General information**
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Organisations: Manufacturing Engineering, Department of Mechanical Engineering
Authors: Cantatore, A. (Intern), Müller, P. (Intern)
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**Cloud RAN for Mobile Networks - a Technology Overview**
Cloud Radio Access Network (C-RAN) is a novel mobile network architecture which can address a number of challenges the operators face while trying to support growing end-user’s needs. The main idea behind C-RAN is to pool the Baseband Units (BBUs) from multiple base stations into centralized BBU Pool for statistical multiplexing gain, while shifting the burden to the high-speed wireline transmission of In-phase and Quadrature (IQ) data. C-RAN enables energy efficient network operation and possible cost savings on base-band resources. Furthermore, it improves network capacity by performing load balancing and cooperative processing of signals originating from several base stations. This article surveys the state-of-the-art literature on C-RAN. It can serve as a starting point for anyone willing to understand C-RAN architecture and advance the research on C-RAN

**General information**
State: Published
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Authors: Checko, A. (Intern), Christiansen, H. L. (Intern), Yan, Y. (Intern), Scolari, L. (Intern), Kardaras, G. (Intern), Berger, M. S. (Intern), Dittmann, L. (Intern)
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Main Research Area: Technical/natural sciences

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Scopus rating (2014): SJR 3.792 SNIP 9.057 CiteScore 13.78
Web of Science (2014): Indexed yes
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Scopus rating (2013): SJR 2.85 SNIP 9.056 CiteScore 11.14
ISI indexed (2013): ISI indexed yes
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Scopus rating (2012): SJR 3.739 SNIP 10.636 CiteScore 13.43
ISI indexed (2012): ISI indexed yes
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Scopus rating (2010): SJR 2.985 SNIP 6.059
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Modular Multilevel Converter Modelling, Control and Analysis under Grid Frequency Deviations
A tool for component sizing for MMCs has been developed and tested through simulations in PLECS. The steady-state behaviour under grid frequency deviations - interesting for offshore wind farm connections - has been analysed, providing insights in MMC characteristics and further testing the proposed tool.

General information
State: Published
Authors: Sztykiel, M. (Ekstern), da Silva, R. (Ekstern), Teodorescu, R. (Ekstern), Zeni, L. (Intern), Helle, L. (Ekstern), Kjaer, P. C. (Ekstern)
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Electronic versions:
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Projects:
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Publication: Research - peer-review › Article in proceedings – Annual report year: 2012

Cloud Radio Access Network (C-RAN) is a novel mobile network architecture which can address a number of challenges that mobile operators face while trying to support ever-growing end-users’ needs towards 5th generation of mobile networks (5G). The main idea behind C-RAN is to split the base stations into radio and baseband parts, and pool the Baseband Units (BBUs) from multiple base stations into a centralized and virtualized BBU Pool. This gives a number of benefits in terms of cost and capacity. However, the challenge is then to find an optimal functionality splitting point as well as to design the so-called fronthaul network, interconnecting those parts. This thesis focuses on quantifying
those benefits and proposing a flexible and capacity-optimized fronthaul network. It is shown that a C-RAN with a functional split resulting in a variable bit rate on the fronthaul links brings cost savings due to the multiplexing gains in the BBU pool and the fronthaul network. The cost of a fronthaul network deployment and operation can be further reduced by sharing infrastructure between fronthaul and other services. The origins of multiplexing gains in terms of traffic burstiness, the tidal effect and various possible functional splits are analyzed and quantified. Sharing baseband resources between many cells is possible for traditional C-RANs. However, in order to further benefit from multiplexing gains on fronthaul, it is recommended to implement a functional split yielding variable bit rate in the fronthaul. For the analyzed data sets, in deployments where diverse traffic types are mixed (bursty, e.g., web browsing and constant bit rate, e.g., video streaming) and cells from various geographical areas (e.g., office and residential) are connected to the BBU pool, the multiplexing gain value reaches six. Using packet-based fronthaul has the potential to utilize fronthaul resources efficiently. However, meeting synchronization and delay requirements is a challenge. As a possible solution, the use of IEEE Precision Time Protocol (PTP) (also known as 1588v2) has been evaluated, and for the analyzed scenario it can assure synchronization on the nanosecond level, fulfilling mobile network requirements. Furthermore, mechanisms to lower delay and jitter have been identified, namely: source scheduling and preemption. An innovative source scheduling scheme which can minimize jitter has been proposed. The scheme is optimized for symmetric downlink and uplink traffic, but can also be used when downlink traffic exceeds uplink. Moreover, a demonstrator of a Software Defined Networking (SDN) controlled Ethernet fronthaul has been built.

General information
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Quantitative assessment of Lawsonia intracellularis in feces by real-time PCR

General information
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Remote Sensing for Wind Energy
The Remote Sensing in Wind Energy report provides a description of several topics and it is our hope that students and others interested will learn from it. The idea behind it began in year 2008 at DTU Wind Energy (formerly Risø) during the first PhD Summer School: Remote Sensing in Wind Energy. Thus it is closely linked to the PhD Summer Schools where state-of-the-art is presented during the lecture sessions. The advantage of the report is to supplement with in-depth, article style information. Thus we strive to provide link from the lectures, field demonstrations, and hands-on exercises to theory. The report will allow alumni to trace back details after the course and benefit from the collection of information. This is the third edition of the report (first externally available), after very successful and demanded first two, and we warmly acknowledge all the contributing authors for their work in the writing of the chapters, and we also acknowledge all our colleagues in the Meteorology and Test and Measurements Sections from DTU Wind Energy in the PhD Summer Schools. We hope to continue adding more topics in future editions and to update and improve as necessary, to provide a truly state-of-the-art ‘guideline’ available for people involved in Remote Sensing in Wind Energy.

General information
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Organisations: Department of Wind Energy, Meteorology, Test and Measurements, University of Stuttgart, Leosphere, University of Colorado, Karlsruhe Institute of Technology, ZephIR Ltd., National Renewable Energy Laboratory, Institute for Atmospheric Science and Climate
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Tragacanth Gum: Structural Composition, Natural Functionality and Enzymatic Conversion as Source of Potential Prebiotic Activity
Gum tragacanth derived from the plant (Astragalus sp.) has a long history of use as a stabilizing, viscosity enhancing agent in food emulsions. The gum is mainly produced in the Middle East, and permitted for food use in the US as well as in Europe (E-number E413). Gum tragacanth is known to confer very high viscosities when in aqueous solution, and is described as a complex, highly branched, heterogeneous hydrophilic polysaccharide. The gum contains pectinaceous arabinogalactans and fucose-substituted xylogalacturonans. The objective of this PhD study were to evaluate tragacanth samples from six species of Iranian Astragalus for their emulsion stabilizing effects and their detailed chemical
composition in order to examine any possible correlation between the make-up and the emulsion stabilizing properties of gum tragacanth. Also, enzymatic modification of highly fucose content of tragacanth gum and separation via membrane technique to get different molecular size. Furthermore, examination of compositional structure and effect of different molecular size on potential prebiotic was evaluated.

The first part of the present study was selected of six different species of Astragalus and exudates of gum and fractionated by centrifugation to soluble and insoluble. To examine correlation between composition structure, sugar composition and methoxyl and acetyl content was determined. The six gum samples varied with respect to their levels and ratios of water-soluble and water-swellable fractions, their monosaccharide composition, methoxylation, and acetylation degrees. Emulsion and rheological properties of different gum solution was assessed with WPI as an emulsifier in protein base emulsion and correlation of each composition on emulsion stability was established. Tragacanth gum solution added in emulsion and without emulsion showed shear thinning properties in all gums. The emulsion stabilization effect correlated linearly and positively to the methoxylation degree, and galacturonic acid content of the gums, but not to acetyl or fucose content. A particularly high correlation was found between methoxyl level in the soluble gum part and emulsion stabilization.

The results of this work provide some important clues to the emulsion stabilization mechanisms in relation to the structure composition of tragacanth gums.

From our knowledge and many research for application of this gum in food industry and unique properties of this gum with arabinogalactan and fucosylgalacturonans in the structure of we decided to evaluate bioactivity of this gum. To date, different commercial of prebiotic compound available but still new compound is needed and interested. The main process for the production of prebiotic is enzymatic process. Thus, the next study of work was using commercial pectinolytic enzyme to get different molecular size and purified with membrane technique and get three different fraction: HAG1 < 2 kDa; 2 kDa < HAG2 < 10 kDa; HAG3 > 10 kDa. HPAEC results shown that these three fractions varied with respect to composition and HAG1 and HAG2 were enriched in arabinose, galactose, and galacturonic acid, but low in fucose and xylose; whereas HAG3 was high in xylose, fucose and galacturonic acid, but low in arabinose and galactose. The structural composition of different fractions with linkage analysis shown that the structure of gum tragacanth fractions was different and included 1,4-bonded galacturonic acid backbone with terminally linked fucose and (1,2-linked xylose, as well as terminally linked xylose called fucosylgalacturonan. In addition, the presence of (1,4)-galactose linkages and 1,5 Ara linkage presumably correspond to arabinogalactan-derived galactan. Determination of prebiotic effect of different fraction in vitro were assessed on seven different probiotic strains in single culture fermentations on: Bifidobacterium longum subsp. longum (2 strains), B. longum subsp. infantis (3 strains), Lactobacillus acidophilus, B. lactis, and on one pathogenic strain of Clostridium perfringens. The fractions HAG1 and HAG2 consistently promoted higher growth of the probiotic strains than HAG3, especially of the three B. longum subsp. infantis strains, and the growth promotion on HAG1 and HAG2 was better than that on galactan (control). HAG3 completely inhibited the growth of the Cl. perfringens strain.

In summary of this study:
- Emulsion stabilization of the gum is related to the gum composition and structure, and mainly galacturonic acid content and degree of esterification are important
- low molecular size oligosaccharides produced enzymatically has higher potential prebiotic activity than longer chain gum saccharides
- Tragacanth gum can be a new source for development of innovative functional foods with health claims

**General information**

State: Published
Organisations: Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering
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**European Wind Atlas**

**General information**

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Organisations: Risø National Laboratory for Sustainable Energy, Wind Energy Division
Authors: Troen, I. (Intern), Lundtang Petersen, E. (Intern)
Number of pages: 656
Publication date: 1989
The energy efficiency of onboard hydrogen storage

Global warming resulting from the use of fossil fuels is threatening the environment and energy efficiency is one of the most important ways to reduce this threat. Industry, transport and buildings are all high energy-using sectors in the world and even in the most technologically optimistic perspectives energy use is projected to increase in the next 50 years. How and when energy is used determines society’s ability to create long-term sustainable energy systems. This is why this book, focusing on energy efficiency in these sectors and from different perspectives, is sharp and also important for keeping a well-founded discussion on the subject.

Large-scale Roll-to-Roll Fabrication of Organic Solar Cells for Energy Production

The global energy consumption is increasing steadily while natural energy sources are running out sooner or later. Solar electricity is one of many renewable energy sources that contributes to the world’s demand. Organic solar cells (OPV) are an attractive 3rd generation solar technology that can be produced cheaply and very fast from solution with printing processes. The current research all around the world is still focused on lab-scale sized devices ~ cm², ITO-glass substrates, and spin coating as the main fabrication method. These OPV devices are far from any practical application although record efficiencies beyond 10% could be achieved.

This dissertation describes process workflows and roll-to-roll (R2R) fabrication methods for upscaling the OPV technology to solar module sizes that enable real power production even at efficiencies <2 %. The fundamental cell technology was based on flexible plastic substrates and ITO-free transparent conductive electrodes made from special designed flexo printed silver grids, rotary screen printed PEDOT:PSS, and slot-die coated ZnO (= Flextrode). The organic solar cell was fabricated by slot-die coating a light absorbing photoactive layer (e.g. P3HT:PCBM) on top of the Flextrode substrate and completed by rotary screen printed PEDOT:PSS and silver electrodes. All layers were R2R printed and coated from solution under full ambient vacuum-free conditions with fabrication speeds reaching 25mmin⁻¹ for some of the layers. Fabrication of modules with high power output requires intelligent connection of single cells that should involve as less as possible manual processes such as wiring or soldering. The problem was solved by serially connecting thousands of single cells entirely during the R2R processing by printing thin-film silver conductors. High voltage networks require only thin conductors to efficiently transport the relatively low current of the organic solar cells. The serial connection was possible through a special designed pattern layout that combined 1-dimensional coating and 2-dimensional printing.
processes. The so-called Infinity concept allowed the fabrication of virtually infinitely large module sizes without manual wiring. High voltage modules with 21000 cells, open circuit voltage >10 kV and power output >220Wpeak could be successfully manufactured while having only two terminal contacts.

Real energy production from these modules was studied by setting up a whole solar park based on OPV modules. Infinity modules with a length of 100m (width 0.3 m) were rolled out and taped onto a wooden structure. The maximum power output of six parallel-connected modules with a total active area of 88.2m2 was beyond 1.3 kW while having energy payback times P1 year. Alternative installation concepts such as a balloon or special designed solar tubes on land or water were proved to be functional as well. Solar tubes with Infinity modules of around 200W generated 18 kWh in 5 weeks. The energy was fed back into the Danish power grid.

The dissertation contains a brief introduction of organic solar cell technology and reviews important R2R compatible manufacturing methods including photonic sintering. The fabrication, design, and challenges of Flextrode and Infinity modules are described in detail. The potential future energy production is presented through large-scale OPV installation scenarios and performance analyses. Fatal failures such as fully burned cells are described while easy repair mechanisms are shown that avoid costly replacements of full modules. A conclusion and outlook finalizes the dissertation.
propose a general method for solving aggregated formulations, such that the solution is optimal to the original problem. The method is based on applying Benders’ decomposition on a combination of the original and aggregated formulations. Put in a branch-and-bound context, branching can be performed on the original variables to ensure optimality. We show how to apply the method on well-known optimization problems.

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Organisations: Department of Management Engineering, Management Science
Authors: Gamst, M. (Intern), Spoorendonk, S. (Intern)
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Wind Forces on Container Ships
An investigation of the wind forces acting on a 9,000+ TEU container ship has been carried out through a series of wind tunnel tests. It was investigated how the wind forces depend on the container configuration on the deck using a 1:450 scale model and a series of appropriate container configurations. The wind tunnel tests were carried out in the naturally existing boundary layer of the wind tunnel. The longitudinal and transverse forces and the yaw moment were measured and the measurements were corrected for the effects of the boundary layer and blockage in the wind tunnel. The results are presented as nondimensional coefficients. It is concluded, that the measured forces and moment depend on the container configuration on deck, and the results may provide a general idea of how the magnitude of the wind forces is affected by a given container stacking configuration on a similar container ship.

General information
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Organisations: Department of Mechanical Engineering, Fluid Mechanics, Coastal and Maritime Engineering
Authors: Andersen, I. M. V. (Intern)
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Life cycle assessment of the wave energy converter: Wave Dragon
Any power production technology should be able to demonstrate that it’s able to comply with current and future environmental regulation and that it demonstrates a considerable surplus in the energy balance being a part of the entire power system. This means that the energy used throughout all the lifecycle stages; from provision of materials over manufacturing of components and assembly, to deployment and use and eventually the disposal stage, is considerably less than the energy produced by the devise during its use/production stage.

General information
State: Published
Organisations: Quantitative Sustainability Assessment, Department of Management Engineering, Wave Dragon ApS, University of Copenhagen
Authors: Hans Chr., S. (Ekstern), Stefan, N. (Ekstern), Stefan, A. (Ekstern), Hauschild, M. Z. (Intern)
Publication date: 2007
Environmental sustainability of wastewater sludge treatments

The European Water Framework Directive addresses the issue of pollution from urban waste water and is thereby changing the scope of sewage treatment. As part of this process, the Neptune project (EU, FP6) focuses on developing new and upgrading existing technologies of waste water and sludge treatment for municipal waste water. A special focus area in Neptune is sludge handling because the sludge amount is expected to increase due to advanced waste water treatment. The main sludge processing methods assessed in Neptune can be divided into two categories: disintegration processes before anaerobic digestion (thermal hydrolysis and ultrasound disintegration) and inertisation processes performed at high temperatures (incineration, pyrolysis, gasification, wet oxidation) but they all aim at volume reduction and removal of biodegradable compounds before safe sludge disposal or reuse of its resources. As part of a sustainability assessment (or "best practice evaluation"), a comparison between the existing and new sludge handling techniques have been done by use of life cycle assessment (LCA). The concept of induced impacts as compared to avoided impacts when introducing a new sludge treatment technology is used for the environmental comparison. Emissions from the treatment of the sludge as well as energy consumption and production, chemical consumption, infrastructures and transport are taken into account. This poster will present the results of LCA's performed on different inertisation technologies. Incineration is used as the reference process, as it is the only existing well-developed technology, while other techniques like pyrolysis and gasification are relatively new, and only exist at lab-scale or pilot-plant scale.

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Organisations: Department of Management Engineering, Quantitative Sustainability Assessment, Technical University of Denmark
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Kedeleffektiviteter for oliefyr og naturgaskedler i enfamiliehuse

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Authors: Furbo, S. (Intern), Shah, L. J. (Intern), Christiansen, C. H. (Ekstern), Frederiksen, K. V. (Ekstern)
Publication date: 2004

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Absorption and refractive index dynamics in waveguide semiconductor electroabsorbers

This thesis describes the optical characterization of waveguide semiconductor electroabsorbers with an INGaAsP multi-quantum well heterostructure. The investigations have focused on applying the electroabsorbers as electroabsorption modulators or as saturable absorbers. The components have been manufactured with the Danish research council sponsored SCOOP-programme (Semiconductor Components for Optical signal Processing) in collaboration with the Danish company GIGA-An Intel Company. The focus of the SCOOP-programme is to develop new semiconductor components for optical signal processing in telecommunication systems. Both the amplitude and phase transfer functions of electroabsorption modulators as function of reverse bias and wavelength, are measured using a heterodyne detection technique. With this information, the bias and wavelength dependent $\Delta H$-parameter is calculated and so is the electroabsorption modulator response to a 10 Gb/s modulation of the bias. It is concluded that operation close to the absorption edge is advantageous both chirp-wise and with respect to lowering the drive voltage. This however becomes at the expense of a higher insertion loss. A comparison between a component with 10 shallow quantum wells and a component with 5 deep quantum wells shows that the shallow 10 quantum wells component is preferable with respect to chirp, extinction ratio and potentially also the insertion loss. Calculations of the refractive index changes confirm the measurements and show, that the fabricated electroabsorption modulators can generate high quality pulses for optical fiber transmission. The all-optical wavelength conversion and demultiplexing capabilities of the electroabsorbers, when operated as saturable absorbers, are investigated using femtosecond laser pulses in an amplitude and phase sensitive heterodyne pump-probe experiment. It is shown that the absorption can be bleached effectively by optical generation of carriers. The absorption recovery is measured as a function of pump pulse energy and reverse bias applied to the component and it is shown that a 10 ps switching window with 9.6 dB of extinction ratio can be realized. The sign of the refractive index change, induced by optical generation of carriers in the active region, is seen to depend both on the optical power and on the reverse bias applied to the saturable absorber. The trends of the observed refractive index dynamics are explained from a combination of band filling and field screening. It is concluded, that for the right bias and wavelength it is possible to wavelength convert into negatively chirped pulses.

On the way to successful European eel larval rearing: Impact of biophysical conditions and gamete quality

The European eel is a widely distributed fish species of economic and cultural importance. It inhabits both coastal and freshwater systems, and is targeted by fisheries and treasured as food item. Although eels are reared in aquaculture, this industry relies solely of wild-caught juvenile glass eels that arrive to the European coasts after a 6000 km journey from the Sargasso Sea, where they were hatched. The adolescent eels start their long migration from the European continent back to their spawning area in the Sargasso Sea in late autumn as silver eels. As long as the eels are within the European continent, they are in an immature stage, and they do not start migration and maturation until the silvering stage. This stage is however tightly controlled by brain and pituitary hormones, preventing maturation of gonads remote from their natural breeding area. This hormonal inhibition of maturation is the main reason why it is difficult to reproduce European eel in captivity. Although, attempted since 1930ies, utilizing maturational hormones primarily from other fish species, we only recently succeeded in refining reproduction protocols that enable rich quantities of viable gametes from this species. In view of these obstacles, the last decade’s research has shown substantial progress. This PhD has contributed to this progress through new knowledge and development of procedures for successful egg activation and fertilization as well as incubation and larvae culture. My PhD work addressed biophysical determinants fundamental to producing healthy eggs and larvae. One of my aims was to improve methods and results of in vitro fertilization. This research included characterisation of sperm density, “optimal” sperm to egg ratios and gamete mixing. Eel gametes are activated by salt water and incubated in a marine aquatic environment. In this regard, my aim was to identify suited salinities and seawater sources, supporting a good embryonic development. Embryonic development lasts two days from fertilization to hatch. During this time, as well as in early larval stages, mortality is high. Here, my aim was to assess effects of temperature and microbial interference during incubation and larval rearing on order to reduce this mortality in cultures. The results have provided valuable new insights, contributing to progress of in
vitro fertilization methods and reduced mortality in egg and larval culture. Our fertilisation procedures initially applied spermatocrit as for sperm quantification technique to standardise sperm:egg ratio. Although being a practical method, it featured moderate precision. Spectrophotometry in contrast, showed high precision in addition to being a fast and practical and subsequently supported experiments that identified optimal sperm:egg ratio. Egg activation and swelling are among the processes often seen to fail in experiments. Activation salinity was found to be a determinant of egg fertilisation, buoyancy, and egg size although egg size effects differed among individual females. Fertilization percent was typically high in the range 30 and 40 ppt, while rate of un-activated and dead eggs rose in higher salinities. Egg swelling could be optimized using certain artificial salt types and impeded using others. During egg incubation, microbial interference was found to be a major obstacle for hatch, rather caused by microbial activity than presence. Larval mortality was highly dependent on whether antimicrobial conditions were bacteriostatic of bactericidal. This calls for future technology and microbial management, e.g. by matured water integrated in RAS technology. The results obtained through these studies have added to Danish progress within artificial reproduction in European eel by improved fertilization protocols and identification of important parameters during the early life stages. Such progress has led to present focus on eel larval culture and feeding, which has brought attention to eel as a potential “new species” in aquaculture.

General information
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Organisations: National Institute of Aquatic Resources, Section for Marine Ecology and Oceanography
Authors: Sørensen, S. R. (Intern), Tomkiewicz, J. (Intern), Munk, P. (Intern), Bossier, P. (Ekstern)
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Experimental Study and Modelling of Asphaltene Precipitation Caused by Gas Injection

General information
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Authors: Verdier, S. C. R. (Intern), Stenby, E. H. (Intern), Andersen, S. I. (Intern)
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Prediction of noise in ships by the application of "statistical energy analysis."
If it will be possible effectively to reduce the noise level in the accomodation on board ships, by introducing appropriate noise abatement measures already at an early design stage, it is quite essential that sufficiently accurate prediction methods are available for the naval architects. In general, the structure-borne noise contribution from the various noise sources may be precalculated with a reasonable accuracy using empirically based calculation models. The prediction very often fails, however, when the empirically based calculation model is applied for an untypical structure or for a special noise abatement measure, e.g., increased structural damping. The paper discusses whether it might be possible to derive an alternative calculation model based on the "statistical energy analysis" approach (SEA). By considering the hull of a ship to be constructed from plate elements connected by combination of L junctions, T junctions, and cross junctions, a SEA-calculation model has been derived. Examples on application of the SEA model for prediction of the structure-borne sound transmission are given, partly through simple two-element structures consisting of stiffened and unstiffened plate panels, partly through a hull section consisting of several stiffened plate sections. The results of the SEA calculations are compared with corresponding results of vibration measurements on the structures. ©1979 Acoustical Society of America
Indicators of energy innovation systems and their dynamics. A review of current practice and research in the field: Radar report

The purpose of this ‘radar report’ is to give an overview of the state of the art concerning indicators of energy innovation systems and their dynamics. As part of this, it is the aim to discuss current challenges and efforts made by researchers and other professionals working in the field. Through this, the radar report shall contribute to the discussion of how the field might develop in the future; both for the sake of understanding the dynamics of energy innovation systems in general and, more specifically, for the sake of understanding the role energy innovation systems play for moving towards more climate-friendly and sustainable energy systems.

The analysis behind the radar report builds on a search and review of research literature, databases, statistics schemes, etc., on indicators of energy innovation systems as such and on relevant connected issues. In addition, it builds on assessment and insights from experienced researchers in the field. It is the intention with the report to communicate knowledge from researchers to other interested parties; not only to other researchers, but also to stakeholders more broadly, e.g. interest organisations, policy makers, statisticians, etc. However, a one-way communication picture is not entirely correct. Not only do researchers in many cases build on nationally or internationally recognized indicator schemes and databases established by governmental bodies, statistics agencies or international organizations like the OECD (Organisation of Economic Cooperation and Development) and the IEA (International Energy Agency). Researchers are also in a number of cases involved in establishment and development of official indicator schemes for example by acting as advisors or carrying out background studies. The interaction between research and practitioners is complex, and it makes little sense to address scientific research activities only, without taking into consideration the broader picture of indicator schemes. What we researchers most obviously can contribute with compared to other professional bodies in the field, is an explicit theoretical analysis perspective, in this case based on innovation system theory. Through this we can hopefully point out issues and raise questions that would otherwise not have been addressed.
Effect of pomegranate (Punica granatum) and rosemary (Rosmarinus officinalis L.) extracts on shelf-life for chilled Greenland halibut (Reinhardtius hippoglossoides) fillets in modified atmosphere packaging at 2 °C

The present study evaluated the effect of pomegranate extract (1% v/w) and rosemary extract (1% v/w) as natural preservatives as well as their combination (1% v/w) on shelf life extension of previously frozen and chilled Greenland halibut fillets in modified atmosphere packaging (MAP, 40%CO2/60%N2) at 2 °C. Parameters that were monitored were: microbiological (aerobic plate counts (APC), lactic acid bacteria (LAB), Lactobacillus spp., and Photobacterium phosphoreum), biochemical (pH, thiobarbituric acid (TBA), trimethylamine (TMA) and total-volatile-nitrogen (TVN)), and sensory (color, flavor and texture) attributes. For microbiological results, irrespective of treatments, APC reached levels ≥107 CFU/g during storage. The spoilage microflora of fillets in MAP was dominated by LAB, but the concentration of Lactobacillus was very low. During storage, P. phosphoreum was not detected in any sample. Among the chemical indices examined, TBA values of control samples exceeded the limit of 2 mg malondialdehyde (MDA)/kg (2.78 and 4.08 mg MDA/kg) on days 18 and 23 of storage, respectively, while TBA values for samples treated with extracts remained below the limit throughout the storage period. Final (TMA) and (TVN) values for all treatments ranged between 0.15 to 0.37 mg N/100 g and 16.90 to 24.10 mg N/100 g after 23 days of storage, respectively, not exceeding upper acceptability limit set by EU. Sensory analysis correlated well with TMA and TVN analysis, indicating a shelf life of longer than 23 days for all samples. The research was supported by the Federation of European Microbiological Societies (FEMS) and performed during a research visit by Ilke Uysal Unalan at DTU Food.

Leaching potential of nanomaterials during different human contact scenarios and end-of-life

In order to understand how much, when and by which mechanisms nanomaterials are released during the life cycle of a given application, we have experimentally investigated the release of nanoparticles (NP) from a wide range of products. These include silver and titanium dioxide NP released from food storage containers, titanium dioxide released from coated ceramic tiles, iron (III) oxide NP from polyethylene granulates and silver NP released from toothbrushes. In our investigation, we focused specifically on release during the consumer use phase and the waste handling phase as these two aspects of the life cycle seem to be especially important and not well understood. In order to get an estimation of the overall release potential of nanomaterials during the consumer use phase and the waste phase, we also mapped consumer products on the EU marked claiming to be nano-enabled and commercially available online (see www.nanodb.dk) as well as the waste flows of these consumer products. We identified more than 1275 products to be available in the EU. Almost 200 products of these are claimed to contain nanosilver, but for more than 800 products the identity of the nanomaterial used was not reported. Based on information available online, the consumer products were categorized into waste material fractions, and we found that "Dirty plastic" (e.g. used bottles and containers) was clearly the dominating waste fraction for nano-enabled products. CNTs and other nanomaterials were primarily represented in one or two waste fractions, whereas nanosilver was found to be present in six of the eight identified waste fractions.
Rapid Radiochemical Analysis of Radionuclides Difficult to Measure in Environmental and Waste Samples

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Organisations: Center for Nuclear Technologies, Radioecology and Tracer Studies
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Thule-2003 - Investigation of radioactive contamination

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State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Radiation Research Division
Authors: Nielsen, S. P. (Intern), Roos, P. (Intern)
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Publication date: 2006
Wind Farm Optimization and Multi-Fidelity Wake Modelling: Presentation of TOPFARM I & II, FUSED-Wake

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Organisations: Department of Wind Energy, Aeroelastic Design
Authors: Réthoré, P. (Intern)
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Global drivers for transformation of energy systems

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