WORKSHOP ON

RENEWABLE ENERGIES AND SMART GRID

GUC, New Cairo, 25th - 26th June, 2011

Background

The GUC has been established in 2003 in cooperation with the Universities of Ulm, Stuttgart and Tübingen, the German Academic Exchange Service (DAAD), the State Government of Baden-Württemberg, and the Stifterverband für die deutsche Wissenschaft. Today, the GUC offers 18 Bachelor/Master programs in Information/Media Engineering, Engineering & Material Sciences including Applied Sciences and Arts as well as Architecture and Civil Engineering, Pharmacy & Biotechnology Sciences, and Management Technology, for more than 8000 students. After the successful introduction of the study programs, the sustainable establishment of research has currently the highest priority.

Teaching, research and exchange of students and faculties are practiced under the 2nd Cooperation agreement between the GUC and its German partner universities. The Integrated Joint Research Project “Renewable Energies and Smart Grid” aims at an interdisciplinary cooperation activity between the GUC and its German partner universities to build up interdisciplinary research, to attract research funding and, finally, to foster the creation of start-up enterprises which are considered as an essential basis for a sustainable and long-term cooperation of high mutual interest. The Integrated Joint Research Project has been positively supported by the GUC Board of Trustees and the representatives of the German partner Universities.

The aim of this kick-off workshop is to start the joint project, to convene all related experts, to present their views and individual project proposals in form of Bachelor, Master, PhD and joint research projects as a basis for later funding applications by public and private (industrial) funding organizations.

Thank you very much for your cooperation.

Workshop Coordinators

Prof. Dr.-Ing. Paul J. Kuehn
Founding Dean Faculty IET (GUC)
Study Dean International Programs
(University of Stuttgart)

Prof. Dr. Carmen Gervet
Professor, Head of Computer Science and Engineering Department, Faculty of MET (GUC)
Workshop Organizing Committee

Prof. Dr. Slim Abdennadher  
Vice President for Academic Affairs  
Professor, Faculty of MET (GUC)

Prof. Dr. Carmen Gervet  
Head of Computer Science and Engineering Department; Professor, Faculty of MET (GUC)

Prof. Dr. Hans-Peter Grossmann  
Founding Dean of Faculty of MET (GUC)  
Professor, University of Ulm

Prof. Dr. Yasser Hegazy  
Dean of Faculty of IET  
Professor, Faculty of IET (GUC)

Prof. Dr.-Ing. Paul J. Kuehn  
Founding Dean of Faculty of IET (GUC)  
Study Dean Int. Programs  
Professor, University of Stuttgart

Acknowledgements

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Sat., June 25, 2011

09:00 am  Welcome Coffee

09:30 am  Opening Session

Addresses by
the President of the GUC, Prof. Abdel-Kader
Representatives of the Government/Ministries of Egypt
Workshop Coordinators (C. Gervet and P.J. Kuehn)

10:15 am  Overviews
Ongoing Research Initiatives for RE and Smart Grid in Europe and Germany
P.J. Kuehn (University of Stuttgart)

Brief Overview of Current Research Efforts in RE at the GUC
C. Gervet (GUC)

11:00 am  Technical Session: Smart Grid

Smart Grid Communications and Applications
R. Lehnert, (Technical University of Dresden)

Information Security and Privacy Problems in the Smart Grid
P.J. Kuehn (University of Stuttgart)

Modeling and Performance Evaluation of Self-Adapting Algorithms for Power-Saving Operation
M. Mashaly (GUC), P.J. Kuehn (University of Stuttgart), T. El-Shabrawy (GUC)

12:00 pm  Lunch (Buffet) Break

1:00 pm  Technical Session: Wind Energy

Fluid Structure Interaction of Wind Turbine Blades
M.A. Sayed (GUC)

Aero-Elastic Analysis of Wind Turbines
A.A. El-Badawy, M. Sayed, M. Mehrez (GUC)

The Development of Materials for Wind Turbine Blades with Properties
Markedly Resistant to Surface Degradation
N. El Mahalawy, A. Klingner, B. Okolo (GUC)
2:00 pm **Coffee Break**

2:30pm **Technical Session: Solar Energy & Energy Cogeneration (I)**

Development of Solar Absorbers for Concentrating Solar Power  
*N. El Mahalawy, A. Klingner, B. Okolo (GUC)*

Concentrated Solar Power (CSP) - Technical and Ecological Assessment Within EnerKey Project  
*T. Telsnig, L. Eltrop (Univ. of Stuttgart)*

A Hybrid System: A Solar Concentrated Linear Fresnel PV/Thermal Collector and 1kW Wind Turbine for Energy Cogeneration  
*T. Khalil (Physics, GUC)*

Pt/Ru Promising Catalyst for Low-Temperature Direct Methanol Fuel Cells  
*A.M. El-Aziz (GUC), L. Kibler (National Research Center, Egypt), D.M. Kolb (University of Ulm)*

4:00 pm **Coffee Break**

4:30pm **Technical Session: Solar Energy & Energy Cogeneration (II)**

Hybrid Semiconductor-Metallic Nanoflowers and Core-Shell Nanocrystals: Towards Low-Cost Light-Harvesting Materials for Solar Cell Applications  
*M.B. Mohamed, K.M. AbouZeid, M.S. El-Shall, Al-Sayed Al-Shirbini, M.H. Abdel-Kader (GUC)*

Nanostructured Iridium for Electrochemical CO Oxidation  
*K. A. Soliman, Ludwig A. Kibler, Dieter M. Kolb, Timo Jacob (University of Ulm)*

Red Sea Phototrophic Bacteria as Solar Bioreactors  
*Khaled Abou Aisha, Hans-Georg Breitinger (GUC)*

6:00 pm **Reception (at the GUC)**
Sun., June 26, 2011

9:00 am  **Welcome Coffee**

9:30 am  **Technical Session: Techno-Economics of Renewable Energy**

- A Simulated Case Study of Solar Energy Cost Efficiency in Egypt
  *D. El Bassiouny (GUC)*

- Adequate Assessment of Power Systems Integrated with Wind and Solar Energy-Based Generators
  *Y.G. Hegazy (GUC)*

- Decision Support Tool for the Optimal Placement of Wind and Solar Parks at Minimal Cost
  *C. Gervet (GUC)*

10:30 am  **Coffee Break**

10:45 am  **Technical Session: Energy Storage**

- First-Principles Modeling of Electrochemical Interfaces
  *T. Roman, G. Chong, A. Gross (University of Ulm)*

- Improved Materials for Renewable Energies
  *S. Schmauder (University of Stuttgart)*

- Photochemical Conversion and Storage of Solar Energy
  *M.H. Abdel-Kader (GUC)*

- Stationary and Mobile Storage Technologies to Integrate Renewable Energy into the Grid
  *N. Hartmann, C. Kruck, L. Eltrop (University of Stuttgart)*

- The Development of Metallic Micro-Tubes for Hydrogen Storage
  *N. El Mahalawy, A. Klinger, B. Okolo (GUC)*

12:20 pm  **Lunch (buffet) Break**

1:00 pm  **Technical Session: Photovoltaic Modules**

- Dynamic String Interconnection of Photovoltaic Modules
  *T. Wurster, R. Merz, A.S. Garamoun, M.B. Schubert, J.W. Werner (University of Stuttgart)*

- Fully-Automated Cleaning Systems for Photovoltaic Panels and Reflectors
  *H. Kandil, H. Elsherif (GUC)*

- Status of Photovoltaic and Topics for Cooperation
  *M.B. Schubert, B. Zinsser, J.H. Werner (University of Stuttgart)*
2:00 pm  **Technical Session: Solar Energy and Water Treatment**

   Water Desalination Using Solar Energy  
   *M.S. Abd-Elhady, H. Kandil (GUC)*

   Solar-Driven Water Desalination/Distillation  
   *T. Khalil (GUC)*

   Key Drivers for Sustainable Operations in Developing Countries  
   *S. Elwan Ibrahim (GUC)*

   Solar Treatment of Waste Waters  
   *T.M. Hashem (GUC)*

3:00pm  **Coffee Break**

3:15pm  **Keynote speaker: Mr. Mohamed Aly El-Hamamsy**

   The Deserts as Eternal Power Houses  
   *DESERTEC representative in Egypt*

4:00 pm  **Panel Session**

5:00 pm  **End of Workshop**
Invited talk

The Deserts as Eternal Power Houses

Mr. Mohamed Aly El-Hamamsy
DESERTEC representative in Egypt
mohamed.hamamsy@desertec.org

Abstract: The DESERTEC Concept is based on the idea that the world’s deserts receive within 6 hours more energy from the sun than the humanity uses within one year.

Deserts are found all over the world. With technologies available today, it is possible to harvest enough energy from wind and solar radiation, convert it to electricity and transmit this electricity by means of high voltage direct current (HVDC) to urban districts within 3000 km around these deserts. Thus ensuring supply of about 90% of the humanity with clean, sustainable and “on demand” electricity.

A series of three studies, MED-CSP, TRANS-CSP and AQUA-CSP commissioned by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety; and conducted by the German Aerospace Center (DLR) in cooperation with several institutions from Middle-East and North-Africa (MENA) demonstrate the economic feasibility of this concept as applied to the region EU-MENA.

The studies showed that Concentrating Solar Power (CSP) with thermal storage for 10-14 hours and a backup emergency boiler could supply sufficient electricity for the peoples of MENA and an additional portion that can be transmitted to EU by means of HVDC lines around and through the Mediterranean.

Another portion of the harvested energy can be used – in a most economic way by waste heat from the steam turbine exhaust – for seawater desalination. Clean and sustainable water is urgently needed in MENA due to the increase of population.

Observing the continuously climbing costs of fossil fuels used for electricity generation and at the same time decreasing costs of renewable energies, it is easy to predict that business as usual (burning fossil fuel and nuclear power generation) will turn out to be the most expensive option, while going renewables may look expensive at the beginning, however, - after an initial push that enables their establishment in the market – they will continue their evolution of cost reduction following their learning curves.

The complete studies can be found at http://www.menarec.org.
Abstract:

Communication networks today account for 2% of the worldwide emissions of CO$_2$ with an exponentially rising trend. Currently electrical energy is generated in a few power plants and distributed to the user. Efficient use of energy requires distributed generation and distributed control of alternative energy generators. Therefore the power grid has to become a *smart grid*, which in turn requires a communication network for controlling the power grid. Smart grid communications can be realized by all communication technologies, wired or wireless. Applications range from meter reading to home automation and entertainment and the control of distributed power plants.

We present the requirements to implement a communication network for making the power grid smart. The traffic for grid control, metering and home surveillance is discussed.

Some ongoing research projects are described.
Information Security and Privacy Problems in the Smart Grid

Paul J. Kühn
Institute of Communication Networks and Computer Engineering, University of Stuttgart Germany
paul.j.kuehn@ikr.uni-stuttgart.de

Abstract Renewable energies on the basis of wind, solar or biomass sources are unsteady and need to be stored to avoid exhaustion during peak periods of energy consumption. The “Smart Grid” is a highly intelligent communication network for the control of energy generation, storage and delivery. For this purpose, the instantaneous power requirements have to be monitored from which optimized schedules may be derived for the energy to be transported, delivered or even refused if the delivery can be deferred into times of lower demand or abundant energy available.

This smart grid is a highly complex and distributed network. Besides the technical problems to design and operate such a complex system, problems arise with respect to network security caused by cyber attacks or by device breakdowns which may lead to disastrous situations. On top of that, gathering usage parameters from individuals or organizations is subject to legal requirements about protection against unauthorized profiling. Currently, requirements with respect to protection of the smart grid against such situations are under study within national and international standards organizations as the NIST (US National Institute of Standards and Technology).

The contribution addresses at first the architecture and technologies for energy information networks and summarizes the most important security and privacy requirements and principal solution approaches.
Modeling and Performance Evaluation of Self-Adapting Models for Power Saving Optimization

Maggie Mashaly¹, Paul J Kühn² and Tallal El-Shabrawy¹
¹Networks Department, German University in Cairo, Egypt
²Institute of Communication Networks and Computer Engineering, University of Stuttgart Germany
maggie.ezzat@guc.edu.eg

Abstract: Energy savings in ICT systems are one of the most important and urgent research topics nowadays. Being a huge source of energy consumption over the past few years (almost 10% of total power consumption), the amount of energy consumed by ICT systems has to be regulated. An approach for reducing the amount of consumed energy at any multiple server facility is to adapt the number of active servers to the current load. Within this context different models for setting thresholds of activating and deactivating servers allow for significant reduction in energy consumption. However, with reduction of energy consumption the risk of increased delays constitute a main drawback. Accordingly, a compromise between both goals has to be made. As a consequence, an optimization problem has to be solved: Find the number of servers to be activated and the thresholds for activation of the next server and deactivation of an activated server under a given load level and under a given threshold of the mean delay of packets.

The problem is modeled by a multi-server queuing system with finite buffer capacity and various hysteresis levels for the activation of new servers or deactivation of activated servers; the model is controlled by a finite state automaton on the basis of the current state of the system. This multi-dimensional queuing model is analyzed exactly by a new recursive algorithm for the probabilities of state, from which all interesting performance values can be derived such as the mean queue length, the activation/deactivation rates of servers including an upper bound estimation on the distribution function for the packet delays or the percentiles of packet delays. The exact analysis is based on Markovian assumptions for the inter-arrival times of packets and service times of the servers. For the more general case of generally distributed inter-arrival times and service times characteristic performance results are obtained from simulations which show that the exactly obtained values are close enough for applications even for the more general application cases. The optimized parameter settings can be found iteratively from systematic parameter variations and performance analysis.
Development of solar absorbers for concentrating solar power

Nahed El Mahalawy¹, Anke Klingner², Brando Okolo³

¹Department of Engineering Design and Production, GUC, Egypt
²Physics Department, GUC, Egypt
³Materials Engineering Department, GUC, Egypt

Abstract: Concentrating solar power systems use solar absorbers to convert sunlight to thermal electric power. The purpose is to produce a low cost absorber for operating at temperatures from 400 to 500 °C. for this selective coatings are needed that have high absorptance and low emittance at this temperature range. Our previous experience is on application of selective coating on copper and aluminium substrates using different techniques: electroplating of black nickel- electroless plating of black nickel – sol gel of mixed oxides. Different process parameters were applied and excellent optical properties were achieved (Absorptivity 0.96 to 0.97 and very low Emissivity of less than 0.01.
Concentrated Solar Power (CSP) – Technical and Ecological Assessment within Enerkey Project

Thomas Telsnig¹, Ludger Eltrop¹

¹Institut für Energiewirtschaft und Rationelle Energieanwendung (IER), Abt. Systemanalyse und erneuerbare Energien (SEE); Univ. of Stuttgart, Germany

tt@ier.uni-stuttgart.de, le@ier.uni-stuttgart.de

Abstract: The EnerKey project is a South African – German collaboration, which aims to develop and implement innovative pathways and projects in urban energy supply and use in order to improve the sustainability in the region of Gauteng, South Africa (www.enerkey.info). EnerKey stands for the focus of the project on “Energy as a key element of sustainable development of the City Region of Gauteng, South Africa”.

Within the project different energy sectors (e.g. transport, residential and energy supply) are addressed. The major part of South African energy supply is made up by coal fired power plants which are the main reason for South Africa’s extremely high greenhouse gas emissions. The supply group of the EnerKey project investigates different and sustainable pathways of abating GHG emissions by using renewable energy technologies.

Concentrated Solar Power

Similar to Egypt, South Africa is in a very fortunate position regarding its high solar irradiance to push ahead its energy policy towards solar thermal technologies. Especially the different concentrated solar power (CSP) technologies could be an option for South Africa and for the city region of Gauteng Province.

System analysis of solar power generation

Beside the solar resource, grid connectivity and the possibility to generate a higher availability by the use of different thermal storage systems play a crucial role. The assessment of the different CSP technologies compromises a technical, environmental and economic approach.

Therefore, a parameterised life cycle assessment (P-LCA) model was build up to get a very flexible tool to assess the benefit and impact of Concentrated Solar Power technologies in different climatic and economic environments. To take this into account the presented model can be adjusted to the conditions of the investigated site and an optimised configuration which is also depended on the electricity demand can be found.

Reference

A Hybrid System, a Solar Concentrated Linear Fresnel PV/Thermal Collector and 1 kW Wind Turbine for Energy Cogeneration.

Tarek Khalili
1Physics Department, German University in Cairo, Egypt
tarek.khalili@guc.edu.eg

Abstract: A Linear Fresnel PV/T as a Concentrating solar Collector with a low geometric concentration ratio of ~ 10 and a 1 kW Wind turbine for cogeneration of Electricity and heat at two levels; a low ~60˚C and a higher Temperature storage more than 100˚C. The thermal energy storage system will use different PCM for optimization of the thermal storage. The Research team has a good experience in Design and Development of the Cleaning System, the Tracking system. A specialized Lecturer from the research team will study the Financial and Market Feasibility of the system. Funded by the RCREEE; Regional Centre for Renewable Energy and Energy Efficiency
Pt/Ru promising catalyst for low temperature direct methanol fuel cells

A.M. El-Aziz\textsuperscript{1,2}, L. Kibler\textsuperscript{3}, D. M. Kolb\textsuperscript{3}
\textsuperscript{1}German University in Cairo, Egypt, \textsuperscript{2}National Resarch Centre, Egypt, \textsuperscript{3}Ulm University, Germany
ahmed.aziz@guc.edu.eg

Abstract: Direct-methanol fuel cells or dmfcs are a subcategory of proton-exchange fuel cells in which methanol instead of hydrogen is used as a direct fuel. The main problem of these cells is carbon monoxide (co) formation resulting in blocking the anode material. Therefore, more interest have been given to find high reactive catalyst anode material.

Pt/ru alloys have long been recognized as one of the best bimetallic catalysts for the electro-oxidation of small organic molecules. The material is among the least sensitive for poisoning and can oxidize strongly adsorbed intermediates like co at highly reduced overpotenitals. The electrochemical behaviour of a pt50ru50(111) single crystal is investigated for the first time by means of cyclic voltammetry and scanning tunnelling microscopy (stm). Depending on the cooling conditions after inductive heating in various gas atmospheres, ru rich or pt rich surfaces have been obtained. Analysis of the surfaces by stm shows typical topography with smooth terraces separated by monoatomic high steps. A voltammetric characterisation clearly reveals the altered electrochemical behaviour of the ptru(111) surfaces compared to pt(111) and ru(0001) in acid media. Systematic reactivity changes are observed for hydrogen adsorption, underpotential deposition of copper, carbon monoxide stripping and methanol oxidation as test reactions. Within the so-called d-band model, it can be rationalized that the pt-rich and the ru-rich phases of the alloy bind adsorbates weaker and stronger than the pure single crystal electrode surfaces, respectively.
Hybrid Semiconductor-Metallic Nanoflowers and Core-Shell Nanocrystals: Towards Low Cost Light Harvesting Materials for Solar Cell Applications

Mona B. Mohamed\textsuperscript{1,2}, Khaled M. AbouZeid\textsuperscript{1,2,3}, and M. Samy El- Shall\textsuperscript{1}, Al-Sayed Al-Shirbini\textsuperscript{2}, Mahmoud H. Abdel-Kader\textsuperscript{2}

\textsuperscript{1}Department of Chemistry, Virginia Commonwealth University, Richmond, VA, 23284
\textsuperscript{2}National Institute of Laser Enhanced Science (NILES), Cairo University, Egypt
\textsuperscript{3}German University in Cairo, GUC, Cairo, Egypt

Abstract: This work reports the development of a general approach, based on the heterogeneous nucleation and growth of CdSe nanostructures on Au or Ag nanocrystals, for the synthesis of Au-CdSe and Ag-CdSe hybrid nanostructures. The new approach provides a versatile “one-pot” route for the synthesis of hybrid nanoflowers consisting of a gold or silver core and multipod CdSe rods or an intact CdSe shell with controlled thickness depending on the nucleation and growth parameters of the metal core and the CdSe shell. At lower growth temperatures such as 150 °C, the CdSe clusters are adsorbed on the surface of the metal cores in their surface defects, then they start to form multiple arms and branches resulting in the nanflower shape hybrid structures. Increasing the size of the metal core through the choice of the reducing and capping agent of the metal core nanocrystals results in improving the interface between the metal and CdSe domains and produces core-shell structures. Similarly, using inefficient Cd precursors such as Cd stearate instead of Cd oleate results in slow nucleation of the CdSe domain and prevents the formation of a multiple rod shell structure. The growth temperature appears to be the most important factor that determines the nature of the interface between the metal and CdSe domains. At relatively high temperatures such as 300 °C, the formation of large faceted Au cores creates preferential growth sites for the CdSe nanocrystalline shell, thus resulting in well-defined Au-CdSe core-shell structures with large interfaces between the Au and CdSe domains. The present approach is expected to foster systematic studies of the electronic structures and optical properties of the metal-semiconductor hybrid materials for potential applications in photothermal, photovoltaic and nanoelectronic devices.
Figure 1. Absorption spectra as a function of reaction time of the hybrid Au-CdSe nanocrystals prepared at 150 °C. TEM images of samples obtained at different reaction times: (b) 0 min (Au nanocrystals only), (c-g) 5 min, (h) 10 min, (i) 15 min, (j) 25 min, and (k) 40 min
Nanostructure iridium for electrochemical CO oxidation

Khaled A. Soliman, Ludwig A. Kibler, Dieter M. Kolb, Timo Jacob
Institut für Elektrochemie, Universität Ulm, 89069 Ulm, Germany
khaled.soliman@uni-ulm.de

Abstract: The effect of the cooling gases after using the inductive heating approach on the reactivity of iridium single crystal surfaces [i.e. Ir(210), Ir(110) and Ir(311)] towards the CO adlayer oxidation has been studied using stripping voltammetry and in-situ STM. Cooling Ir(311) in a hydrogen atmosphere (Ir(311)-H$_2$ cooled) results in atomically flat terraces with monoatomic high step (see Fig. 1.) Furthermore, cooling in a CO atmosphere (Ir(311)-CO cooled) leads to higher amounts of crystalline defects compared to the Ir(311)-H$_2$ cooled surface (Fig. 2). CO adlayer oxidation occurs at significantly lower overpotentials on the Ir(311)-CO cooled surface. Three voltammetric peaks are observed for CO adlayer oxidation on Ir(311)-CO cooled surface, while only one peak develops in case of a Ir(311)-H$_2$ cooled surface (Fig. 3). Random crystalline defects on Ir(311), which appeared after cooling in a CO atmosphere, lead to enhanced CO adlayer oxidation. These studies clearly indicate that well-defined nanostructured surface can indeed be used to tailor the activity and selectivity for electrocatalytic reactions.

Fig. 1. In-situ STM of Ir(311)-H$_2$ cooled

Fig. 2. In-situ STM of Ir(311)-CO cooled

Fig. 3. Current potential curve for CO adlayer oxidation on CO and H$_2$ cooled Ir(311) in 0.1 M H$_2$SO$_4$
Red Sea Phototrophic Bacteria as Solar Bioreactors

Khaled Abou Aisha¹, Hans-Georg Breitinger²,
¹Department of Pharmaceutical Biology, GUC
²Department of Biochemistry, GUC
khaled.abou-aisha@guc.edu.eg

Abstract: Egypt enjoys high intensity of sunlight over most of the year with only few rainy or overcast days. Thus, insolation is mainly of direct sunlight with high energy density, placing Egypt in the zone of countries with the best natural conditions for solar energy use.

We suggest an exploitation of anoxygenic phototrophic bacteria as sinks of the solar radiation and potential source for phototrophic hydrogen production. Use of bacteria has the advantage of yet simpler culture conditions and robust photoproduction. Bacterial culture can take place in tanks, so it does not require arable land and does not require drinking water for culture.

A natural source for phototrophic bacteria is the Red Sea, a semi-enclosed basin in which evaporation greatly exceeds precipitation, making it one of the saltiest seas in the world. There is no river inflow, nor seepage from agricultural activities. The seawater is therefore, typically nutrient depleted. However, the sea supports a highly diverse and productive coral reef ecosystem with a dominant coral constituent. Sources of primary production include phototrophic non-sulfur bacteria, small microfilamentous algae, large macroalgae, encrusting calcareous macroalgae, and, zooxanthellae within corals and mangrove stands and seagrass beds. Suggested sources of nutrients include nitrogen fixation by microfilamentous cyanobacteria, and sediments, in case of phosphorus. Initial examination of the communities of primary producers (seagrasses and macroalgae) shows that vegetation is extremely patchy with standing crop values averaging from 0.2-0.4 kg / m². It seems that the organisms recycle nutrients very efficiently and rely on a steady supply of large amounts of the nutrient-poor waters.

A brief overview of the biochemical processes underlying photosynthetic hydrogen generation will be given and requirements for process optimization reviewed.
Abstract: The aim of this research is to find the optimum wind turbine blade which will be suitable for different wind conditions. The wind turbine blade is always subjected to a variable wind speed, hence there are heavy dynamic loads on the blade. The presence of the aero-elasticity analysis is the most dominating phenomenon. The aero-elasticity is a Fluid-Structure interaction (FSI) problem. At the first, the aerodynamics analysis will performed by using ANSYS CFX commercial software for wind turbine aerodynamics aimed at providing aerodynamic loads on wind turbine blade airfoils. The airfoils under consideration will be selected from those developed by the National Renewable Energy Laboratory (NREL) for horizontal axis wind turbines (HAWT). The HAWT blades usually experience significant time varying aerodynamic loads, potentially causing adverse effects on structures, mechanical components, and power production. The structural analysis will be performed by using ANSYS Mechanical package by using the aerodynamic forces results from the ANSYS CFX to find the one-way FSI behavior. Moreover, the two-was FSI will be performed by ANSYS to find the aero-elastic response of the blade and the optimum blade profile can be selected based on the results.

The outcome of the current work is to develop aero-elastic response for wind turbine blades, and hence to find the optimum blade for the wind distribution in Egypt.
Aero-elastic analysis of wind turbines

A.A. El-Badawy\textsuperscript{1}, M. A. Sayed\textsuperscript{1}, Mohamed W. Mehrez\textsuperscript{1}
\textsuperscript{1}German University in Cairo, Egypt
ayman.elbadawy@guc.edu.eg

Abstract: In this work, steady and unsteady aerodynamic simulations were performed on a horizontal axis wind turbine (HAWT). Based on the Blade Element Momentum theory (BEM), the aerodynamic analysis is performed using an open source code (AeroDyn) which is developed by the National Renewable Energy Laboratory (NREL). These simulations were verified using Finite Element Method. The reference wind turbine used in the simulations is the Controls Advanced Research Turbine (CART) which is a machine rated at 600 kW with S809 blade profile. To be able to capture the unsteady effect of wind on the blade, a Kaimal turbulence power spectral density model has been used. The results obtained from the numerical simulations are used to determine the normal and tangential force components on the wind turbine blade. Since dynamic stall is a critical phenomenon which has an important effect on the operation of HAWT, the simulations were also used to determine the coefficients of a semi-empirical dynamic stall state-space model of the wind turbine airfoil section.

On the structural dynamics side, a free general-purpose multibody dynamics code (MBDyn) is used to analyze the aero-elastic behaviour of the same wind turbine. The wind turbine model has been built up with beam elements, joints, aerodynamic elements. An impulsive wind is applied to the turbine rotor plane. The blade and tower natural frequencies are obtained. Steady wind speeds are applied. Simulation results are obtained, presented and discussed in terms of the variation of blade tip deflection (flap wise, edgewise, and torsional) as a function of time together with its effect on the output power.

The outcome of the current work is to develop aero-elastic simulation software for wind turbines, based on coupling free general-purpose multibody dynamics software (MBDyn), with an open-source software library for wind-turbine aerodynamics (AeroDyn).
The development of materials for wind turbine blades with properties markedly resistant to surface degradation

Nahed El Mahalawy\(^1\), Anke Klingner\(^2\), Brando Okolo\(^3\)
\(^1\)Engineering Design and Production department, \(^2\)Physics department, \(^3\)Materials Engineering department, German University in Cairo, Egypt
nahed.elmahalawy@guc.edu.eg

**Abstract:** Wind turbine blades suffer the most cyclic loading and exposure to environmental elements in wind energy systems. While the focus of research has often been to reduce weight and optimize blade geometry, less attention has been given to blade materials degradation and the potential role of degradation in system failure. In the present study, the association between contact-wear (induced by air gusts on the blade material) and exposure to environmental elements (such as rain and temperature variations) on the one hand, and the onset and progression of turbine blade material degradation on the other hand are investigated. Physical parameters such as wear induced mass-loss, surface defects such as cracks and pitting and delaminated layers are assessed and used as key indicators for materials degradation. Mechanical tests such as wear tests, fatigue tests and hardness measurements are employed to develop predictive models for materials degradation.
Solar Energy Cost Efficiency: A Simulated Case Study in the Context of Egypt

*Dina El Bassiouny*¹, *Ehab K.A. Mohamed*²

¹Accounting and Financial Control department, Faculty of Management, GUC, Egypt

dina.elbassiouny@guc.edu.eg

**Abstract**: With the increase in energy needs, rise in fossil fuel prices, and swelling of green house gas emissions, the use of renewable and more environment-friendly energy sources to supply power is gaining increased attention. In Egypt, electric energy coming from fossil fuels represents around 85% of total electricity requirements. However, the supply of energy in the Arab world is expected to run dry in the coming 30-50 years. Egypt has great potential in utilizing solar energy to generate energy products and electricity. However, solar energy is still abandoned in Egypt due to its high costs. This paper examines the relative significance of several accounting and economic variables to reduce solar energy costs. The results of the study provide a number of policy implications that can be applied to make solar energy closer to cost-competitiveness and contribute to solve the energy problem in Egypt.

(to be presented at AAAI’11, Denver, USA)
Abstract: Utilization of renewable energy resources such as wind and solar energy for electric power supply is currently receiving serious considerations around the world due to environmental concerns associated with the conventional generation and potential energy shortages due to increasing electricity demands. Wind and solar energy are promising alternatives because of their tremendous environmental, social and economic benefits. The wind and sunlight, however, are unstable and variable energy sources and behave far differently than conventional sources. The actual benefits obtained and the adequacy of power supply associated with such energy systems can be quantitatively assessed using reliability evaluation techniques.

This presentation will focus on the adequacy assessment of power systems incorporating wind and solar energy based generators. Sequential Monte Carlo simulation approach is implemented for the evaluation of generating capacity adequacy and the estimation of risk indices related to different operation strategies. This approach is based on the development of appropriate models for the conventional and renewable generation technologies and the integration of these models with chronological load models to determine reliability and economic indices.
A Decision Support Tool for the Optimal Placement of Wind and Solar Parks at Minimal Cost

Carmen Gervet¹, Mohamed Atef¹, Amira Zaki¹, Christine Fouad¹, Marlien Nelhela¹, Yahya Mowiena, Amal El Nahas¹, Slim Abdennadher¹
¹Department of Computer Science, Faculty of Media Engineering and Technology, GUC, Egypt
carmen.gervet@guc.edu.eg

Abstract: Our research aims to provide private and governmental investors into Renewable Energy (RE) systems, valuable techno/economical insights to make informed short and longer term decisions with respect to the optimal placement of wind and solar parks in Egypt by using simulation and decision support tools.

The expected impact is an informed support to ensure a cost-effective and successful migration from fossil fuel to RE. Egypt enjoys tremendous wind and solar resources, and has the potential to become a major RE distributor along the Mediterranean coast and the Middle East, using the electricity grids. Countries like Germany and Japan are aware of this and have sought partnerships in developing various RE prototype plants. Furthermore the energy demand increases every year, together with emissions of CO₂, rendering the migration to RE more urgent every day. Investing in RE parks is inevitable but the amount of techno/economical parameters involved makes it a complex multi-criteria optimization problem.

The objective is to build a model and decision support tool, based on state of the art constraint programming and optimization technology to help seek the best trade-off cost/return on investment over a certain time line.
Photovoltaic modules

Thomas Wurster¹, Rainer Merz¹, Ahmed S. Garamoun¹, Markus B. Schubert¹, and Jürgen H. Werner¹
¹Universität Stuttgart, Institut für Physikalische Elektronik, Germany
markus.schubert@ipe.uni-stuttgart.de

Abstract: Inhomogeneous illumination, e.g. due to partial shading of one photovoltaic (PV) module in a series-connected string, increases the mismatch losses and thereby reduces the output power of the affected PV system by a much greater amount than just the lack of PV yield of the shaded area. In order to minimize such and similar losses, our Dynamic String Interconnection (DSI) provides independent maximum power point (MPP) tracking of multiple photovoltaic strings by time-multiplexing the PV power of the single strings into one common buck converter and grid-connected inverter. We present prototypes of DSI circuits and outdoor testing of their performance at the rooftop of the ipe by continuously switching four strings of five PV modules each between parallel connection and DSI operation, and monitoring their output power. DSI operation of PV systems is promising not only for partial shading, but also reduces the effects of soiling and module degradation on the overall system performance. Some GUC students already prepare their Bachelor theses at the ipe facilities, or join us for internships in this field of PV power electronics.

Principle of operation of the DSI: n PV strings $S_n$, n capacitors $C_N$ connected in parallel to the strings, and n switches $SW_n$ in series to each of the strings connect them to the buck converter. The control unit CU measures the voltages $V_{Sn}$ and currents $I_{Sn}$ to calculate the momentary power of each string and track it into its respective MPP.

Characteristics of a first DSI test system: The efficiency $\eta_{DSI} (t < t_1) = 4.25\%$ in DSI mode is about 1.2 % higher than the efficiency $\eta_{PC}(t < t_1) = 4.2\%$ in parallel mode. The shading of one module drops the efficiencies at $t_1 = 7.5$ min to $\eta_{DSI} (t > t_1) = 4.05\%$ which is a gain of 9.5 % over the parallel interconnection with an efficiency $\eta_{PC} (t > t_1) = 3.67\%$. Moreover, the tracking in DSI mode is much faster than in parallel mode.
Abstract: A very important factor that seriously affects the performance of photovoltaic (PV) solar panels is the process of "shading" that occurs naturally due to the accumulation of dirt on the solar panels or reflectors. Dirt, however, is only part of the problem because the system operators must also compete with the build-up of dust, tree debris, moss, sap, bugs, bird droppings, water spots, mold and more. Implementing a cleaning system for the solar panels would be a beneficial project that would help in extracting the maximum power from the solar panels and increasing their efficiency.

Many researchers reported the drop of the PV system output because of the dust accumulation. The aim of this project was to design and implement a fully automated cleaning system for photovoltaic panels and reflectors. The developed system is a self contained system that can work with no external water supply which enables the system to work in desert and remote areas. The system is controlled entirely by a set of sensors and a programmable logic control (PLC) systems that will determine the suitable time for cleaning as well as the suitable amount of water needed.

The proposed systems will be built based on our experience in designing and implementing automatic cleaning systems for the PV system in the German University in Cairo (GUC).

It is believed that the automatic cleaning system is a cost effective solution that will typically pay for itself in a few years especially in countries like Egypt where a huge amount of dust is expected around the year. The proposed system is superior to manual cleaning because it saves time, money and it is safer.
Status of Photovoltaic and Topics of Cooperation

Markus B. Schubert¹, Bastian Zinßer¹, and Jürgen H. Werner¹
¹Universität Stuttgart, Institut für Physikalische Elektronik (ipe)
markus.schubert@ipe.uni-stuttgart.de

Abstract: The worldwide photovoltaic (PV) market and application is growing rapidly. This contribution gives a short overview of PV installations and production in Germany and worldwide. The German feed-in tariff for PV electricity was significantly cut since 2009 but lower prices promote further PV installations and market growth in Germany, and all over Europe. Major restructuring of the complete value chain of PV production is in progress. Therefore research in photovoltaics faces quickly moving targets, emerging and disappearing partners and technologies, and it is much more applied than fundamental. Research at the ipe focusses on silicon PV and additions to it, with the clear goal to improve industrial processes and transfer novel approaches into PV production.

In cooperation with the GUC and the University of Cyprus, ipe operates outdoor test systems for monitoring their PV performance and annual energy yield. An ongoing exchange programme between GUC and ipe addresses topics of common interest like cleaning and optimizing the operating conditions of PV power plants. Especially interesting for undergraduate students is our cooperation in the field of power electronics for photovoltaics.

Three times 13 identical PV test systems with a peak output of 1 kW are grid-connected and continuously monitored at ipe (Stuttgart), UCY (Nicosia), and GUC (Cairo).

The evaluation of outdoor data not only provides the annual energy yield, but also temperature and intensity dependence of the PV performance.
Abstract: In order to improve the performance in the electrochemical energy conversion and storage, a detailed understanding of the elementary processes at electrochemical interfaces is required. Unfortunately, it is certainly fair to say that our knowledge about such processes is still rather limited. However, due to the increase in computer power and the development of efficient algorithms, complex structures and processes at interfaces can nowadays be studied theoretically from first principles, i.e., without invoking any empirical parameters, mainly based on periodic density functional theory (DFT) calculations. Furthermore, ab initio molecular dynamics (AIMD) simulations have become possible that can be run for a sufficiently long time to perform meaningful thermal averages.

In this contribution, we will present recent results of periodic DFT calculations with respect to the structure of the electrochemical water/metal interfaces [1,2]. Because of their large dipole moment and strong polarization, water layers lead to a significant work function change of metal electrodes. This translates into a close relation between the structure of the water layer and the electrode potential. In general, the modeling of external electric fields and varying electrode potentials is an important prerequisite for the realistic description of electrochemical devices. We will discuss a recent implementation that allows a realistic description of electric field effects at interfaces. Finally, concepts to describe the interface structure of battery materials will be addressed.

References
Improved Materials for Renewable Energies

Siegfried Schmauder

\textsuperscript{1}Material Test Center, MPA, University of Stuttgart

Abstract: New technologies in the frame of renewable energy fields require improved materials for higher efficiency in production and transport. Computational methods are presented which support the development of such materials on a virtual base in the computer. The materials which are dealt with are improved steels, metal matrix composites as well as fiber reinforced composites and polymer based composites. The aim is to safe developing time by reducing the experimental time and cost to a minimum.
Stationary and mobile storage technologies to integrate renewable energy into the grid

Niklas Hartmann\textsuperscript{1}, Christoph Kruck\textsuperscript{1}, Ludger Eltrop\textsuperscript{1}
\textsuperscript{1} Institute of Energy Economics and the Rational Use of Energy (IER), Deut. System analysis and Renewable Energies (SEE), Univ. of Stuttgart, Germany

le@ier.uni-stuttgart.de

Abstract: The focus on renewable energy – especially wind and solar - is increasing immensely and will constitute a large proportion of the total generated electricity in near future. The integration of renewable energy into existing technical and economic energy structures is a key role in this context. Especially storage facilities are expected to be required to compensate for the fluctuating character of renewable electricity generation. At IER model based studies are being carried out to analyse and assess storage technologies as well as future energy systems with high penetration of renewable energy.

Integration of storage technologies – An alternative to adapt power generation to the demand

One use of storage technologies is the temporal shifting of power generation. As an example, wind power can be stored at times of higher production than demand until a situation when the demand is higher to better match the power generation and the demand. The figure displays the combined power generation of an exemplary wind farm and a diabate compressed air energy storage. The original power fluctuations of the wind farm are balanced on most hours. As a result the combined plant can offer a guaranteed power generation of 5,000 MW to the grid operator.

Using electric vehicles – An alternative for demand side management

Aside of hydro pumped storages and compressed air energy storages, mobile storages such as Li-Ion Batteries in electric vehicles are an option to apply for demand side management. Plug-In electric vehicles (with directional or bidirectional grid connection) will become more interesting in near future. In a directional case unmanaged charging will have negative effects on the grid since peak demand of vehicles correlates with peak demand in the power system. However the potential of electric vehicles to support the grid by the implementation of charging strategies is high. This becomes even more valuable if vehicles are connected via a bidirectional plug, which allows storing renewable energy in these mobile storages as well as participating at ancillary service markets.

Fluctuating renewable energy in power systems – Effects on the overall system

To evaluate the intensified utilization of fluctuating renewable energy in power systems and markets, stochastic optimization models are developed and applied at IER. Hereby research focuses on the optimal development of storage technologies and the generation system as well as the cost optimal operation of storages and power plants in a system with high penetration of renewable energy. Another focus lies on questions concerning the assignment of storage technologies (e.g. serving ancillary service markets).

Literature

The development of Metallic Micro-Tubes for Hydrogen Storage

Nahed El Mahalawy¹, Anke Klingner², Brando Okolo³
¹Department of Engineering Design and Production, GUC, Egypt
²Physics Department, GUC, Egypt
³Materials Engineering Department, GUC, Egypt
brando.okolo@guc.edu.eg

Abstract: The notion that hydrogen can be stored under standard temperature and pressure (STP) conditions for use in fuel cell systems is the focus of this research study. To realize this, polymeric fibers with thicknesses in the micrometer and sub-micrometer length scales are produced using electrospinning methods. The as-produced fibers are then coated with pure metallic materials ensuring that the metallic films form a continuous coverage over the fiber. By thermally or chemically separating the fiber from the metal, a metallic tube with an internal diameter comparable to the thickness of the fiber is obtained. Metals such as palladium, vanadium, titanium and lanthanum in their pure or alloy form are already experimentally proven in the literature to have a high affinity for hydrogen. Therefore in the present project, it will be demonstrated that exposing the fabricated metallic tube (with enhanced surface area) to hydrogen will foster adsorption and a possible formation of metal hydrides which are stable at STP. Ultimately hydrogen can easily be released from the metal hydrides via simple dissociation processes, on demand, as energy in fuel cell systems.
Solar energy and water treatment

Water desalination using solar energy

Mohamed S. Abd-Elhady, Dr. Hamdy Kandil
1 German University in Cairo, Egypt
mohammed.abdelhady@guc.edu.eg
hamdy.kandil@guc.edu.eg

Abstract: Water as well as energy shortages are one of the great challenges facing the development in Egypt. Water desalination using fossil fuels is very expensive and even not feasible, especially with the rise of oil prices every day and the threat of extinction of fossil fuels. Water desalination using solar energy is a promising technique especially in the Middle East and Egypt. The Middle East receives within 9 hours more energy from the sun than humankind consumes within a year, and the sun irradiates our planet with a power of more than 8000 times the current power consumption. However, fouling of desalination units utilizing solar energy as the heat source represents the major uncertainty in the design and operation of such units. Fouling is defined as the accumulation of particles on a heat exchange surface forming an insulating layer. Fouling leads to inefficient operation and sometimes operation failure of the desalination plant, which may lay lead to unscheduled shut down for maintenance. The objective of this research is to develop a new desalination technique based on solar energy, which minimizes fouling in the desalination unit and prevents inefficient operation and operation failure.
A solar driven water desalination/distillation thermal

Tarek Khalil
Physics Department, German University in Cairo, Egypt
tarek.khalil@guc.edu.eg

Abstract: Humidification/dehumidification unit has been built to research this important and vital field and to help design and locally manufacture solar driven water desalination unit. An interesting point which enhances this field of research is the renewable hybrid electricity generation (PV, wind and Fuel cell) for RO water desalination.
Key Drivers for Sustainable Operations in Developing Countries

Dr. Sherwat Elwan Ibrahim
Operations Management Department, Faculty of Management, GUC, Egypt
sherwat.elwan@guc.edu.eg

Abstract: There has been a recent paradigm shift towards sustainable development of business operations worldwide. Limited resources and the need for a cleaner and unpolluted global environment, along with recent developments in governmental legislations have made it difficult for international companies to take advantage of developing countries more lenient environmental policies. This study presents the case of a leading company’s role in sustainable development in the textile industry in Egypt (Hesni Group, HG). While the Egyptian government has recently conducted several adjustments to the legislations that govern the textile industry in terms of emissions and water usage, HG responds to more stringent regulations enforced by the top management and governed by the regulations of its clients. Literature reviews and comprehensive interviews with the different stakeholders suggest a three-pillar model presenting the different key drivers that promote sustainable operations in developing countries. We aim to motivate organizations in developing countries to think greener, and to contest the notion that sustainability means giving up on current processes and incurring irredeemable losses.
Solar Treatment of Waste Waters

Tarek M. Hashem
Department of Material Sciences, Faculty of Engineering and Material Sciences, German University in Cairo, Egypt.
tarek.hashem@guc.edu.eg

Abstract: The feasibility of any solar application at a specific location can be estimated by measuring the amount of solar radiation actually delivered at that location along the year. In fact, many studies have clearly indicated a considerable flux of the global solar radiation reaching the Earth at various geographical sites in Egypt. Although solar radiation has been applied in several industries, applications of solar radiation in the field of waste water treatment still calls for many investigations to establish reliable data.

The present work is aimed at the installation of a solar pilot-plant to examine the efficiency of Solar-Assisted Advanced Oxidation Processes (AOPs) for waste waters treatment. AOPs are effective treatment methods for many pollutants, and are considered as promising alternatives to conventional technologies. AOPs are characterized by the generation of hydroxyl radicals which are able to oxidize and mineralize almost every organic molecule yielding carbon dioxide, water and inorganic ions. Among different AOPs is the photo-Fenton reaction. In the latter, Decomposition of H$_2$O$_2$ using ferrous iron (Fe(II)) or ferric iron (Fe(III)) under acidic conditions yields hydroxyl radicals. The rate of removal of organic pollutants and the extent of mineralization using the Fenton reaction can be enhanced considerably by solar irradiation.
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