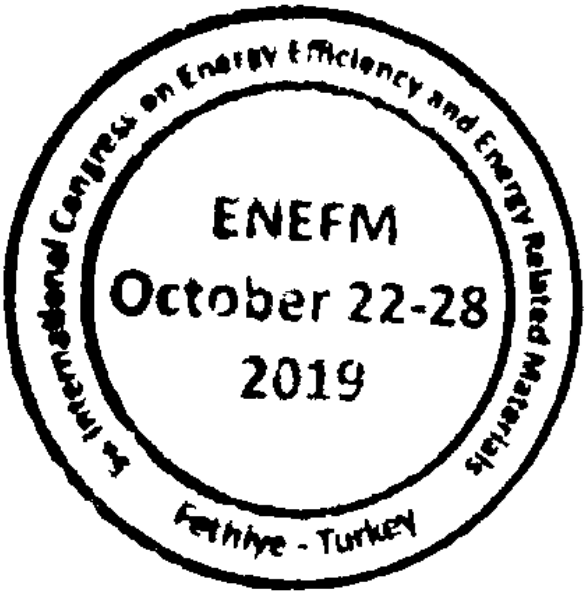
# Book of Abstracts

# ENEFM 2019

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# 5th International Congress on Energy Efficiency & Energy Related Materials (ENEFM 2019)

**Oludeniz/Mugla - Turkey**

**October 22-28, 2019**

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# INVITED SPEAKERS

## Id-005

## Optimizing of Densification Process Parameters for Solid Biofuels Production Using the Mathematical Modelling

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**Abstract:** In this research study authors would like to present the research findings represented the effect and interaction of technological variables and material parameters during densification and evaluation methodology for relevant experimental plan in order to determine the final biofuels quality and to design the mathematical model. One of the recovery possibilities for waste biomass raw materials is production of solid biofuels. In this paper are presented research findings which are defining the effect and interaction of influencing variables during densification of selected Slovakian woods. From biofuels production point of view and also from densification machines constructions point of view is very important to know mutual interaction of these influencing parameters on final biofuels quality (properties). Using a variety combination of influencing variables can be improve the final quality of solid biofuels. Raw biomass material variables influence, especially (type of raw material, particle size, moisture content, pressing pressure and pressing temperature) can be recognized during the production of solid biofuels. Their effect can be seen through the quality indicators; especially mentioned variables significantly influence the physical - mechanical indicators of quality of solid biofuels. The main goal of this experiment was to obtain such results which can be used for mathematical models design. This statistical mathematical models based on the proposed experiments are used of the measured data processed and can be very useful tool for final biofuels prediction before densification and thus the densification process can be improved and adjusted according to properties of raw material to be pressed. For this experiment were selected as an influencing variables pressing temperature, pressing pressure, raw material moisture content and raw material particle size – which is represented by particles distribution. Experiment based on the single-axis densification of the selected woods were realized by experimental pressing stand which is a part of hydraulic press (piston and die). Raw material parameters were achieved by disintegration, drying and separation equipment. Experiment were evaluated and influencing variables were optimized to achieve the optimum values for the best value of physical properties of the solid biofuels. In this case a several Slovakian woods were chosen for this research study prepared in a sawdust form, like pine, oak and acacia wood. Useful practical output of this experimental research are designed mathematical models for all of input raw materials, which describes the densification process at various adjusted levels of influencing variables. These models can be implemented into the densification machines control system and thus the final quality of solid biofuels can be predicted, adjusted and controlled during densification. Also were defined the optimal

ranges of pressing pressure, pressing temperature, moisture content and particle size for each investigated raw material, from a final quality point of view and from solid biofuels dilatation point of view.

**Keywords:** Biomass, solid biofuels, pressing temperature, moisture content, particle size, pressing pressure, mathematical model

**Acknowledgments:** The paper is a part of the research done within the project KEGA 061STU-4/2017 – Increasing the level of the educational process in the field of production and environmental technologies by implementing of innovative tools. The authors would like to thank to the Ministry of Education of Slovak Republic.

# INVITED SPEAKERS

## Id-012

### Waste Energy Recovery From Furnace Slag of Steel Industrial Based on Dry Centrifugal Granulation Method: Heat Transfer Analysis on Moving Bed

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**Abstract:** The metallurgical industry in China consumed about 868 million tons of standard coal, accounting for 20.40% of the total energy consumption in the industry. Metallurgical industry shows great potential because of the waste heat resource in slag. Moreover, the amount of liquid slag whose sensible heat per ton of molten slag is equivalent to 60 kg of standard coal in China is about 343 million tons, equivalent to about 20.58 million tons of standard coal. However, there is no effective technology to recycle the blast furnace slag and steel slag with high-quality waste heat resource at present.Furthermore, a significant amount of sensible heat energy is dissipated in vain, which means the enormous potential of energy conservation and emission reduction. Water quenching is a conventional treatment method within the physical and chemical methods for blast furnace slag, which face problems such as the massive consumption of the fresh water, the low utilization of sensible heat, and the pollutant emission of sulfur dioxide, hydrogen sulfide, et al. It is unable to adapt to the urgent demand for energy saving and emission reduction in the iron and steel industry in China. Thus, it is necessary to find an efficient and pollution-free technology to recycle liquid slag.

The chemical method has been proved to be an effective way to employ the waste heart and convert some heat energy into chemical energy. Thus, in this report, the thermal effect and kinetic analysis of the biomass mixed with furnace slag at different mass ratios (10 wt%, 30 wt.% and 50 wt.%) was investigated via TGA from ambient temperature to 900 oC. Cellulose was selected as the primary organic compound in biomass, and iso-conversional method was applied for calculating activation energy. The maximum decomposition rate and temperature of maximum decomposition rate get higher as the heating rate increases. Furnace slag shows positive synergistic effects under 30% mass ratio with 6% higher volatile yield than that from theory calculation. The average activation energy values of CE, Slag-CE-10, Slag-CE-30, Slag-CE-50 were 187.54 kJ·mol-1, 260.81 kJ·mol-1, 132.79 kJ·mol-1, and 159.45 kJ·mol-1.

**Keywords:** Furnace slag; steel industrial; energy recovery; chemical method

**Acknowledgments:** This work was supported by the National Key R&D Program of China (Grant No: 2017YFB0603603) and National Natural Science Foundation of China (Grant Nos: 51606149, 21576219).

# INVITED SPEAKERS

## Id-033

## Latency Evaluation as an Integral Part of the Design and Development Process for Time-Critical Smart Grid Measurement, Control and Protection Systems

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**Abstract:** Automated measurement, control and protection systems, based on synchrophasor measurements, are seen as having an important role in smart grid control. However, these systems differ significantly from control applications based on Big Data and distributed computing as they are closed-loop control systems, with stringent latency requirements. They have much in common with industrial control systems but may also need to operate over significant distances. Failures in the system can lead to serious consequences, therefore, it is important to ensure that latency requirements can be met, prior to the system becoming operational. Currently, automated systems are deployed within substations for local area control, with synchrophasor measurements being used in the wide area to support near-real-time visualisation applications. However, it has been proposed that in the near future, automated control should be extended into the wide area. The motivation for this being the need to provide greater efficiency in the uses of current energy generation, and to include a wider range of renewable, but more variable, energy sources.

In line with the proposal for wide area automation, we are developing performance analysis and evaluation techniques that can: firstly, advise and support the design and development of future real-time devices; and secondly, guide the development of these time-critical control applications. Our objective is to derive generic and parameterized models to support the performance evaluation of these systems, and to develop techniques and methods to evaluate the temporal performance of specific models of particular systems under construction. Currently, we are focusing on the case of communication over a packet switched network that supports strict priority for time-critical sources. Later work will address other options

By analysing a combination of potential data-flow and process-flow models, and taking into account the influence of the required latency targets, it can be shown that Queuing Network Models (QNMs) would be an appropriate generic modelling tool for the evaluation process. However, it can also be shown that due to the synchronized nature of the sources and the stringent latency requirements, queuing behaviour will be short term and periodic. Therefore, in general, simulation will be the most suitable technique for evaluating the models. There are, however, exceptional cases for which Network Calculus can be used as an alternative. These exceptions can occur when devices are able to produce output at rate higher than that of the transmission links. We have shown that this situation may be exploited to speed up the evaluation process.

For time-critical systems, average latency values are not an issue. The main focus needs to be on evaluating the worst-case reachable delay. This inevitably results in longer simulation run times. To mitigate this, we have developed strategies that can exploit the nature of the system by identifying special cases, that can then be either be eliminated from the simulation, or be replaced by a constant. Finally, this work is not being carried out in isolation, but is part of a wider investigation into the benefits of emerging architectural approaches, for smart grid control applications.

**Keywords:** Smart Grid Control, automated control, Synchrophasor measurement systems, Performance evaluation.

# INVITED SPEAKERS

## Id-067

## Novel Heating and Cooling Technology as a Flexible Load for Optimized PV Utilization in buildings

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**Abstract:** Renewable energy sources are deployed in massive numbers in EU as well as other countries. Effective local use of renewable energy is not that easy due to the missing load with flexibility. Heat production and domestic hot water preparation is a good way how to utilize the energy. Problem is seasonal demand for heat in periods of low PV production. Therefore conversion of PV energy to cold generation makes meaningful utilization of PV peaks in summer season. [1]

A novel construction of air handling unit with heating and cooling capability will be introduced. The technology is designed to use PV energy for cooling, heating as well as to fulfil the requirements for fresh air supply. The unit uses a combination of passive counterflow heat recovery exchanger together with active counterflow exchanger with thermoelectric modules. The active thermoelectric exchanger is used to adjust air temperature and to improve heat/cold recovery from the interior. The cooling or heating mode is changed only by reversing the DC current in thermoelectric modules [2]. The advantage of the technology is that it uses solid state components for cold and heat generation and is ideal as a flexible load for building integrated PV systems. Due to the fact that it can generate cold from electric energy it can perfectly utilize the summer PV production peak which would be a problem to use in households during the summer time and energy would be fed to grid otherwise.

Results of seasonal simulations for residential and administrative buildings in various climatic zones will be shown in the presentation together with energy performance when the technology is powered by installed photovoltaic system on the building roof or envelope. Seasonal COP and ERR will be presented for the simulation case studies for three climatic zones. Required conditions and measures to replace main heat or cold source by introduced technology will be given in the summary and conclusion.

**Keywords:** Air Handling Units, heating, cooling, flexibility

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# INVITED SPEAKERS

## Id-082

## Research on the Application of Multi-Energy Complementary Coordination and Optimization of Distributed Renewable Energy

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**Abstract:** This paper researches on the Application of Multi-Energy Complementary Coordination and Optimization of Distributed Renewable Energy. Object to the key technologies, which include scheduling architecture, scheduling technology, energy management technology and operation comprehensive evaluation technology for multi-source coordination & optimization, the principles will be described and discussed in detail. As a case study, the paper researches the optimal capacity design of independent micro-grid system for wind-solar combined cooling heating and power system with energy storage, puts forward a dispatching method based on expert time-judge for dynamic control of wind-solar direct permeability and a hierarchical design based on energy storage module. Because of the uncertainty of wind -solar system, this paper adopts fuzzy parameters to describe the system constraints and clarify the opportunity constraints, then optimizes the capacity design on fuzzy constraints and particle swarm optimization, analyses the operation results of optimal capacity allocation under dispatching method and hierarchical design of energy storage.

**Keywords:** Multi-Energy, distributed Renewable Energy, complementary coordination, optimization

# INVITED SPEAKERS

## Id-083

## Radiological Issues on the VVR-S Nuclear Research Reactor Buffer Tank Dismantling

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**Abstract:** One of the main aspects of the VVR-S nuclear reactor decommissioning consisted in the radioactive liquid effluent's management and buffer tank for temporary storage dismantling. The reactor decommissioning generated radioactive effluents. There were from structures emptying (e.g. primary circuit, cooling pond for the spent nuclear fuel), wet cutting of the activated or contaminated components (pumps, heat exchangers, ion-exchange filters, de-aerator, reactor vessels) as well as from decontamination. The liquids were transferred by the leakage system into an underground (6 m) buffer tank (30 $m^3$ capacity), a stainless-steel cylinder embedded in a 120 tones concrete block, located near the reactor building. The buffer tank and connecting pipes was dismantled in the last phase of decommissioning process. For this purpose, the liquids were transferred to the Radioactive Waste Treatment Plant (RWTP) for treatment. For each transfer the water samples were analysed by gamma ray spectrometry method. The stainless steel and concrete samples from dismantled parts as well as soil and sand samples were measured by gamma ray spectrometry method. The specific activities were compared with the unrestrictive release levels provided by the Romanian legislation in order to establish an adequate management of the radioactive waste. Direct measurement of the surface contamination of the materials/areas were performed during the buffer tank dismantling.

**Keywords:** Reactor, decommissioning, buffer tank dismantling, radiological characterisation

# INVITED SPEAKERS

## Id-085

### Environmental Impact Assessment of Wind Farms: Noise Issues

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**Abstract:** The Environmental Impact Assessment (EIA) is an environmental management tool that was born about 1970; its methodology has improved over time. The main technical document in an EIA process is the Environmental Impact Study (EIS). An EIS is a technical study carried out by an interdisciplinary team. It has to include the following contents: the description of the baseline; the description of the project to be carried out; the identification, quantification and evaluation of expected environmental modifications; and an environmental management plan to improve the environmental results of the project. When doing an EIS of a wind farm, the main concerns are related to noise pollution, flicking shades, and impacts on flying vertebrates (birds and chiropters). When focusing on noise issues, there are different points of view about how to build the sound pressure levels baseline, how to carry out the prediction of the expected environmental sound pressure levels during the wind farm operation, and which reference values should be used for assessing the admissibility of the predicted sound pressure levels. These three main points are to be discussed here. Building the sound pressure levels baseline is not an easy task; the more detailed it is, the better guarantees both for the sound emitter (the owner or the operator of the wind farm) and for the receivers (the neighbors). There is still no consensus about how to predict the environmental sound pressure levels related to the operation of wind turbines. The prediction model developed at the Environmental Engineering Department of the Faculty of Engineering (Universidad de la República, Uruguay), which has shown a good agreement with measured data at about ten different wind farms across the country. Its main features are: taking into account the atmospheric stability condition for determining the acoustic power of the machines; describing noise generation along the blades due to turbulent phenomena; and computing noise propagation at different distances from the tower taking into account the atmospheric absorption, the turbulence energy dissipation and the geometric divergence. This easy-to-use method has been programmed in Matlab®. The obtained results show almost 80 % cases within in ±3 dB range. At last, which values are to be considered for comparing the acceptability of the predicted sound pressure levels is discussed. The importance of considering both indoors and outdoors standard levels is stated, as well as the need of using not only A-weighted sound pressure levels but also octave frequency bands' levels.

**Keywords:** Environmental impact assessment, noise pollution, windfarms, acoustic impact study

# INVITED SPEAKERS

## Id-114

### Development of Anode and Cathode Materials for Microbial Fuel Cells

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**Abstract:** Microbial fuel cells (MFCs)-electrochemical devices that can generate renewable energy using waste biomass have shown impressive developments over the past decade [1,2]. Even with the noticeable improvements in power density, the large-scale application of MFCs is still limited due to the low-power generation and high cost. To take this technology from laboratory-scale research to commercial applications, the cost and the performance of these systems need to be optimized further. Since anode and cathode electrodes play an important role in both the performance and cost of MFCs, we focus on developments of some carbon-based anodes and cathodic catalysts for MFC application. In this talk, the synthesis methods, principal mechanisms in the enhancement of MFC performance of some electrode materials such as three-dimensional (3D) N-doped carbon foam, some heteroatoms-doping carbon materials and bio-functional catalysts in both cathode and anode will be investigated and compared with commercial platinum (Pt/C).

The anode material design has attracted an enormous number of studies over the past decade. Among the different anode materials, carbonaceous anode materials have been explored extensively in MFCs owing to their good electrical conductivity, chemical and thermal stability, high mechanical strength, and most importantly, their comparatively low cost [1]. Recently, 3D N-doped open-porous carbon foam was fabricated using the simple procedure of calcining a melamine sponge [3]. The MFC with the carbon foam anode produced approximately 2 times higher power density than the commercial graphite felt. The superior performance of the as-prepared carbon foam in MFC was attributed to the higher surface area (687.19 $m^2$ $g^{-1}$) and open-porous scaffold structure, and the appearance of the hydrophilic functional groups. The surface of the as-prepared carbon foam facilitated extracellular electron transfer, resulting in a decrease in charge transfer resistance and an increase in biocompatibility. Similarly, the N-doped carbon foam prepared by freezing method with an optimized resorcinol-formaldehyde content show both power generation and storage capacity [4].

The metal-free, carbon-based oxygen reduction reaction (ORR) catalysts are also excellent alternatives to conventional Pt/C. One of the most recent approaches to develop ORR catalysts is doping the carbon texture with a heteroatom. The heteroatom-doping carbon materials are well known to improve ORR activity remarkably through the favorable adsorption of oxygen and weaker molecular bonding. A carbothermal process-derived hierarchically porous N-doped carbon produced a maximum power density of 55 $mWm^{-2}$. By depositing molybdenum nitride ($MoN_x$) on N-doped carbon, the performance increased 1.6 times, which is comparable to Pt/C. Moreover, sulfur-doped graphene (S-GN) synthesized

*via* the facile one pot electrochemical exfoliation of graphene exhibited a high ORR performance in MFC. The MFC equipped with the S-GN cathode produced a maximum power density of 51.22±6.01 mW $m^{-2}$, which is 1.92±0.34 times higher than that of Pt/C [5]. The excellent performance of these cathodic catalysts in MFCs could be due to the doping of carbon texture with heteroatoms, which increased the specific surface area and conductivity.

Bifunctional catalysts as an efficient and cost-effective anode to promote extracellular electron transfer (EET) as well as a cathodic catalyst with high catalytic activity for the ORR is an efficient approach to decrease the cost of MFCs, making it more practical. Recently, a ternary Polyaniline Graphene and $TiO_2$ nanocomposite (PANI-$TiO_2$-GN) was used successfully to improve the performance of both the cathode and anode MFC [6]. The PANI-$TiO_2$-GN catalyst exhibited better oxygen reduction reaction activity in the cathode, particularly as a superior catalyst for improved extracellular electron transfer to the anode. This behavior was attributed to the good electronic conductivity, long-term stability, and durability of the composite.

**Keywords:** Microbial fuel cell, oxygen reduction reaction, three-dimensional carbon foam, heteroatom-doping carbon materials

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# INVITED SPEAKERS

## Id-116

### Energy Monitoring and Saving in Medium-Sized Companies

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**Abstract:** Today's medium-sized companies have a lot of energy consuming components like heaters, production machines, coolers, computers etc. A lot of them also have energy producing components like solar thermal, photovoltaic systems, combined heat and power units, process heat and so on.

State of the art is in such companies that these different components run independently from each other and that one does not even know how much energy is produced or consumed by the individual components. This paper discusses the energy saving potential by synchronizing the production processes with the energy consuming and producing components of a real medium-sized company producing parts for the automotive industry.

A first step to realize this energy saving potential is to monitor the energy production or consumption of the above-mentioned components individually by using modern IOT technologies. The used energy monitoring solution for the company is shown and discussed, showing first results for energy saving possibilities. We also show how part of the energy saving potential could be realized by controlling and adapting the production processes based on these data. An outlook is given, how the energy saving can be further increased by coupling the energy components of several local companies with each other.

**Keywords:** Energy monitoring, energy saving, IOT, medium-sized companies

# INVITED SPEAKERS

## Id-120

### Complex Fluid Flow in Power Nuclear Reactors Core; Cases of BWR, PBMR and HTR-PM

Kamel Sidi-Ali

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**Abstract:** The cooling of nuclear reactor cores is the keystone of nuclear safety. Since the advent of the nuclear technology of GEN I, GEN II to GEN III and III+, nuclear reactors have evolved continuously. Each line and each generation have its own technology, design and nuclear safety requirements. An element common to all these generations and all these lines is ensuring the nuclear reactor core cooling whether in normal operation or in accidental one. Nuclear reactors using plate or cylindrical fuels and not operating under fluid phase change mode are easier to cool than other types of nuclear reactors. One takes the example of Pebble Bed Modular Reactors (PBMR), High Temperature Reactor-Pebble Modular (HTR-PM) or Boiling Water Reactor (BWR). For the first two nuclear reactors, the flow is so complex that the porous media theory approach has to be applied for all physical and thermalhydraulic calculations, whereas for the last nuclear reactor the two-phase flow theory approach is the only one that can provide a sure answer to physical and thermalhydraulic calculations of this type of nuclear reactor.

In this work, the technology of PBMR, HTR-PM and BWR as well as the nuclear reactor core constitution with fuel elements arrangement are presented. The mathematical part: conservation equations for continuity, momentum and energy as well as equations of state and boundary conditions, for both porous media theory and two-phase flow theory are developed and applied to each type of nuclear reactor.

For the case of the HTR-PM and PBMR nuclear reactors, two approaches cases are applied. The first approach is the study of a channel saturated with a porous medium consisting of fuel spheres and cooled by an inert gas, this to approach the HTR-PM. The second is an application for a case of porous medium consisting of the same fuel spheres but arranged in an annular domain to approach the PBMR. For the case of BWRs, a nuclear thermalhydraulic channel is defined and the different two-phase flows presented. The same set-up equation is applied except that it is written for each phase and for the interface between the two phases, the specific case of annular two-phase flow is studied.

The obtained results, presented in figures and physically analyzed, are very satisfactory. It can thus be concluded that applying the model of porous media and the two-phase flow one for complex flows respectively for PBMR, HTR-PM or BWR power nuclear reactors core can ensure a well behavior of the nuclear reactor core thermalhydraulics.

**Keywords:** Nuclear reactors, htr-pm, pbmr, bwr, core, thermalhydraulics, complex flow, porous media, two-phase flow.

# INVITED SPEAKERS

## Id-121

### Settlement Renewable Energy Production and Sharing Energy

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**Abstract:** The changing of energy consumption to renewable energy sources is an increasingly urgent global task, which need of implement wide range and even more horrible climate-research-results are supported.

In Hungary, started off the process of energy change relatively late, but it had achieved significant results primarily by making carbons neutral in electricity production/generation in the last ten years.

The energy professional organizations are performing analyzes for they determine the part of renewable energy mainly in global and national level, in the electricity generation, heating and cooling and also in the transport sectors. Only same research institutes, non-profit organizations and national initiations are concerned with settlement-level investigations. The examination of the settlement self-sufficiency wasn't widely spread.

The purpose of our energy-geography research is, that we determine the share of local renewable energy sources in the settlement level electricity supply in the Hungarian stock settlement.

The Hungarian energy system determines four power plant categories based on built-in capacity of electricity generating units. From this power plant categories, we allowed for the theoretical annual electricity generation of small-size household power plants (SSHPP) which built-in capacity is not greater than 50 kW's performance and the small power plants with under 0.5 MW's performance. In the above power plant categories can be established power plants under the Electricity law since 2008. With reservations, however this renewable energy recovery small power plants can be connected mostly to the settlements and it can be defined the energy change performance of the particular settlement.

Based on the 2017 data we set up a settlement ranging, which show the level of self-sufficiency in the area of the electricity generating from renewable energy sources. The results provide opportunities to the planning of realization of energy change and we can create developmental prognosis and scenarios looking ahead until 2030. The results show, that the realization of the energy self-sufficiency settlements is within reach and this goal can be provided on the small settlements and it isn't impossible even in small and big towns.

Those settlements, which can produce more renewable electricity than their own consumption, have the opportunity to share their excess energy with the neighboring settlements. So the electricity demand of several settlements can be provided by one settlement's locally produced renewable electricity.

**Keywords:** Renewable energy, self-sufficiency settlements, small size power plants, RES in Hungary, sharing energy

# INVITED SPEAKERS

## Id-126

## Frequency Synchronization of an PV Generation System Using PLL Technique

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**Abstract:** Synchronization with the utility grid is one of the most important aspects in the control of an increasing number of single-phase and three-phase grid-tied power conditioning systems, such as: active power filters, dynamic voltage restorers (DVRs), and distributed power generation and energy storage systems.

Various synchronization techniques have been proposed in recent years. Among these techniques, the phase locked loop (PLL) has found much attention, due to its simplicity, robustness, and effectiveness. This research paper explains the technique of the PLL which has been used for synchronization process with the AC power networks.

The PLL technique is widely used when photovoltaic (PV) generation systems are installed and connected with an existent AC power network (grid). Because, the generated AC voltage; from the DC-to-AC converter in the PV generation system; needs to be synchronized with the frequency of the AC power network.

There are several topologies of the PLL, but we have chosen the topology of the synchronous reference frame in order to perform this research study.

The PLL method is essentially a feedback control system, where a reference phase angle ($\theta^*$) and feedback phase angle ($\theta_r$) are compared in the phase detector, and an error signal ($\Delta\theta$) proportional to the phase difference is generated at the input of a loop filter. The amplified error control signal drives a voltage controlled oscillator (VCO) to generate the desired output phase angle ($\theta_r$).

Commonly, all PLL techniques are composed of three building blocks that are: phase detector, loop filter, and VCO. Where, the main difference among different PLL methods typically lies in how the phase detector block is implemented.

In order to study and understand the method of the PLL, it is important to address how to convert the electric quantities; such as: voltage and current; in both stationary and rotating reference frames. Where, the transformation approaches of Clarke and Park are used to implement the control circuits of PLL technique. For example, we need to convert the ABC domain voltages ($v_a, v_b, and\ v_c$) to the αβ ($v_\alpha\ and\ v_\beta$) or dq ($v_d\ and\ v_q$) axes by using the transformation matrices of Clarke and Park.

The MathCad software and the Alternate Transient Program (ATP) were used to investigate the accuracy of resultant simulated results, and also to emphasize that the designed control circuits operate properly and accurately.

Based on the ATP simulation results, we can state that the PLL circuit generates a phase angle ($\theta_r$) that tracks the grid frequency each $2\pi$ cycle.

**Keywords:** Phase looked loop, photovoltaic, ATP

# INVITED SPEAKERS

## Id-127

## Japan Gears Up Renewable Energy Usage After 3.11 – A Case Study of a Small Hydropower Plant in Osaka

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**Abstract**: Since the collapse of the bubble economy in 1889, Japan has been experiencing the so-called lost decades—that is, prolonged stagnation. The Japanese economy has largely experienced a nose-dive in terms of both land and stock prices. During the longest-running economic crises in Japan, the Japanese government and people realized the importance of renewable energy and started emphasizing renewable energy such as solar and wind energy. However, the disastrous Great East Japan Earthquake and the following Fukushima Daiichi Nuclear Power Plant accident on March 11, 2011 (the so-called 3.11) forced the Japanese government to drastically change its energy policy from being nuclear-energy oriented to being renewable-energy oriented.

Japan, which has abundant water resources and mountainous areas, has been utilizing hydropower plants for a long time. Japan's first hydropower plant, Keage Hydropower Plant in Kyoto, was constructed and started operation 128 years ago in 1891.

Hydropower had been a major source of electricity for Japan until about the 1960s. However, the soaring demand for electricity that accompanied the high economic growth after World War II and the increasing reliability and economy of thermal-generated power facilities led to the replacement of hydropower with thermal power generation.

After the two oil crises of the 1970s, the Japanese government changed its energy policy and, since then, began pursuing an energy policy with nuclear power as its pillar. However, the abovementioned disastrous 3.11 accidents in Fukushima Prefecture forced the Japanese government to change its energy policy again and led to a new focus on renewable energy.

There is a variety of renewable energy sources, such as solar, wind, biomass, and geothermal power. However, recently, small hydropower generation systems have drawn particular attention, because they have many advantages: (a) The energy produced is called *chisan-chisho*, that is, it is produced and consumed locally. (b) No greenhouse gas is produced. (c) Unlike some renewable sources of energy, such as solar and wind energy, small hydroelectric power plants produce energy constantly. (d) There is substantial potential for utilizing small hydroelectric power plants in Japan. (f) These small plants can be operated for an extended time period.

This study selected a local governmental project that utilizes a small hydropower plant in Toyonaka City in Osaka Prefecture. Applying an analytical method to evaluate the project and its social impact, this study measured the economic and social impacts of the small hydropower plant project on the city. The results of this study are applicable to other municipalities with similar resources.

**Keywords:** Renewable energy, community development, FIT, social economic impact

# INVITED SPEAKERS

## Id-129

## The Modeling of Planned Hydroelectric Power Plants Influence on the Ecosystem

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**Abstract:** Estimates of the influence of Hydroelectric Power Plants (HPPs) on the ecosystem are obtained on the example of the planned construction of HPPs in Mongolia on the transboundary Selenga river basin. Realization of the projects of HHPs can lead to essential changes in natural hydrological regime of the Selenga River basin in the Russian Federation, which will influence the state of regional ecosystems and economy. The international status of natural objects in Russia, which can be affected by realization of these projects, is an important factor. First of all, this concerns the Lake Baikal – the World natural heritage site. The work contains main results of this problem research. On the base of the analysis of hydrological characteristics of Mongolian and Russian parts of the Selenga basin, the prospects for development of water supply systems and hydro energy of Mongolia there was modeled regulated flow of the Selenga River for different possible operation conditions of projects of HPPs and hydraulic engineering structures (projects of Shuren HPP, Egiin Gol HPP, Orkhon-Gobi water pipeline). Possible risks of the effect of potential Mongolian HPPs are revealed first of all the risks for the ecosystems of Russian part of the Selenga. The influence are estimated for separated and joined projects (cumulative influence). Under risk impact of the construction and operation of HPP refers to the probability of the values of hydrological, hydromorphological, morphometric, physics-chemical and other abiotic and biotic characteristics of ecosystems beyond natural variability.

The objective of the work; the main goal of the study is to identify the characteristics of environmental flow, taking into account the response of ecosystems to flow alteration under regulations. In the framework of the "flow – environment" there was developed a special system models to generate estimates of the impact of regulated flow on the ecosystem of Russian part of the transboundary Selenga river basin. The system includes various models (HPP regimes management, water consumption and water use, hydrological, environmental) implemented as autonomous software components and performing a set of functions that take inputs and parameters and transmit the results to other components.

The results and accomplishments and their significance; the simulation results showed that construction of HPPs in Mongolia will inevitably lead to negative changes in ecosystems. Under certain conditions of water content (extreme low water) and the flow regulation regimes there is a high probability of abiotic and biotic characteristics of ecosystems beyond natural variability (environmental flow). The main risks for the ecosystem are annual changes in hydrological regime, including higher discharge in winter, this

will lead to increase in flow speed, will reduce the efficiency of natural reproduction of omul (the main type of fish in the basin of Lake Baikal) in the Selenga river – migration of fish, spawning, incubation of spawn, moving of larval fish to the delta, as well as other types of fish. Under low discharge during summer the floods will have less impact on soil formation, groundwater level will reduce, especially in the border area of the Selenga river.

Among all considered HPPs in Mongolian part of the transboundary Selenga river basin, the greatest negative impact on the territory of the Russian Federation will have HPP Shuren. The impact of HPP Egiin-Gol will be relatively less, while keeping the risk of negative impact on ecosystems, similar to HPP Shuren. The project of water pipeline Orkhon-Gobi has minimal impact. When regulating regimes of HPP Shuren and HPP Egiin-Gol the greatest deviation from natural flow (up to 3-5 times) are observed for winter period all over the Russian territory of the Selenga river. The greatest deviation from natural flow in summer period occurs in condition of extremely low water content. Upper border territory Naushki-Dzhida is under the highest impact. Getting closer to the inflow of the Selenga, the impact of HPP will decline. Taking into account environmental requirements and the adoption of environmental flow will reduce negative impact, but will not be able to guarantee the preservation of ecosystems close to natural. Their realization is extremely challenging in practice.

The results of the study are used by official representatives of the Russian Federation in negotiations with the Mongolian side on the use of water resources of the transboundary Selenga river basin.

**Keywords:** Hydroelectric power plants, environmental flow, abiotic and biotic characteristics, ecosystems

# INVITED SPEAKERS

## Id-144

## Inspecting Critical Infrastructure in the Energy Sector Using Mobile Robots to Perform Non-Destructive Testing

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**Abstract:** Reliable Non Destructive Testing (NDT) is vital to ensure the integrity, performance management and sustainability of capital assets in safety critical energy industries such as oil and gas, wind and nuclear power generation.

Automating the deployment of non-destructive testing sensors to inspect these structures (which can be located in hazardous and extreme environments) promises the means to improve the health and safety of NDT operators, reduce inspection costs and enable in-service inspection in some cases.

The talk will describe recent European and UK funded projects that we are carrying out to improve the NDT of industrial structures and decrease the cost of inspection by automating the NDT with mobile robots.

These projects are developing mobile wall climbing and submersible robots that can provide access to test sites to look for fatigue cracks, corrosion and weld defects on very large vertical structures thereby eliminating the large expense of erecting scaffolding or lengthy preparation for rope and platform access before inspection can start. Some of these developments provide the possibility of saving costs by reducing outage times or carrying out the NDT in-service thus preventing expensive outages.

The projects have addressed the following inspection tasks:

1. NDT of Wind turbine blades: These projects are developing robot platforms equipped with robotic arms that climb wind turbine towers to deploy the NDT techniques of X-Ray radiography [1, 2, 3] and shearography [4].
2. NDT of off-shore flexible oil and gas risers: A project is developing a robot capsule that is placed around a flexible riser by a remotely operated vehicle and uses radiography to inspect multi-layered riser pipes [5]. Preliminary results are reported in [6, 7]. A recently started project is developing a robot that uses inch-worm motion to move along a riser and perform X-ray NDT [8].
3. In-service NDT of oil storage tanks: Two projects have developed mobile robots that operate while submerged in oil in order to NDT the floor of oil storage tanks [9, 10, 11] to assess the extent of underfloor corrosion. A new project is developing a prototype for a swarm of robots to look for floor corrosion [12].
4. NDT of mooring chains securing floating production and storage of oil platforms (FPSO's): A European funded project has developed a climbing robot to NDT mooring chains [13]. A UK funded project is developing a robot and a phased array ultrasound system to NDT mooring chains [14, 15].

5. Internal NDT of nuclear pressure vessels with climbing robots: A previous project has developed robots that climb on the walls of a pressure vessel while submerged in water to inspect a circumferential weld inside a nozzle [16]. A new project is developing a robot to inspect welds with phased array ultrasound inside a 5MW nuclear pressure vessel.

An overview of these robots will be provided with the aim of describing the opportunities available to apply them to real inspection tasks in energy production.

**Keywords:** NDT of energy infrastructure, Robotic NDT, Mobile robots

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# INVITED SPEAKERS

## Id-154

## Possibility of Silicon Recycling from Waste Crystalline Solar Cells by a Cascade Process of Metallic Floatation aAnd Chemical Etching

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**Abstract:** In this study, efficient separation of metallic particles from waste crystalline solar cells was investigated by combining the metallic floatation and chemical etching.

First, the separation of mixed particles of silicon and aluminum were carried out by floating method in order to purify silicon from waste solar cell module. The control of electric charge, wettability of the solid particles, surface tensions and bubble surface area are important for separation of solids by floating method. Sodium dodecyl sulfate (SDS) can increase the hydrophobicity of aluminum powder due to the difference of surface potential between silicon and aluminum. SDS behaves as a collector of aluminum as well as a frothing agent to decrease the bubble size. At a SDS concentration of 2 g/L and sample dipping time of 10 min and, 80.1 mass% of aluminum was floated and separated, and the sedimentary silicon reached a purity of 90.7 % from a mixture of 50 mass% aluminum and 50 mass% silicon.

Next, copper and aluminum particles derived from waste crystalline silicon solar cell modules were etched with mixed acid containing $HNO_3$ and HCl and the optimal mixing conditions were examined. The crushed particles of waste silicon solar cells were used after sieving between 450 and 600 μm particle size. The Cu etching rate decreased with the increasing HCl concentration in the region of $HNO_3/HCl \geqq 3.36$, whereas it increased at $HNO_3/HCl < 3.36$. The Al etching rate increased when HCl was added, although it was almost independent of the amount of $HNO_3$. 99.6% silicon purity was achieved at the treatment time of 30 min. The CuCl coating was observed on the residuals of Cu. The increasing HCl blocked the Cu etching, but the excess $Cl^-$ promoted the dissolution of CuCl due to complex formation, corresponding to the region of $HNO_3/HCl \geqq 3.36$ and $HNO_3/HCl < 3.36$, respectively.

Finally, a possibility of cascade process of the above metallic floatation and chemical etching was discussed.

**Keywords:** Waste solar cell; recycling; crystalline silicon; floatation; chemical etching

# INVITED SPEAKERS

## Id-156

### Hydrogen Production by Microwave Plasma Biogas Reforming

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**Abstract:** New energy sources alternative to fossil-based fuels become an attractive research subject for sustainable energy development. The declining reserves of primary energy sources, such as fossil fuels, and the thread of global warming impose that the newly developed energy source must simultaneously meet the requirements of being renewable and ecological. In this aspect hydrogen ($H_2$) is one of the most promising renewable and environmentally clean energy sources. Being produced from a primary energy source, $H_2$ is a secondary energy source, which like electricity can be used as an energy carrier. Although $H_2$ exhibits a high combustion heat (142 kJ/g), it is envisaged to be used in the future as an energy carrier for activating the fuel cells rather as a fuel for heat production through the combustion. This boosts an interest in new sources and production methods of $H_2$. Biogas is regarded as a new ecological and renewable $H_2$ source, replacing methane ($CH_4$) commonly used in $H_2$ production.

Biogas is a gas produced during the breakdown of organic materials like green waste, household waste, agricultural and municipal wastes, sewage etc. It consists mainly of $CH_4$ and volatile organic compounds (VOCs), and carbon dioxide ($CO_2$). The production-and-use cycle of biogas does not generate any net $CO_2$ in the nature.

Since the major component of biogas is $CH_4$, several conventional $CH_4$ reforming processes have been adopted for producing $H_2$ from biogas (pyrolysis, steam reforming, dry reforming, partial oxidation, and auto-thermal reforming). Recently an alternative technology has been proposed and developed for $H_2$ production. This technology uses thermal and non-thermal plasmas for reforming gaseous and liquid compounds containing $H_2$, including biogas.

In this paper, we present a microwave plasma-based technology (MPbT) for $H_2$ production from $CH_4$-containing gases, in particular from biogas. The MPbT appears to create the most promising plasma environment for such processing as coal/biomass/waste pyrolysis/gasification, waste gas treatment, plasma reforming and $CO_2$ conversion. The MPbT for $H_2$ production presented in this paper focuses on the efficiency of $H_2$ production via reforming of the so-called synthetic biogas (a mixture of $CH_4$ and $CO_2$) flowing through a waveguide-supplied metal cylinder-based microwave plasma source (MPS, 915 MHz, up to 10 kW, gas flow rate 12 m3/h). This kind of processing is called a microwave plasma dry ($CO_2$) reforming of $CH_4$. We found that the microwave plasma dry reforming of $CH_4$ resulted in the $H_2$

production rate of about 160 g($H_2$)/h and the energy yield of $H_2$ production of about 30 g($H_2$)/kWh. The results obtained were compared with those of the other methods used for $H_2$ production, showing the attractiveness of the microwave plasmas for biogas conversion into $H_2$.

**Keywords:** Hydrogen production, microwave reforming of biogas, dry reforming, microwave plasma, microwave plasma reforming

# INVITED SPEAKERS

## Id-158

### Poly(2,5-benzimidazole) Nanocomposite PEMs for FC Application in a Wide Range of Temperatures

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**Abstract:** Proton exchange membrane fuel cells (PEMFCs) operating at wider temperatures (covering the temperatures of LT and HTPEMFC) under various humidity conditions (or without any external humidification system) is highly desirable. To achieve high proton conductivity under such critical conditions, fabricating novel proton conducting paths in a PEM is essential. Generally, proton transport in a PEM is explained by vehicle ($H_3O^+$) and/or Grotthuss (proton hopping) mechanisms. The vehicle mechanism is mainly regarded as proton transferring with the form of $H_3O^+$ in the sulfonated ionomers, while the Grotthuss one is mainly supposed to proton hopping between PA molecules in the PA-PBI membranes. Due to the dependence on the relative humidity or acid concentration, the activation energies of the proton transport via these two mechanisms normally increase greatly with the decrease of relative humidity, indicating that there is a limitation for the proton transport based on those conventional PEMs such as Nafion.

One of the promising polymer materials for wide range temperature PEM is Poly (2,5-benzimidazole) (ABPBI), due to its high thermal stability, good mechanical properties and low methanol crossover backbones. When doped with phosphoric acid (PA), the polymer membrane is able to conduct protons at high temperature (above 120°C) in anhydrous environment. The proton conductivity of the system strongly depends on the PA doping level, which, however, is restricted by the absorptivity of pristine ABPBI and limited its applications for PEMFCs. The PA doping level of ABPBI membranes could be improved by addition of inorganic fillers, in particular nanofillers. In this work, different nanofillers including polyhedral oligomeric silsesquioxane (POSS), montmorillonite (MMT) sodium nanoclays and sepiolite (Sep) nanofibers were prepared via *in-situ* synthesis. The desirably enhanced mechanical, thermal, and oxidative stabilities of ABPBI nanocomposite membranes were achieved by dispersion of the nanofillers in the ABPBI matrix with controlled microstructures. Benefiting from the richness of high temperature stable bound water and the excellent water absorbability of nanoparticles that enable the formation of additive proton conducting paths, the composite membranes retained bounded PA and achieved much higher proton conductivities under both anhydrous and hydrous conditions compared to PA-doped ABPBI membranes. Proton conductivity values above 0.01 S/cm at 40-90 °C/20-98% RH conditions and 90-180 °C/anhydrous conditions for the composite membrane are more holistic compared to Nafion at low temperatures and polybenzimidazole-based membranes at high

temperatures, respectively. The excellent properties of ABPBI nanocomposite membranes suggest them as prospective candidates for PEMFCs applications in a wide temperature range.

**Keywords:** Proton exchange membrane, poly(2,5-benzimidazole), nanocomposoite, ğroton conductivity, wide temperature range

# INVITED SPEAKERS

## Id-166

### Model Based Control Algorithms for Electric Vehicles Recharging Management: from Vehicle to Grid Control

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**Abstract**: This invited talk will discuss past and ongoing research in the field of electric vehicle (EV) charging control, with a focus on model-based control algorithms, which are at the core of the author's contributions in this research area.

The massive deployment of connected electric vehicles will revolutionize, among the others, the transport and the power system sectors. To allow for a safe electrification of road transport, it is necessary to deploy control intelligence at different levels, going from the control of the EV battery pack, up to the real time coordination of the EV recharging processes happening, e.g., at city level. The talk will discuss some significant EV charging use cases and will present control frameworks that have been designed, deployed and tested to date, including real demonstration pilots from European funded projects.

A first use case considers the problem of controlling the recharging process of one or more EVs, with the objective of minimizing the energy bill, while ensuring the maximisation of the self-consumption of locally produced renewable energy. The recharging control problem includes a set of boundary conditions to ensure that the grid constraints (e.g. maximum local available power), the EV technical constraints and the user's preferences (desired final state of charge level and maximum allowed charging time) are met. Of particular importance is the integration into the control problem of a sufficiently detailed model of the battery pack, to ensure that the computed recharging commands do not result into unacceptable accelerated battery aging and degradation.

A second use case presented will deal with the problem of controlling in a coordinated way a large number of recharging processes ongoing in a same region of the electric grid, with the objective of ensuring that the resulting aggregated electric load remains within the limits set by the operator of the grid (i.e., the distribution system operator). The scenario of EV aggregators providing ancillary services to the grid is also discussed.

The presented charging control algorithms are based on a control technique called model predictive control (MPC). MPC is one of the few available control methods to deal with constrained control in real applications. It is widely applied in industrial practice, owing to its peculiar characteristics: it is optimization based, and hence it allows to directly embed end user's goals into the control framework, through the proper selection of the objective function terms. In addition, MPC makes possible to include a set of mathematical constraints, through which it is possible to directly map the real constraints

characterizing the process to be controlled (the constraints possibly being of different nature: technical, economical, user-driven, etc.).

The talk will finally discuss also implementation details, such as the control architecture, the different actors involved, the control sequence diagrams, etc. Also, some relevant technical standards in the field, to be considered for an implementable control design, are discussed, together with an outline of possible cyber-physical security concerns associated with the deployment of large-scale EV control.

**Keywords:** Electric vehicle recharging, smart grids, batteries, model predictive control

# INVITED SPEAKERS

## Id-182

### $MoS_2$ Hetro-Dimensional Nano-Structures Wrapped Graphene via Two-Step Sonication Process for Hydrogen Evolution

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The increasing interest in 2-dimensional $MoS_2$ structures can be associated with its graphene-like morphology and cost-effective production feasibility. Exfoliated $MoS_2$ can be used as an excellent electrocatalyst for hydrogen evolution reaction as well as an electrode material for batteries and supercapacitors. Synthesis route for these materials includes micromechanical peeling and chemical vapor deposition [1, 2]. However, the aforementioned synthesis procedure restrains from bulk production of these materials. Currently, large scale production of such 2D materials is facilitated by sonication of bulk powders in a suitable solvent. The latter is very well demonstrated for graphene and can be employed for other 2D materials to produce large volumes of the layered structure.

We report the synthesis of hetro-dimensional $MoS_2$ nano-structures wrapped in graphene via sonication of graphite flakes/Bulk $MoS_2$ powder in NMP solvent. This unique morphology was tailored in a two-step sonication process, bath sonication followed by probe sonication. The resultant dispersion was dip coated and directly used as electrode material for the hydrogen evolution reaction application.

An onset potential of ~ 110 mV was achieved. We genuinely believe that the process can be employed for large-scale synthesis of such nanostructures for the aforementioned application.

**Keywords:** Electrocatalysis, sonication, graphene, mo-lybdenum sulfide, energy application

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# INVITED SPEAKERS

## Id-185

## Efficiency of DSSC on the Variation of Chlorophyll Dye Concentration Extracted from Sargassum Sp

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**Abstract:** Dye sensitizer solar cells (DSSC) are devices for converting visible rays into electricity based on the sensitivity of semiconductors which have a wide band gap and are included in thin layer cell groups. Increased efficiency of DSSC in light absorption is a topic of research that has continued to be developed in the last decade. DSSC performance is largely determined by the material sensitizer. Where the use of dyes can increase the absorption spectrum by semiconductors. Because simple, easily obtained, and widely available preparation techniques, natural dyes are very promising to be used as an alternative sensitizer for dye sensitizer solar cells. Various sources of organic material base coatings have been applied as sensitizers. This research has made sensitizers obtained from macro *Sargassum* sp. algae to be applied to TiO2 semiconductors. It is expected that the efficiency of the absorption of visible light from dye pigments can be comparable to the use of organic pigments from conventional methods that use large (non-nano) particles. The TiO2 coating method used is the doctor blade method. Two fabricated cells had an area of 1 cm2 soaked with chlorophyll dye with a variation of 5 - 60 hours, and chlorophyll concentration from 36.4 - 10.8 mg / L. These cells are tested using direct sunlight. The level of efficiency is indicated by pigment stability and solar cell voltage testing. The efficiency level obtained ranges from 0.16 - 1.43. The concentration of TiO2 plate coating solution on dye chlorophyll extract affects the efficiency value produced by solar cells. Improvements to the stability of chlorophyll as coatings still need to be improved so that these semiconductor products can be used to replace semiconductors made using organic or synthetic dyes.

**Keywords:** Chlorophyll, dye-sensitized solar cell, Sargassum sp.

# INVITED SPEAKERS

## Id-193

### Synergistic Effect from Co-Pyrolysis of Low-Rank Coal and Microalgae: Products Distribution, Kinetic Characteristics, and Radical Analysis

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**Abstract:** Co-pyrolysis of coal and microalgae biomass can not only effectively cope with the challenges such as environmental pollution and greenhouse gas emissions, which caused by the traditional utilization of coal, but also open up a tremendous potential of biomass energy. The thermochemical reaction activity of microalgae biomass is high, and the synergy effect in the co-pyrolysis process can promote coal decomposition. It is significant that revealing the mechanism of product formation of co-pyrolysis between coal and microalgae. This report focuses on the co-pyrolysis behavior, products distributions, kinetic characteristics as well as the change of free radicals in pyrolysis products of the Shenmu low-rank coal, microalgae biomass, and its main components.

Synergistic effects occurred with different forms from co-pyrolysis of microalgae primary compounds(glycine, medium chain triglyceride and starch) and coal. Positive synergistic effects, which were defined as higher volatile yield than calculated value, were found in medium chain triglyceride and coal mixtures at all mass ratio. Whether positive or negative synergistic effects on products yield from glycine or starch blended with coal hinged on the temperature and mixing ratio. Non-additivity phenomenon was observed on the distribution of average activation energy. The free-radical evolution characteristics from semi-coke of the organic components of the low-rank coal and the typical organic components of the microalgae were analyzed. The EPR (Electron Paramagnetic Resonance) was performed for the acid coal, glycine and their mixtures at different pyrolysis temperatures. The results showed that low-rank coal and glycine generated plenty of free radicals and the radicals recombined in the co-pyrolysis process. The synergy effect in the co-pyrolysis was that free radicals interact with each other lead to the yield of the product not equal the simple linear superposition of the two samples. The results showed that in the pyrolysis process of low-rank coal, aromatic hydrocarbon radicals, heteroatom radicals, oxygen-containing radicals, and aliphatic hydrocarbon radicals were mainly included.

**Keywords:** Synergistic Effect, co-pyrolysis, low-rank coal, microalgae, radical Analysis

**Acknowledgments:** This work was supported by the National Natural Science Foundation of China (Grant Nos: 51606149).

# INVITED SPEAKERS

## Id-195

### Lignocellulosic Waste Biomass to Methanol-Potential and Challenges

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**Abstract:** Lignocellulosic waste biomass such as agricultural, forestry and wood industry waste creates an abundant source of renewable energy and valuable materials. Bio-methanol as a very lucrative chemical used as renewable liquid fuel or as a reagent in organic syntheses can be produced via conversion of waste biomass. The use of methanol from a renewable source in transesterification of bio-oil to biodiesel is of particular importance. Hydrogen and CO, the reagents of methanol syntheses, are the main components of gas produced by waste biomass gasification. However, this gas contains also $CO_2$, $CH_4$, light hydrocarbons and contaminants such as particulates, tar, $H_2S$, $NH_3$, HCl etc. Producer gas from biomass gasification can be used as feedstock in bio-methanol syntheses after treatment comprising particles and tar removal, $H_2S$, $NH_3$ and HCL removal and reduction of $CO_2$ concentration. When synthesis gas is used for methanol production, concentration of $H_2S$ has to be below 100 ppb, concentration of HCl below 1 ppb and concentration of $NH_3$ below 10 ppb. Need for multi-step gas treatment, heterogeneous character of waste biomass feedstock and obtaining required $H_2$/CO mole ratio in the syngas can be considered as the most important technical challenges in waste biomass to methanol technology. As a result, production of methanol from waste requires more investment compared to the conventional technology using natural gas. However, taking into account the environmental impact and the requirement of using bio-methanol in the biodiesel process, production of methanol from renewable sources becomes very important.

Producer gas composition can be influenced by the type of used biomass feedstock, gasification technology, used oxidizing agent and process conditions. Setting optimal conditions in the gasifier can reduce the number of operations required for gas treatment. Beside feed composition, oxygen to feed and steam to feed mass flow ratios have significant influence on gas composition. Also gasifier temperature is controlled by the oxygen to feed mass ratio.

In this work, the potential of methanol production from agricultural waste mixtures was studied by mathematical modeling and simulation of all processes from waste gasification to methanol syntheses via gas cooling, tar, $H_2S$ and $CO_2$ removal, gas compression and energy integration. Required data for mathematical modeling were obtained by laboratory measurements and partially from literature sources. The effect of feed composition was studied using two different feeds with different compositions. Oxygen to biomass ratio and steam to biomass ratio were optimized at maximum produced methanol to biomass ratio. Required gasifier temperature was 900 $^oC$. Technical challenges such as gas tar content and $H_2S$ and $CO_2$ removal energy consumption were discussed.

The application of steam ensured increased $H_2$ yield and the use of pure oxygen led to low concentrations of $N_2$, $CH_4$ and tars in the product gas. The best methanol to biomass ratio for samples and conditions studied in this work was 0.43 at the optimum oxygen to biomass ratio of 0.57, and steam to biomass ratio of 0.89. Feed moisture content and heating value influenced the methanol theoretical yield. Lower moisture and higher heating value of biomass led to higher methanol to biomass ratio. Waste biomass to methanol ratio provides an interesting choice for waste valorization. However, required operations for producer gas treatment to syngas can significantly influence the process economics. Higher investment costs compared to production of methanol from natural gas can be considered as the main reason of the slow commercialization of the waste to methanol process.

**Keywords:** Waste biomass, methanol, gasification

**Acknowledgement:** This work was supported by the Grant APVV-15-0148 provided by the Slovak Research and Development Agency

# INVITED SPEAKERS

## Id-215

### Estimating In-Situ Thermal Diffusivity by Using Temperature Recovery Model

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**Abstract:** The determination of thermal diffusivity is a pre-requisite for geothermal site characterization and utilization. The temperature recovery (TR) method is one of the popular method for determining the in-situ thermal conductivity along with the thermal response test and the thermal conductivity probe methods. The TR method records the decaying temperatures during the recovery period to determine in-situ thermal properties of subsurface after the thermal disturbance produced by drilling processes or heating cable in a borehole. However, there are no study by using up-welling water in a well. In this study we develop a 1D numerical method to estimate in-situ thermal diffusivity of subsurface by using up-welling thermal water as a heat source in an artesian well. Our numerical model also includes parameters of position of sensor in borehole, thermal properties of well casing and annulus. Two data set from literatures are used to verify our model. Field data from the Jiashi Hot Spring, Taiwan are used to demonstrate the numerical model. Our result shows that determination for the in-situ thermal diffusivity in the depth of 5 m by the temperature recovery event in the artesian well CLD is 7.9 × 10-7 $m^2/s$. The upper 27.6 m of well CLD is composed of coarse-medium sand and our model's value of thermal conductivity is consistent within the range of values 1.5-3.7 W/m°C for the saturated sand in the literatures.

**Keywords:** Temperature recovery; in-situ thermal diffusivity, artesian

# INVITED SPEAKERS

## Id-225

### Effect of the Morphological Parameters on the Photo-Electrochemical Activity of $TiO_2$ Self-Organized Nanotube Arrays

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**Abstract:** Since the 1972 revolutionary report by Fujishima and Honda on the water splitting into oxygen and hydrogen using a $TiO_2$ electrode, rigorous research has been devoted to hydrogen production through solar water-splitting processes. The photo-electrochemical water-splitting application critically depends on the development of efficient, durable, and low-cost water oxidation catalysts that can enhance the surface reaction kinetics.

In this work, highly ordered and self-organized $TiO_2$ nanotube arrays were fabricated using rapid anodization process. A series of $TiO_2$ nanotubes are prepared under different anodization potentials, electrolyte composition and anodization time, and the effect of the varying anodization conditions on the $TiO_2$ nanotubes geometrical parameters as well as their photo-electrochemical properties is investigated. The optimal anodization parameters are demonstrated by means of photocurrent measurements and linear sweep voltammetry in order to achieve the most efficient charge carrier separation. This permits the optimization of the photocurrent density and the incident photon-to-energy conversion (IPCE) and contributes to further improvement of the photoelectrochemical water splitting performance of $TiO_2$ nanotubes photoelectrodes.

**Keywords:** $TiO_2$, photoelectrochemical activity

# INVITED SPEAKERS

## Id-227

### Ab Initio Parameters of Thermoelectric Magnesium Silicide Alloys

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**Abstract:** The need of clean and sustainable energy sources has driven an intense research effort in the field of material science. Besides abundant and reciclable, these materials must show rich transport properties to ensure their efficiency in energy conversion. Magnesium silicide ($Mg_2Si$) has shown to ehnance its electrical power factor when alloyed by germanium (Ge) or tin (Sn), notwithstanding their scarcity and price. We explain this improvement using density functional theory (DFT) based calculations of the electronic properties of intermediate alloys.

**Keywords:** DFT, thermoelectrics, alloys

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# INVITED SPEAKERS

## Id-230

## Nanoporous Carbon Paper Electrodes for High Performance of Vanadium Redox Flow Batteries.

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**Abstract:** Carbon paper (CP) is commonly used electrode material in vanadium redox flow battery (VRFB) due to its large surface area, porosity and chemical stability in highly acidic solution. However, poor electrochemical activity toward oxidation and reduction of vanadium ions due to low surface wettability arising from its hydrophobic nature limits its effectiveness. Several modification techniques have been used to improve the catalytic activity of CF toward vanadium redox couples mainly including thermal, chemical, thermo-chemical and electrochemical treatments. Most of the reported modification techniques resulted in increased activity of CP by changing its active surface area and surface functional groups. Besides the initial performance boosts by various modification techniques, the sustainability of electrode activity is also considerably important factor for a long term operation of VRFB cell.

Here we report the catalytic etching technique to modify CP resulting formation of nanopores on its surface. When used as electrode in VRFB, the E-CP showed remarkable performance improvement in terms of electrolyte utilization by 110%, discharge energy density by 155% and energy efficiency by 29% as compared to the one using pristine electrodes at a current density of 50 mA $cm^{-2}$.

**Keywords:** Nanoporous, vanadium redox flow battery, energy storage, renewable energy

# INVITED SPEAKERS

## Id-231

## Accessing Electronic Structure of Electrode-Electrolyte Interface: Surface Science Approach

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**Abstract:** Currently, commercially available supercapacitors (SC) - make use of activated carbon (specific surface area ~1000 m2g-1 and specific surface capacitance ~0.01mF cm-2) as the electrode material and water based electrolytes (potential window limited to 1.23 V) - have almost reached their capacitance limits. The main charge storage mechanisms in SC are: charge accumulation in electrical double layer (EDL) and Faradaic (redox) reactions at the electrolyte-electrode interface. In this talk we report on an alternative charge storage mechanism – space charge accumulation in a subsurface layer of ~100 nm – experimentally observed in pure VN thin films and responsible for impressively high surface capacitance up to ~3 mF cm-2 in aqueous electrolytes. Combining electrochemical testing with X-ray photoelectron spectroscopy (XPS) has revealed that redox reactions play no or little role in the electrochemical response of pure VN, in contrast to the common wisdom stemming from the electrochemical response of oxygen-containing films.

Room temperature ionic liquids (RTIL) (electrochemical window up to 6 V, thermo stable up to ~300oC) have been introduced as an alternative to aqueous and organic (electrochemical window 2.5-2.8 V, flammable) electrolytes [1]. Recently it has been reported, that in the concentrated electrolyte solutions (1-10M), including room temperature ionic liquids, the Debye length is ~100 times (!) larger then that predicted by classical the Debye-Hückel theory, thus revealing remarkable long range interactions in concentrated solutions regardless of their chemical composition [2]. In this work we address the puzzling problem of the long range interaction (~10nm) in concentrated electrolytes by taking “surface science” approach –combining in-situ electrochemical XPS, AFM and thin film deposition techniques. The experimental setup allowed to measure potential distribution in the interface between HOPG and [EMIm][FSI] RTIL. Mapping of the electrochemical shifts of the XPS lines was deployed to measure potential gradient across the electrode-electrolyte interface. We observed potential driven reversible morphological transformations of the RTIL, which was tentatively explained as the liquid-solid transition under the conditions when the screening length was comparable with thickness of the electrolyte layer.

**Keywords:** XPS, ionic liquids, Vanadium nitride

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# INVITED SPEAKERS

## Id-240

### Smart Algorithm for Energy and Cost Management Within Smart Grid

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**Abstract:** Energy demand has increased significantly in the past two decades due to several reasons. First, many new technologies and industries have emerged, second, developing countries have increasing power demands, and finally, the rising of several new urban areas and big cities. This power demand requires more developed power grid system with smart solutions. Smart grid, on the other hand, provides methods that enable users and consumers to use energy efficiently. Demand Side Management (DSM) and house consumption scheduling have been recently proposed in order to manage power consumption at user's end. These can enable users to collaborate among themselves in urban areas, where normal electricity consumption patterns are changed by reducing the energy demand at peak times. This is achieved by offering a new price model that encourages users to do so [1]. In addition, new methods that promote supplying users with renewable energy sources and storage facilities, in order to reduce demand on power grid. This requires the design and deployment of power consumption scheduling methodologies that enable users in urban areas to know to better schedule home appliances in order to reduce consumption and final costs.

**Keywords:** Energy management, cost management, demand side management, smart grid

# INVITED SPEAKERS

## Id-256

### A New Potential Class of Anode Materials for Lithium-Ion Batteries

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**Abstract:** New inorganic metal phosphites have been investigated for the first time as anode materials for lithium-ion batteries. Phosphite groups $(HP^{III}O_3)^{2-}$ are interesting thanks to their tendency to form new framework structures which can be very useful to host ions in ionic batteries. In the present work, titanium and tin phosphites materials with new structures were synthetized and electrochemical tests were investigated to show their ability to insert lithium ions. The choice of titanium is based on the operating voltages of the $Ti^{4+}/Ti^{3+}$ active redox couple which takes place above the electrolyte decomposition threshold. Tin has been chosen to increase the electrode capacity as it is known to form alloys with lithium. Furthermore, the compound Sn-Phosphite is advantageous because each component gathers the volume change of the other during cycling, making the stability of the electrode and its long life. Materials have been synthesized using hydrothermal method thanks to its scalability, rapidity and cost-effectiveness. Solid-state structure was determined from powder X-ray diffraction data. The vibrational modes of the $(HPO3)^{2-}$ oxoanions were showed by IR and Raman spectroscopy. All synthesized phases exhibit an insertion host for reversible accommodation of $Li^+$.

**Keywords:** Lithium-ion batteries,anode,inorganic metal phosphites

# INVITED SPEAKERS

## Id-269

### Effects of Exhaust Gas Recirculation on Temperature, Using Biodiesel Blends

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**Abstract:** This present work focused on experimental work to compare the effects of temperature and emissions produced using WPPO biodiesel blends under the influence of EGR. The mixtures were prepared in the ratios of 10 %, 20 %, 30 %, 40 % and 100 %, for WPPO10, WPPO20, WPPO30, WPPO40 and WPPO100 respectively. The EGR flow rate was 5 %, 10 %, 15 %, 20 %, 25 % and 30 % respectively. Testing and performance was on a Kirloskar engine, water cooled, direct injection operating at 1500 rpm and a torque of 28 Nm. The EGR system was modified with an addition of the EGR and valve in the exhaust system. The study has three objectives: (i) to investigate the effect of temperature on the emission characteristics of a diesel engine using WPPO biodiesel blends compared to conventional diesel baseline fuel. (ii) To find the effect of EGR on WPPO biodiesel ratio on the exhaust gas temperature compared to baseline conventional diesel fuel. (iii) To find out the trade-off point for the WPPO biodiesel blends temperatures in relation to the EGR % flow rate. Following testing and evaluation, the highest temperature obtained for conventional diesel was 456 ºC compared to 490 ºC for WPPOB100 blend both at 0 % EGR flow rate. However, the other WPPO blends show trends of decreasing temperatures with the application of EGR % flow rate. Other results show increasing blend ratio and the EGR percentage, flow rate increased smoke emissions across all the WPPO blends tested. This study confirms that the WPPO biodiesel blends can produce lower EGT temperatures with application of the EGR technique of $NO_X$ control, but with higher emissions of UHC for WPPO100 blend.

**Keywords:** Biodiesel blend ratio, EGR flow rate, Exhaust gas temperature, waste plastic pyrolysis oil.

# INVITED SPEAKERS

## Id-273

### Wind Farming: India Perspective, A Case Study

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**Abstract***:* In addition to the Solar energy, wind energy has turned out to be one of the most economical renewable energy sources. Hence the related techniques to extract a maximum efficient technologies have been started adopting. This has ultimately resulted in 'Wind farming'. This paper abstract addresses certain issues related to the location of such farms, losses, transportation losses and costs, storage capacity, etc. An attempt is made to overcome the conventionally adopted methodologies. The issues are addressed considering Indian perspective plans of 'Wind Farming'. A live case study is discussed that will give an insight to the problems and issues.

**Keywords:** Wind Farming, storage capacity, efficiency

# INVITED SPEAKERS

## Id-274

### Geothermal Energy Potential for Future Utilization in Jordan

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**Abstract:** In Jordan, one fifth of the national GDP goes for conventional fuel imports. Due to population growth with refugees` influx in parallel with modern industrialization, energy demand has been raised very fast last five years. Geothermal energy is one of such resources which exhibit high potential for utilization to satisfy the national demands. Jordan is blessed with shallow geothermal resources all over the country. In some areas the geothermal gradient exceeds 4.5 °C / 100 m. More than 100 thermal wells and 50 hot springs spread out in four geothermal fields with the highest water temperature of 68.5 °C. Consequently, geothermal resources would be utilized for direct and indirect applications according to the geothermal field's locations, geothermal gradients and local community needs. Geothermal energy applications are differing upon the source geocharacteristics; reservoir depth, source heat, rocks permeability, porosity, thermal conductivity and water chemistry. Power production could be utilized at the highest geothermal field NE Jordan. The seasonal temperature variations stress heating and cooling requirements in the country. Ground source heat pumps is very suitable especially with the recorded steady subsurface temperature in the area. Greenhouse heating at cold winter nights will protect the crops from freezing. Furthermore, fish farming will give a chance for new exported good fish quality and satisfy the local market's needs. Fruits, herbs and different crops would be dried in high quality preservation for exporting purposes. Finally, different disorders could be treated on future designed spa while enjoying the ancient history of Jordan. An integrated plan for geothermal applications in Jordan is becoming very essential soon for energy policies and strategies. Geothermal resources utilization will lead to have a positive environmental and economic contribution to the national bill. In addition, it will contribute to solve socio-economic and environmental problems challenging poor areas.

**Keywords:** Geothermal energy potential for future utilization in jordan

# REGULAR SESSIONS

## Id-021

## Drivers' Response to Fuel Taxes and Efficiency Standards: Evidence from Germany

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**Abstract:** Using household travel diary data collected in Germany between 1997 and 2015, we employ an instrumental variable (IV) approach that enables us to consistently estimate both fuel price and efficiency elasticities at once. The aim is to gauge the relative impacts of fuel economy standards and fuel taxes on distance traveled. Our elasticity estimates indicate that higher fuel prices reduce driving to a substantial extent, though not to the same degree as higher fuel efficiency increases driving. This finding indicates an offsetting effect of fuel efficiency standards on the effectiveness of fuel taxation, calling into question the efficacy of the European Commission's current efforts to legislate carbon dioxide emissions limits for new cars.

**JEL classification: D12, Q41**

**Keywords:** Automobile travel, instrumental variable approach, rebound effect.

**Acknowledgements:** We are grateful for invaluable comments and suggestions by Christoph M. SCHMIDT, as well as three anonymous reviewers. This work has been partly supported by the NRW Ministry of Innovation, Science, and Research within the project “Rebound Effects in NRW” and by the Collaborative Research Center “Statistical Modeling of Nonlinear Dynamic Processes” (SFB 823) of the German Research Foundation (DFG), within the framework of Project A3, “Dynamic Technology Modeling”.

# REGULAR SESSIONS

## Id-036

## Nitrogen-doped carbon supported gold nanoparticles as an efficient catalyst for glucose and ethanol electro-oxidation

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**Abstract:** This study is focused on the preparation of gold nanoparticles (AuNPs) supported carbon (C) and nitrogen-doped activated carbon (N-doped C) nanocomposites and their application for the electro-oxidation of ethanol and glucose in an alkaline medium. The AuNPs were deposited on the N-doped activated carbon material or carbon using glucose and ascorbic acid as reducing agents. Scanning electron microscopy, Raman and X-ray photoelectron spectroscopy were used for characterization of morphology and composition of the resulting nanocomposites, whereas, the electrocatalytic activity of the ones for ethanol electro-oxidation was investigated using cyclic voltammetry.

It has been determined that the AuNPs/N-doped C nanocomposites had a higher catalytic activity for the electro-oxidation of ethanol and glucose than the pure Au or carbon and N-doped carbon alone, indicating the synergistic effect of AuNPs and N-doped carbon or carbon. Moreover, the highest activity shows the AuNPs supported N-doped carbon as compared with that of AuNPs supported carbon. The obtained N-doped carbon supported AuNPs catalyst seems to be an efficient anode material for direct ethanol and glucose fuel cells (DEFC and DGFC).

**Keywords:** N-doped carbon, gold, nanoparticles, glucose, ethanol, electro-oxidation

**Acknowledgment:** This research was funded by a grant (M-ERA.NET-1/2016) from the Research Council of Lithuania. The author's research was performed in cooperation with the University of Tartu (Estonia), Latvian State Institute of Wood Chemistry (Latvia) and Horizon Pulp&Paper Ltd (Estonia) under the M-ERA.NET 2 project "Wood-based Carbon Catalysts for Low-temperature Fuel Cells (WoBaCat)" (reg. No. project3213).

# REGULAR SESSIONS

## Id-039

## Thermally Stable Polyacrylonitrile (PAN) Based Hybrid Electrospun Nanofibrous Membrane for Separator of Lithium Ion Batteries

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**Abstract:** In this study, a novel thermally stable and anti-thermal shrinkage hybrid polymer separator was proposed. Polyacrylonitrile (PAN) based hybrid membrane was prepared by electrospinning combined with 4,4'-Oxydianiline (ODA), pyromellitic dianhydride (PMDA) followed by oven drying and thermal pressing. The hybrid membrane was investigated as a separator for lithium ion batteries in a coin cell. When compared to commercial Celgard and PAN separator, the hybrid membrane showed the best porosity (73.36 %), electrolyte uptake (558.63 %), and ionic conductivity (2.84 $mScm^{-1}$). The hybrid membrane was characterized by scanning electron microscopy, x-ray diffraction and thermal gravimetric analysis etc. It was found that the hybrid membrane separator has good dimensional stability when exposed to high temperature of 250 °C for 1 hour. The electrochemical performances of hybrid membrane were investigated by electrochemical measurements. The coin cell constructed by hybrid membrane separator exhibits high specific capacity (188.56 $m.Ah.g^{-1}$) at 1C rate, good cyclability and capacity retention (86.76 %) and better efficiency (99.92 %). The hybrid membrane is a promising separator to enhance the cyclability and thermal safety of lithium ion batteries.

**Keywords:** Separator, membrane, polyacrylonitrile, electrospinning, lithium ion batteries

**Acknowledgement:** This research was financially supported by the Basic Science Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education [grant number NRF – 2017R1A4A1015581].

# REGULAR SESSIONS

## Id-040

## Detail Engineering Completion Rating Index System (DECRIS) for Optimal Initiation of Construction Works to Improve Contractors' Schedule-Cost Performance for Offshore Oil and Gas EPC Projects

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**Abstract:** Engineering, Procurement, and Construction (EPC) contractors with lump-sum turnkey contracts have recently been suffering massive profit losses due to re-works and schedule delays in offshore oil and gas EPC megaprojects. The main objective of this research is to develop and implement a detail engineering completion rating index system (DECRIS) to assist EPC contractors to optimize fabrication and construction works schedules while minimizing potential re-work/re-order. This is achieved through adequate detail design development and results in minimizing schedule delays and potential liquidated damages (i.e., delay penalties). The developed DECRIS was based on findings from an extensive review of existing literature, industry-led studies, expert surveys, and expert workshops. The DECRIS model is an evolution, and improvement of existing tools such as the project definition raking index (PDRI) and front-end loading (FEL) developed specifically for the early stage of engineering maturity assessment (i.e., planning, basic design, and front-end engineering design (FEED)), prior to EPC projects. The DECRIS was evaluated and validated with thirteen sample as-built offshore megaprojects completed recently. When the DECRIS was applied to the completed projects post-hoc, a correlation (R-squared 0.71) was found between DECRIS scores and schedule/cost performances. This is much superior to the PDRI-Industrial model's correlation (R-squared 0.04), which was primarily devised for owners' basic engineering or FEED completion assessment. Finally, as a means of further validation, project schedule and cost performance of an ongoing project was predicted based on the correlations found on the thirteen completed projects. The resultant predicted schedule and cost performance was well matched with the current project performance status. Based on the accuracy of the DECRIS model found in the validation, said model is an effective prospective tool for EPC contractors to manage their engineering and procurement/construction risks during the initial detail design stages.

**Keywords:** oil and gas megaproject; engineering; procurement and construction (EPC) project; DECRIS; schedule and cost integration; risks control; profitability; sustainability

# REGULAR SESSIONS

## Id-133

## Energy Efficiency of Small Waste Water Treatment Plants in the Baltic Sea Region – a Comparative Case Study

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**Abstract:** Presented study will compare energy efficiency indexes [1] for three exemplary waste water treatment plants (WWTP) in the Baltic Sea region. Exemplary WWTPs include Goleniów Water Treatment Plant (Location 1 - Poland), Rőnne - Bornholm (Location 3 - Denmark) and Hőőr (Location 2 – Sweden, WWTP of Lyby and Ormanäs). Their geographical position is presented in Fig. 1. Time evolution of energy efficiency indexes and the influence of renewable energy sources on energy efficiency indexes will be analysed.

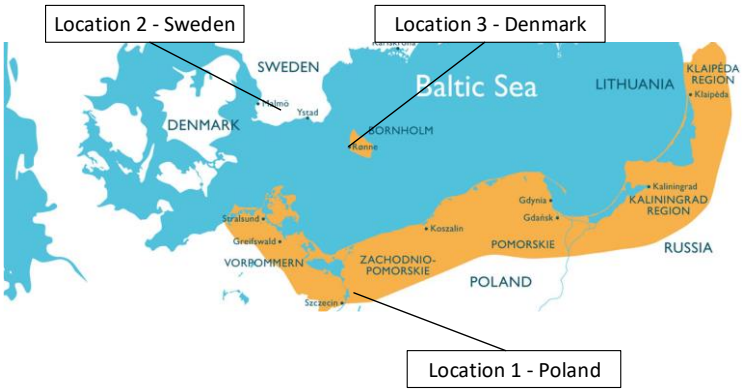


Figure 1. Geographical placement of exemplary waste water treatment plants.

Comparison of WWTP sizes is given in Table 1. As can be noticed WWTP are of limited size and are representative for small and medium municipalities. Incoming flow is comparable even though the person equivalent (PE) varies strongly.

Table 1. Exemplary WWTP size comparison

| WWTP | Incoming flow [$m^3$] | Incoming flow exclusive excess water (estimated) [$m^3$] | PE based on COD | PE based on BOD |
|---|---|---|---|---|
| **Location 1 – Poland** | 2 200 616 | 1 301 975 | 35 828 | 13 666 |
| **Location 2 - Sweden** | 2 693 939 | 1 346 509 | 17 263 | 16 236 |
| **Location 3 - Denmark** | 3 190 701 | 1 800 000 | 65 964 | 46 360 |

Exemplary location 3 (Denmark) produces electrical energy using a photovoltaic installation. Total electrical energy production from this unit was 82 174 kWh in the year 2017. This input will be also analyzed regarding total carbon impact of the waste water processing.

**Reference**

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# REGULAR SESSIONS

## Id-134

## Vırtual Power Plant Operatıon with Solar Power Forecast Errors and Demand Response

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**Abstract:** Intermittent renewable energy production, determined by weather conditions, is increasing in power markets. Their efficient integration calls for flexible participants in smart power grids. It has been acknowledged that a huge underutilized flexibility resource lies on the electricity consumer-side (see e.g.[1]). The activation of this demand flexibility is, however, a big challenge. Despite the recently risen interest towards demand flexibility, there is a gap in the literature investigating the incentives for consumers to offer their flexibility to power markets [2]. It has been proposed that there needs to be a third-party operator aggregating and controlling this flexibility [3],[4],[5]. In this paper we examine a concept of virtual power plant (VPP), which simultaneously optimizes the response of controllable electric hot water heaters to solar power forecast error imbalances. Uncertainty is included in the optimization in terms of solar power day-ahead forecast errors and balancing power market conditions. We show that the virtual power plant can add value from optimizing the combination of these resources. The results indicate that while the total profits are increasing, the marginal revenues are diminishing with the number of participating households. From a policy perspective, our results imply that market efficiency can be increased by allowing the aggregated resources to participate more freely in the markets.

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# REGULAR SESSIONS

## Id-138

## The Impact of Direct Radiation Ratio on Performance of Tracking Photovoltaic Solar Systems

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**Abstract :** Nowadays photovoltaic systems are widely used for electricity generation. For photovoltaic power plant investments, the most important parameter is the payback period for the investors. Generally fixed PV panels, which are located to ground with a predetermined inclination angle, are used for such investments due to their low investment and operating costs. On the other hand some EPC prefers solar tracking PV systems for more electricity generation. In this study, an MS Excel based simulation software was developed for making techno-economic analysis and determining the best application, which has lower payback period, due to selected effective parameters i.e. direct radiation rate, total radiation rate, ambient temperature, inclination angle, sensitivity of tracking system, type of PV cells, number of PV panels, total area of power plant etc. The developed simulation was verified by using experimental results of present PV power plant test system, located in Ankara Turkey, where % 50 of the overall panels are fixed and the other have a solar tracking mechanism. In that plant, ambiebt temperature, direct and total radiation and the electricity generation are recorded continuously. After the verification, the effective parameters which effects the payback period of the investment, were determined by making sensitivity analysis with developed simulation. The electricity generation was calculated for each of the fixed and solar tracking alternative PV systems. By using simulation software the electricity generation for the fixed system is calculated as 9.335 MWh and 13.423 MWh for the solar tracking PV system. Their investment costs were determined as 6.860.000 Euro for the fixed system and 10.150.000 Euro for the solar tracking one. Although the electricity generation for solar tracking PV system was % 44 more than the fixed system, the payback periods was calculated as 7,51 years for fixed system and 8,37 years for the solar tracking system. On the other hand the effect of direct and total radiation rates and the ambient temperature on payback period of same capacity PV power plants for the selected location was analysed by the developed simulation software. As a result, it is concluded that the ratio of direct radiation rate to the total radiation rate is the most important parameter which determines the best PV system selection, i.e for ratio where direct radiation rate is % 70 or more of the total radiation rate, the solar tracking PV systems are more competitive than fixed ones.

**Keywords:** Solar Energy, Photovoltaic, Solar Tracking, Direct Radiation, Techno-economic analysis

# REGULAR SESSIONS

## Id-161

## The Stability of *α*-Zr with Different Concentration of Vacancy and Alloying Elements: A First-Principles Study

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**Abstract:** Zirconium alloys are widely used in nuclear power reactors in view of their special properties: good corrosion resistance, adequate mechanical properties, and a low capture cross section for thermal neutrons. The addition of alloying elements is useful to modify the comprehensive mechanical properties of zirconium alloys. However, the understanding of alloying effects on the deformation mechanisms of zirconium alloys is insufficient. First-principles calculations have capable of predicting the structure stability. Previous works show that vacancy could influence the deformation of zirconium. However, the influence of concentration of vacancy and alloying element (Sn, Fe, Cr, and Nb) on the stability of zirconium has rarely reported, especially, for that of theoretical investigations.

In the present work, the effect of concentration of vacancy and alloying element considered here on the stability of *α*-Zr by calculating the electronic properties *α*-Zr with three different sizes using first-principles calculations based on DFT. The stability of Zr-V-X (V=Vacancy; X= Sn, Fe, Cr, and Nb) have been investigated by first-principles calculations. Calculation results show that alloying elements of Sn and Nb doped in the second site, Cr doped in the first site is the stable site of supercells of pure Zr containing 142 zirconium atoms inside with one vacancy, respectively. However, two sites are both stable for Fe doped in supercells of *α*-Zr containing 142 zirconium atoms inside with one vacancy due to the similar value of Fermi levels. Alloying element of Sn doped in the third site, Fe doped in the first position, and Cr and Nb doped in the second site is the stable site of supercells of *α*-Zr containing 141 zirconium atoms inside with two vacancies, respectively. Thus, based on the calculation results above, it may help to explore the effect of concentration of vacancy on the trap capability of vacancy for the alloying element in *α*-zirconium.

**Keywords:** Metals and alloys; Nuclear materials; Simulation and modeling; Defects; Electronic properties

# REGULAR SESSIONS

## Id-207

### Study on Hydrogen Resistance Behavior of the Al2O3/Fe-Al

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**Abstract:** In order to prevent leakage caused by the transportation and storage process, nuclear energy is wasted and polluted. The hydrogen permeation resistance of the Al2O3/Fe-Al composite coating was studied. The low pressure (0.1-10Pa) permeation at high temperature was carried out. In this paper, the typical sample of the deuterium process system is used as the research object, and the thermal injection temperature and time influence experiment of Al2O3/Fe-Al composite coating under low pressure (0.1-10Pa) is carried out, and the cerium-containing samples with different cerium concentration distribution are obtained. GDEOS was used to measure the concentration depth qualitative distribution curve U-t of the hot-injected ruthenium sample; the ruthenium-containing standard sample was prepared according to the Ti film quantitative sputum and QMS, and the ruthenium-containing standard sample was excited by GDOES to obtain the ruthenium content and GDOES excitation. Quantitative transformation coefficient of strength; on this basis, the quantitative distribution curve (QDP) of the depth distribution of lanthanum concentration in the Fe-Al/Al2O3 composite coating at low pressure (0.1-10Pa) was obtained, according to the lanthanum element in the material. The distribution is combined with the corresponding concentration distribution characteristic equation and characteristic solution, and the diffusion coefficient of each layer of the material and the solubility of the yttrium on the alumina surface are calculated and fitted, which provides an important basis for the Al2O3/Fe-Al hydrogen barrier materials.

**Keywords:** Fe-Al/Al2O3 composite coating; low pressure osmosis; deuterium quantitative analysis; concentration distribution characteristic equation

# REGULAR SESSIONS

## Id-212

### CNNC PWR Designs and Their Latest News

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**Abstract:** China National Nuclear Corporation (CNNC) is a China state-owned nuclear power energy company covers whole nuclear industry chain including mining, uranium enrichment, nuclear power plant (NPP) design and construction, etc. The expertise obtained for 40 years NPP design and operation has converted into state-of-art pressure water reactor (PWR) design ACP1000, a large commercial reactor, also known as HUALONG-1 and ACP100, a small modular reactor (SMR) design. This paper is in order to introduce main technical characteristics of ACP1000 and ACP100 as well as their up-to-date status of their demonstration project.

**Keywords:** CNNC, PWR, ACP1000, ACP100

# REGULAR SESSIONS

## Id-236

## Pavenergy Research Project – New Developments

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**Abstract:** This paper presents the PAVENERGY research project that has been developed in the University of Coimbra, in Portugal from June 1, 2016 and it ends in November 30, 2019. The work packages (WP) of this research project are: WP 1 - Evaluation of the state-of-the-art in terms of pavement energy harvest solutions; WP 2 - Development of a software tool for simulating the interaction between vehicles and energy harvest systems; WP 3 - Development of a pavement electrical energy harvest system; WP 4 - Implementation of a full-scale pavement section with the electrical energy harvest system; WP 5 - Execution of monitored tests using real traffic or a traffic simulator; WP 6 - Application of the pavement electrical energy harvest system in a speed control hump of a municipal road; WP 7 - Dissemination of the results of the research Project. This paper describes what was planned, what has already been done, what will be done during this last year and what are the new possible developments for the next years.

The present research work has been carried out in the framework of project PAVENERGY–Pavement Energy Harvest Solutions (PTDC/ECM-TRA/3423/2014, https://pavenergy.dec.uc.pt/), co-financed by the European Regional Development Fund (POCI-01-0145-FEDER-016676) through the Operational Program for Competitiveness Factors (COMPETE) and by national funds through the Portuguese Foundation for Science and Technology (FCT).

**Keywords:** pavement energy harvesting system, prototype, vehicles, electrical energy.

# REGULAR SESSIONS

## Id-243

## Experimental Study of a Novel Hybrid Solar Photovoltaic/Thermal and Heat Pump System

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**Abstract:** Energy is a sector of huge importance globally and is currently changing as energy demands grow. A large area in which energy is utilised is in heating, which about 50% of global energy production is used for heating. In the UK central heating accounts for approximately 80% of national heat demand, which for 37% CO2 emissions in the UK in 2016. In order to meet the Paris Agreement target the UK should reduce CO2 emissions by 80% by the year 2050 in comparison to CO2 emission levels of 1990. To address this need, a movement towards the de-carbonisation of heating and cooling systems using renewable energies is taking place. In this regard, solar energy is used to generate both heat and electrical power on both large and small scales.

Solar panels are used to convert solar energy into heat and electricity. Most solar panels are designed to convert solar energy to only one of these forms, and an electrical photovoltaic (PV) panel is typically no more than 20% efficient. The rest of the absorbed sunlight rays are converted into heat. The temperature rise due to this heat reduces the performance of PVs. Hence, the energy that is not converted into electricity by the PV panels must be extracted to prevent reduction of PV efficiencies. PV panels can be actively cooled by passing a fluid through the rear of the panel. It then becomes possible to extract both heat and electrical power. This combined solar heat and electrical power system is known as a Photovoltaic/Thermal (PVT) system. The challenge here is that the heat energy recovered from the hot PV panel is does not have high temperature to cover the heating demand of a household.

One solution to this challenge is to integrate the PV panel with a heat pump. An area of research with this technology is in Indirect Expansion PVT Heat Pump (IEPVT/HP) systems. In order to test the validity of the system an experimental rig of the IEPVT/HP system has been designed and built in an indoor monitored environment in which certain parameters of the system can be controlled. In the experimental testing of the system, these parameters are controlled and varied; the solar irradiation received by the cooled solar PV panel (produced by a solar simulator); the mass flow rate through the cooling of the PV panel; the volume of the water tank supplying the cooling water to the PV panel and feeding the heated water to the heat pump. The integrated system utilises a closed water loop to cool the PV panel and transport the heat to the water-to-water heat pump. As the water is not used as the working fluid by the heat pump and only as transport media for heat, the system is called an Indirect Expansion Photovoltaic Thermal Heat Pump (IEPVT/HP) system.

Experimental results show that cooling the PVT panel using the developed integrated system, reduces significantly the panel temperature from 102 °C to 50 °C (for solar irradiation of 650 W/m2), demonstrating the promising function of the system in cooling the solar photovoltaic panels. Such an effective cooling of the panel increases the on-site electrical efficiency of the PV panel by 25% compared to the un-cooled PV panel. The coefficient of performance (COP) of the heat pump found to be as high as 3.5, confirming the high performance of the developed hybrid system.

**Keywords:** Photovoltaic thermal panel, heat pump, hybrid system, indirect expansion

# REGULAR SESSIONS

## Id-270

## Ca-Doped $LaCoO_3$ Thin Film Cathodes for Solid Oxide Fuel Cells

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**Abstract:** Solid oxide fuel cells are the device which converts chemical energy into the electricity. For the intermediate temperature (ca. 500-700°C) SOFCs, main performance degradation occurs because of cathodes. SOFC cathode materials including $La_{1-x}Sr_xMnO_3$ (LSM) and $La_{1-x}Sr_xCoO_3$ (LSC) have displayed exhibition of phase segregation at their outer surfaces upon long term operation, essentially, owing to the incongruity of dopant $Sr^{+2}$ and host $La^{3+}$ cation sizes. The segregated phases cause a decline in the oxygen reduction reaction (ORR) activity. Thus, with intent to get a chemically more stable cathode, $LaCoO_3$, doped with $Ca^{2+}$ (in preference to $Sr^{2+}$) that has a cation radius close to that of $La^{3+}$, is examined in the current study [1].

In this study, $La_{1-x}Ca_xCoO_3$ (LCC, x=0.2 and 0.4) was prepared as a symmetrical half-cell in the shape of a thin film depositing on Yttria-Stabilized Zirconia (YSZ) electrolyte substrates by a facile and economical polymeric precursor technique. The phase, microstructural and surface chemical evolutions of LCC thin films were analyzed by x-ray diffraction (XRD), scanning electron microscopy (SEM) and X-ray photoelectron spectroscopy (XPS) respectively, performed on samples annealed at 700, 800 and 900 °C for 3 hours and after holding these samples at operation temperature (700 °C) for 100 hours in air. The electrochemical performance of the LCC cathodes were examined by electrochemical impedance spectroscopy (EIS) measurements, obtaining cathode polarization resistance values as low as 0.15 $\Omega.cm^2$ with LCC (x=0.4) that heat treated at 800 °C. Prolonged EIS measurements were performed at 700 °C to determine the long-term stability of the developed LCC thin film cathodes.

**Keywords:** Solid Oxide Fuel Cells, Impedance Spectroscopy, X-ray photoelectron spectroscopy, $La_{1-x}Ca_xCoO_3$, LCC, Cathode, Thin Films.

**Acknowledgment:** We gratefully acknowledge Mr. Ahmet Nazım for his help operating the SEM and Gebze Technical University for financially supporting this study by 2018-A105-54 project.

**Refererence**

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# POSTER SESSIONS

## Id-018

### Sn-C Nanocomposites Synthesized by Arc-Discharge Method for Anode Material of Li-Ion Batteries

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**Abstract:** Due to the growth of the portable electronic devices production, interest in Li-ion batteries is increasing. In modern commercial batteries, an anode is made of graphite, which theoretically gives a maximum capacity of 372 mAh/g. The use of tin makes it possible to achieve a greater capacity value: the theoretical maximum capacity is 994 mAh/g. However, the processes of intercalation of lithium ions into the tin material are accompanied by the volume expansion of the anode material, which leads to instability of the solid electrolyte interface layer and the destruction of the anode. An usage of nanoscale tin structures held by a stable matrix helps solve this problem. Moreover, in comparison with bulk tin, the nanoscale tin material has a more expanded surface and shorter diffusion paths for lithium ions, which significantly improves the characteristics of Li-ion batteries.

Composite Sn-C nanomaterials were synthesized by an electric arc sputtering of graphite-tin electrodes. The materials consist of Sn nanoparticles packed in a carbon matrix. Tin nanoparticles have a round shape. The average size of the nanoparticles depends on the synthesis conditions and varies in the range from 7 to 30 nm. The materials showed specific capacity iof 1800 mAh/g at the 1st cycle, 800 mAh/g at the 2nd cycle and nearly 600 mAh/g after 120 cycles. That indicates high efficiently and stability of the synthesized materials.

**Keywords:** Li-ion battery, tin, carbon, nanoparticles, arc-discharge synthesis

# POSTER SESSIONS

## Id-023

## Wastewater Treatment: Overview, Types, Energy Consumption & Actual State in Lebanon with Proposal of Using Renewable Energy

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**Abstract:** This paper provides an overview of Wastewater Treatment issue in Lebanon, past, present, and Future. The paper briefs the status of wastewater types adopted in the general study adopted by Lebanese Government to cover the country at the level of design and implementation along with the relevant energy consumption. Accordingly, we shall consider that paper as a recapitulation on exerted efforts by both Government and Council of Development and Reconstruction (CDR) to reach reliable and sustainable wastewater network and wastewater treatment plants. The perspective that we intend as a conclusion is the potential of renewable energy exploitation and treated wastewater reuse assisting the path of autonomy of WWTP's and improvement of the energy management in wastewater treatment based on the integration of renewable energy and biogas.

**Keywords:** Wastewater, wastewater treatment types, renewable energy, energy, lebanon wwtp's, wwtp's management

# POSTER SESSIONS

## Id-027

## Nitrogen-Doped Carbon as Supporting Material for Gold-Metal Nanoparticle Electrocatalysts for Borohydride Oxidation and Oxygen Reduction

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**Abstract:** The development of novel anode and cathode catalyst materials is the main object of research for fuel cell industry. This study is focused on the fabrication of the nitrogen-doped carbon supported Au-M (M = Co, Ni, Cu) catalysts using a rapid microwave heating method. The synthesized catalysts have been characterized using Transmission Electron Microscopy (TEM), Raman Spectroscopy, X-ray Photoelectron Spectroscopy (XPS) and Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES). The electrocatalytic activity of the prepared nitrogen-doped carbon supported Au-Co, Au-Ni and Au-Cu nanoparticle catalysts for sodium borohydride oxidation and oxygen reduction reaction was evaluated using cyclic voltammetry, chrono-techniques and the rotating disk electrode (RDE) method. The data on the oxidation of sodium borohydride and oxygen reduction reaction on the nitrogen-doped carbon supported Au-Co, Au-Ni and Au-Cu nanoparticle catalysts under various conditions are compared and discussed based on electrochemical data.

**Keywords:** Nitrogen-doped carbon materials, borohydride oxidation, oxygen reduction, fuel cells

**Acknowledgements:** This research was funded by a grant (M-ERA.NET-1/2016) from the Research Council of Lithuania. The author's research was performed in cooperation with the University of Tartu (Estonia), Latvian State Institute of Wood Chemistry (Latvia) and Horizon Pulp&Paper Ltd (Estonia) under the M-ERA.NET 2 project "Wood-based Carbon Catalysts for Low-temperature Fuel Cells (WoBaCat)" (reg. No. project3213).

# POSTER SESSIONS

## Id-035

## Gold Nanoparticles Modified Zinc-Cobalt Coatings as Catalysts for Hydrazine Electro-Oxidation

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**Abstract:** Fuel cells are widely considered as sustainable energy conversion devices, furthermore, low-temperature ones are undergoing rapid development for mobile applications and in particular for the transport sector. The design and development of efficient and low-cost catalysts are significantly vital. In this study, the ZnCo coatings modified with gold nanoparticles (AuNPs) were prepared via a facile electrochemical deposition technique followed by a simple and low-cost galvanic displacement with the aim to use them as electrocatalysts in direct hydrazine fuel cells (DHFCs). The electrocatalytic activity of the ZnCo coatings modified with different amount of AuNPs towards the electro-oxidation of hydrazine in an alkaline medium has been investigated using cyclic voltammetry. Field Emission Scanning Electron Microscopy, Energy Dispersive X-ray Analysis and Inductively Coupled Plasma Optical Emission Spectroscopy were used for the characterization of the surface morphology, structure and composition of the prepared catalysts.

It was found that the ZnCo coatings modified with AuNPs have significantly higher catalytic activity towards the electro-oxidation of hydrazine as compared to that of the bare ZnCo coating. Moreover, modification of the ZnCo coating with AuNPs leads to the rather pronounced shift in the hydrazine electro-oxidation potential to more negative potential region and is followed by a tremendous increase in the direct hydrazine oxidation rate as compared to that of the unmodified ZnCo coating. AuNPs modified ZnCo coatings seems to be an efficient anode catalyst for DHFCs.

**Keywords:** Gold, zinc, cobalt, hydrazine, electro-oxidation

# POSTER SESSIONS

## Id-051

### Modelling Properties of Alkaline Electrolyser

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**Abstract:** Hydrogen is used more and more often in systems of production and storage of electrical energy. To product hydrogen, among other things alkaline electrolysers can be used. These devices are improved all the time, and the aim of designers is to obtain high performance of the process of production of hydrogen and high efficiency of transformation of electrical energy into hydrogen. Not only construction of this electrolyser has essential meaning, but also the system feeding this electrolyser.

In the process of designing of technical devices computer modelling is universally used. In the literature one can find many models describing properties of electrolysers, but typically they are dedicated to descriptions of properties of these devices operating at the power supply from the source of dc voltage. Meanwhile, as it was shown among other things in the authors' previous papers, while power supplying the electrolyser with a rectangular pulses train of regulated frequency it is possible to optimise its productivity or efficiency by selecting frequency of feeding impulses. Unfortunately, models of electrolysers presented in the literature do not take into account such factors as concentration of KOH solution in the electrolyser and nonlinearities of phenomena occurring in this electrolyser at changes of the value of current of the power supply.

In the paper an improved version of the model of the alkaline electrolyser in the form of an electronic subcircuit dedicated for the SPICE software containing controlled voltage and current sources, resistors, inductors and capacitors is presented. This model takes into account dc and dynamic properties of the electrolyser and nonlinearity of dependence of current feeding this electrolyser on a voltage drop on this device. By means of the worked out model one can compute electric characteristics of current-voltage of the electrolyser for selected values of concentration of water solution of KOH contained in the electrolyser. Additionally, it is possible to compute speed of production of hydrogen at given conditions of the power supply of the electrolyser.

In particular sections of the paper the form of the worked out model of the electrolyser will be presented. Moreover, the results of experimental verification of correctness of this model for the selected electrolyser operating over a wide range of changes of the value of current of the power supply and concentration of water solution of KOH in the electrolyser will be shown. Some results of computer analyses illustrating influence of frequency, amplitude and the duty cycle of voltage feeding the electrolyser on the speed of production of hydrogen and on efficiency of this process will be presented and discussed. Selected results of calculations will be compared with the results of measurements. The detailed discussion of the obtained results of analyses and measurements will be performed and some recommendations for constructors of circuits feeding electrolysers will be formulated.

**Keywords:** Hydrogen generation, alkaline electrolyser, modelling, spice

# POSTER SESSIONS

## Id-052

### Modelling Solar Cells Operating at Waste Light

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**Abstract:** Solar cells are basic components of photovoltaic installations which belongs to ecological sources of electrical energy. These cells produce electrical energy using light-radiation falling on their surface. Typically, this is solar radiation, but light originated from artificial light sources can also be used. Of course, energy which can be obtained using waste-light is considerably smaller than energy obtained from solar radiation, but it can be sufficient to power supply different kinds of sensors or controlling devices.

Waste-light can originate from different artificial light sources, which are characterised with different spectral characteristics. Spectral characteristics of light sources can visibly differ from spectral characteristics of solar cells sensitivity. Also the spectrum of daylight can change depending on the time of the day, season and weather conditions. Meanwhile, well-known from the literature models of solar cells do not take into account influence of spectral characteristics of the light source on properties of solar cells.

In the paper a new model of solar cells dedicated for the SPICE software is presented. This model takes into account influence of properties of the light source which irradiates the investigated solar cells on characteristics of this cell. The worked out model has the form of a subcircuit containing controlled current sources, resistors and controlled voltage sources.

In particular sections of the paper spectral characteristics of selected light sources and characteristics of spectral sensitivity of silicon solar cells, measured by the authors, are presented. The form of the worked out model is described in detail and the results of experimental verification of correctness of this model while irradiating the investigated solar cells with daylight, with a bulb, with a halogenous lamp, with a fluorescent lamp and LED lamps are presented. Essential influence of the applied light sources on characteristics of solar cells is shown. It is also shown that the new model assures good agreement of the results of computations and measurements. A possibility of practical application of the waste-light to the power supply of electronic devices by means of solar cells is discussed.

**Keywords:** Solar cells, waste light, modelling, SPICE

# POSTER SESSIONS

## Id-074

## Regulations of Application of Energy Efficiency in Industrial Processes

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**Abstract.** Sources on our planet are limited. Their regeneration is much smaller than its consumption rate. The idea that the existing resources do not belong to our generation only is the base of sustainability doctrine. Efficient consumption of these sources must be a strategic target.

The industry is a significant user of energy where efficient consumption will save a notable percentage of it. Scientific progressions put at the disposition of the sector many technologies that can assure a high potential of energy saving where their application leads to build an energy consumption scale. The aim of this paper is the development of a legislative, technical and hierarchical frame of regulations of energy consumption.

**Keywords:** Energy efficiency, Regulations, Articles, Energy Accreditation body

# POSTER SESSIONS

## Id-076

## Smart System Based on *Silicon* Carbide Semiconductor for Sensitive Detection of Combustible Gas Leakage for Safety Applications

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**Abstract:** Detection and control of fuel leakages for aerospace propulsion systems, clean energy technologies and for automotive technologies requires hydrogen gas sensors that can operate in harsh environments. Consequently, the development of reliable devices is necessary and represents a present concern. Critical requirements must be met: on one hand to ensure high sensitivity for hydrogen leakage monitoring, and on the other hand to operate at high temperatures.

For high temperature sensing applications, metal/oxide/semiconductor (MOS) devices based on Silicon Carbide (SiC) show great promise, particularly above 150 ºC, which represents an upper bound for MOS devices based on Silicon (Si) semiconductor. Metal-oxide-silicon carbide devices have been used in the last twenty years for gas sensing. Silicon carbide (SiC) is a semiconductor with remarkable properties, such as wide band gap, low dielectric constant, high breakdown voltage, chemical stability in reactive environments.

This paper presents an investigation of a smart system based on *silicon* carbide technology used as hydrogen gas sensor in harsh environments as: corrosive medium, high temperature, high radiation. The palladium/silicon oxide/silicon carbide (Pd/$SiO_2$/SiC) sensor was fabricated using microelectronics technology. The semiconductor used was 4H-SiC wafer, with two epitaxial layers: a buffer layer with a thickness of 0.5 µm and an active doped layer ($N_D$=2.07x$10^{16}$ $cm^{-3}$) with a thickness of 8 µm.

The detection performance of the studied system based on Pd (50nm)/$SiO_2$(30nm)/SiC was investigated for concentrations between 0 ppm to 2000 ppm $H_2$ in Ar. The C-V characteristic shifts to smaller voltages with the increase of the gas concentration. This shift of the C-V curve on the voltage axis is proportional with hydrogen atoms adsorption by the metal thin film and the oxide layer and the changing of positive charges in oxide layer and the metal-oxide interface. The flat band voltage reaches a -4.05 V shift at 2000 ppm $H_2$. The electrical performance is correlated with the quality of the palladium thin film, which shows smooth and porous surface, with medium grain size of 30 nm. The sensitivity of Pd/$SiO_2$/SiC structure as sensor is very good for lower concentration of hydrogen (under 200 ppm $H_2$). This increased sensitivity at lower concentration of hydrogen make the sensor suitable for detection of $H_2$ leakages and the prevention of the accidents in aerospace propulsion systems and clean energy technologies.

**Keywords:** Silicon carbide; thin films; hydrogen sensor; MOS structure; palladium

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# POSTER SESSIONS

## Id-078

### Investigation of Boron Diffusion for p+ Emitter Formation on n-Type Silicon

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**Abstract:** This work reports on boron diffusion processes for emitter formation on the front side of n-type mono crystalline silicon based solar cells. Diffusion processes are carried out in a tube furnace using preform source as boron dopant source. Three parameters are varied in this study: drive-in temperature, drive-in duration and temperature ramp-up rate. It is found that sheet resistance measured by four point probe (4pp) decreases from 93 Ohm/sq to 24 Ohm/sq as drive-in temperature increases from 850°C to 950°C, it decreases also from 57 Ohm/sq to 38 Ohm/sq as drive-in duration increases from 20 min to 40 min. Active boron dopant profiles measured by electrochemical capacitance voltage (ecv) exhibit surface concentrations below the solid-solubility limit of boron in silicon for all the studied emitters, the maximum surface concentration of $1.3x10^{20}$ atm./$cm^3$ is reported on emitter formed at 950°C. The Hall Effect measurement method is used for measuring sheet resistance and sheet carrier concentration.

**Keywords:** Preform source, boron diffusion, boron dopant profile, n-type silicon, solar cells

# POSTER SESSIONS

## Id-122

## Comparative Study of an HVAC System Using Geothermal Energy and Other Technologies: Biomass, Diesel and Gas. Case of Study in an Office Building

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**Abstract:** This paper presents an economic and energy analysis between a ground-coupled heat pump system and other available technologies as natural gas, biomass and diesel, providing heating, ventilating and air conditioning to an office building. All the proposed systems are capable of reaching temperatures of 22ºC / 25ºC in heating and cooling mode. Energy Plus software was used to develop a simulation model and carry out the validation process. The first objective of the paper is the validation of the numerical model developed in *EnergyPlus* with the experimental results collected from the monitored building to evaluate the system in other operating conditions and compare with other available technologies. The second aim of the study is the assessment of the position of the low enthalpy geothermal system proposed versus the rest of systems, from energy, economic and environmental aspects. The annual heating and cooling COPsys of the GCHP showed is higher than the others besides. The economic results determined a period between 6 and 9 years in the GCHP system proposed to have lower economic cost than the rest of systems. The results obtained determine that GCHP proposed system can satisfy the thermal demand in heating and cooling conditions, with optimal environmental values and economically viable.

**Keywords:** Low enthalpy geothermal system, renewable energy, simulation models, energy analysis, economic feasibility

# POSTER SESSIONS

## Id-124

## Al-Cu Alloy as a Latent Heat Storage Material for High-Temperature Heat Utilization

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**Abstract:** Phase change material (PCM) is promising thermal energy storage material for efficient use of energy. A latent heat storage system using a metal-based PCM with a high melting temperature is expected for an exhaust heat recovery process and a solar thermal power plant, an encapsulation technology for the metallic PCM has not been achieved because of its high corrosivity. In this research, we aimed to develop the microencapsulation technology of Al-Cu alloy as a PCM.

**Keywords:** Phase change material, latent heat, heat recovery, solar energy

**Reference**

[1]. Nomura T, Zhu C, Sheng N, Saito G, Akiyama T. Scientific Reports (2015)
[2]. Nomura T, Sheng N, Zhu C, Saito G, Hanzaki D, Hiraki T, Akiyama T. Applied Energy (2017)

# POSTER SESSIONS

## Id-149

## Preference Profile Decomposition When Processing Energy Audit Data by Preference Aggregation Method

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**Abstract:** Resource conservation is an important factor in maintaining stability of society. An effective resource saving is ensured by systematic energy audits. Traditionally, energy audit outcomes analysis is a work with a large amount of unstructured data that is difficult to fully take into account. The paper aims to improve a technique based on preference aggregation, which allows to process a big data from instrumental examinations of energy losses by substations of electrical energy distribution networks. The results of the developed method application to real energy audit data have shown, that the decomposition of the preference profile does not lead to a significant change in the outcomes of the energy audit data processing. This means that the decomposition is allowable and justified way of reducing the preference profile dimension when it is necessary.

**Keywords:** Decomposition; energy audit, data analysis, preference aggregation

# POSTER SESSIONS

## Id-151

### Metallic Phase Change Material For Low-Temperature Thermal Management

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**Abstract:** Introduction; recently the importance of thermal management for Li-ion batteries has been increasing because of wide-spread of smartphones and electric vehicles. Operating temperature of Li-ion batteries needs to be maintained at safety range (i.e. -10°C to 50°C). In various kinds of thermal management technologies, latent heat storage technology using Ga PCM (Phase Change Material) is promising due to its ideal melting temperature (29.8°C), high heat capacity, and high thermal conductivity. However, for practical applications, micro-encapsulation of Ga is strongly needed since Ga is high-corrosive to other materials. Therefore, the purpose of this research is to develop Ga micro-encapsulated PCM (MEPCM) for advanced thermal management under low-temperature conditions.

2. Experimental; ga ingot（99.99%、Kojundo Chemical Laboratory）was used as a raw material. The procedure for producing Ga-MEPCM consists of three steps. Firstly, Ga was added to distilled water and atomized by stirring at 16000 rpm for 30 min at 40°C. Then, the prepared Ga particles were put in boiling distilled water and stirred for 3 h for chemical conversion treatment. Finally, the sample after chemical conversion treatment was oxidized in O2 atmosphere for 3 h.

3. Results; the SEM image of the Ga-MEPCM showed Particles which have rod-like crystals on the surface. In addition, EDS elemental mapping from the cross-section of the MEPCM detected both Ga and O on the shell of the MEPCM and only Ga on the core of MEPCM. As the results of XRD analysis of MEPCM, Ga2O3 were detected as well as Ga; these results prove that a Ga2O3 shell has been successfully synthesized on the Ga core. The DSC analysis showed that MEPCM has the latent heat of 46 J/g, which maintained almost half of the latent heat of pure Ga. Besides, the supercooling of the MEPCM was reduced compared to the sample only after chemical conversion treatment.

**Keywords:** Gallium, PCM, low temperature thermal management, micro-encapsulation, lithium ion battery

# POSTER SESSIONS

## Id-152

## Possibility of Bioethanol as Reducing Agent for Ironmaking Process: Exergy and $CO_2$ Emission Analysis

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**Abstract:** Introduction; ironmaking, especially the blast furnace route, recently faces three major issues related to the depletion of coking (high-grade) coal and high-grade ore, as well as the large emission of $CO_2$ and high consumption of energy. Advance modifications in the conventional method are necessary to solve those problems simultaneously. In the previous study, we proposed a new approach in ironmaking called ethanol-assisted ironmaking using low-grade iron ore [1]. Applying bioethanol as a high-exergetic reducing agent to ironmaking is promising in lowering reduction temperature. Moreover, it is counted as carbon-neutral based fuel as produced from biomass, contributing more benefits in environmental aspect. However, process system evaluation like exergy and $CO_2$ emission reduction analysis is needed to explore its contributing benefits.

Methods; the process flow diagram of the ethanol-assisted ironmaking was developed using Aspen Plus consisting: (1) porous ore production from goethite ore mild-dehydration, (2) porous ore reduction by ethanol, (3) hot metal – slag separation, and (4) ethanol recovery from the off-gases. Exergy analysis and $CO_2$ emission reduction were predicted by using mass and energy balance obtained from the simulation results. Some properties related to simultaneous ethanol decomposition and iron oxide reduction reaction were analyzed in the previous fundamental experiments reacting ethanol with low-grade iron ore. The proposed process was then compared to the conventional blast-furnace-route ironmaking.

Results; ethanol decomposes to mainly $H_2$, CO, and deposited-C, which then reduce the iron oxide. Iron reduction by $H_2$ significantly contributes to lowering the reduction temperature. While emitting $H_2O$, it is counted as carbonless reduction, resulting in the significant lower $CO_2$ emission on ethanol-assisted ironmaking. Moreover, $CO_2$ released from ethanol recovery can be counted as carbon-free. However, additional carbonaceous fuel (i.e., coal) is required to supply heat through combustion. As a conclusion, in the overall evaluation, ethanol-assisted ironmaking has 52% of exergy efficiency and 70% of carbon-free emission compared to the conventional blast furnace using coal-based coke as a reducing agent. From the thermodynamic viewpoints, ethanol-assisted ironmaking is an attractive method to solve problem-related resource, environment, and energy in future ironmaking industry.

**Keywords:** Ironmaking, ethanol, low-grade iron ore, exergy analysis, $CO_2$ emission

**Reference:**

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# POSTER SESSIONS

## Id-155

## Polyelectrolytes Application for Water Flooding of Low-Permeable and Hetero-Permeable Oil Reservoirs for Intense Oil Recovery

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**Abstract:** Waterflooding of oil reservoirs with different permeability (heterogeneity) causes non-uniform displacement front and low efficiency of water flooding. This problem for oil recovery is solved by injection of surfactants, polymers, gels and solutions called “smart water”. The main challenge is increasing of water permeability for the low-permeable interlayers with practically unchanged permeability of high-permeable intervals.

The recent work present a novel chemicals – organic polyelectrolytes for this purpose. The chemical composition of organic polyelectrolytes with low molecular salt additives was developed and tested. The strong influence of the composition shows the change in phase permeability in low-permeability formations (less than 100 mD). After injection of polyelectrolyte solutions into core model, an increase in the phase permeability for water was indicated by the significant pressure drop.

The explanation of this effect is the following. The hydrophilic surface of silicon porous media contains both adsorbed water and gravity water near the surface. The adsorbed water increases the capillary pressure. The low molecular salt together with polymer molecules provides transport of cations to the surface of the porous medium. That reduces hydrophilic stress at the surface and capillary pressure in order to create a movement of bound water in the capillary. The considered solutions also have only chemical adsorption mechanism with silicon surface that leads to low waste of reagents.

Thus our investigation of water soluble composition of organic polyelectrolytes provide one with an effective technology with can be applied before water injection into oil wells and gives a number of advantages. Previously undrained reserves in low-permeability interlayers are involved in the development. Reserves drained in highly permeable interlayers continue to participate in the development. The solvent penetrates a long distance in the reservoir with low rate of adsorption. The other advantage is that these solutions are rather cheap because of high degree of dilution.

The implementation of the technology at low-permeable oilfields has shown a perfect effect for 20 oilfields and only one fails of the technology cause by some external factors. The chemicals injection increases the further water injection rate dramatically. It reached more than 200% growth at the waterflooding pattern at the mentioned oilfield. Both lab experiments and field tests show stable effect that does not fade with time.

**Keywords:** Oil recovery factor, waterflooding, low-permeability, smart water, polyelectrolytes

# POSTER SESSIONS

## Id-160

## Synthesis and Investigation of the Electrochemical Properties of β-$Ni(OH)_2$-Doped Al, Co and Cu, and α- $Ni(OH)_2$ Powders for Ni-based Battery

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**Abstract:** In recent times, the requirement of energy has become into existence increasingly an important topic because of demands in the world. Thus, the synthesis of nickel hydroxide ($Ni(OH)_2$) as a cathode material gain importance for researchers. Nickel hydroxide, because of its good electrochemical properties [1], is an important positive electrode material used in the batteries such as Li-ion, and Ni-MH [2]. This cathode material has two different form; one is alpha-$Ni(OH)_2$ and the other is beta-$Ni(OH)_2$ [3]. In this study, nickel hydroxide was synthesized by using urea decomposition method. 0.1 mole $Ni(NO_3)_2.6H_2O$ and 0.25 mole urea ($CH_4N_2O$) were dissolved in distilled water and stirred for 10h at 95°C. After aging in alkaline media, formed $Ni(OH)_2$ was filtered and washed with hot distilled water, and then dried at 80°C in the oven. We doped $Ni(OH)_2$ with different metal such as Co, Al, Cu. The study was investigated by comparing beta-$Ni(OH)_2$ (aged form) and alpha-$Ni(OH)_2$ as to electrochemical performance, specific capacity, and good stability. Here, all electrochemical properties were measured by using cyclic voltammetry (CV). Synthesized materials were characterized by SEM, XRD, BET.

**Keywords:** capacity, battery, stability, electrochemical property, energy

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# POSTER SESSIONS

## Id-165

## The Microstructure Of $U_3Si_2$-Al Dispersed Fuel After Irradiated In HFETR

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**Abstract:** Thermal/mechanical properties of the fuels are dominantly affected by the fission pores produced from fuel particles during irradiation. In this paper, the effect of $U_3Si_2$-Al dispersed fuel,which were irradiated in HFETR for more than 200 days, were studied using the optical microscope (OM), scanning electron microscopy (SEM) and energy dispersive spectrometer (EDS). The microstructure of $U_3Si_2$ was observed,the instrument of SEM was shielded by iron cell.Additionally, the morphology, size and distribution of pores of $U_3Si_2$ ,thickness and component of Interaction layer were analyzed statistically. The results show that when the fission density increases from 2.34×1027 f/m3 to 3.74×1027 f/m3, the gas morphology in the U3Si2 fuel particles is globular and without great change. However, the average pore size and porosity caused by the fission pores increase with the fission density, which go through two stages: when the fission density of the fuel particles increases from 2.34×1027 f/m3 to 3.19×1027 f/m3, the average pore size and porosity are with steady-state growth; when the fission density of the fuel particles increases from 3.19×1027 ~ 3.74×1027 f/m3, the average pore size and porosity increase rapidly. the thickness of the IL was increased from 1.8um to 3.7 um with the the fission density of the fuel particles increases from 2.34×1027 f/m3 to 3.74×1027 f/m3. the component of IL can be described by U(Si+Al)x, in which the value of x is increased from 4.1 to 6.2

**Keywords:** dispersed fuel, microstucture, irradiated, porosity, interaction layer

# POSTER SESSIONS

## Id-168

### Thermo-Gas-Chemical Treatment of Well Bottom-Hole Zone By Water Solutions of Binary Mixes

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**Abstract:** The viscous oil deposits have a common problem with bottom-hole zone, which need some additional heating for the oil viscosity reduction and oil recovery start. This problem is usually solved by steam injection into the reservoir. But efficiency of steam injection is gradually decreasing with reservoir depth. This happens due to heat losses during steam injection through the walls of the well. Decision of this problem is the generation of steam (or heat release) directly in the well bottom-hole zone or in a porous media of the reservoir.

There are several decisions of this problem, one is thermo-gas-chemical treatment of well bottom-hole zone by water solutions of binary mixes containing ammonium nitrate and sodium nitrite as two component reagents which start reaction with when initiator is entered or with temperature growth. The result of laboratory tests of kinetic experiments, measure of heat release and two-step reaction modeling has shown a significant temperature and pressure growth in reservoir conditions, at different temperatures and solution concentrations.

Field application of this technology has shown rapid growth of temperature about 20 $^0$C, pressure peak about 5 MPa (maximum 20 MPa) and further oil recovery stabilization and even growth for about 10%. The treatment was successfully done at 3 wellbores of carbonate heavy oil reservoir. The experimental results with binary solutions at explosive concentrations has confirmed the possibility of reaction self-stimulation in pore media and pressure pulse generation is capable for creating a fracture network in a formation. Local fracturing was also observed at the oilfield after the technology application.

The results of the study show that binary aqueous mixtures can actively react as in a borehole volume, as in pore volume at reservoir conditions. They can act as addition heating and also as addition fracture formation mechanisms. Both of these effects under control by chemical's concentrations are of great importance for heavy oil recovery from deep or low permeable reservoirs.

**Keywords:** Heavy oil, binary mixes, fracturing, ammonium nitrate, sodium nitrit, initiation

# POSTER SESSIONS

## Id-169

## Improvement of Coal Utilization Efficiency through Tar Utilization as a Reducing Agent in Ironmaking Process

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**Abstract:** Introduction; in recent years, the iron and steel industry face a problem with the degradation of coal. To solve the problem, we focused on the improvement of coal utilization efficiency via byproduct carbon source utilization as a reduction agent in the ironmaking process. We have already reported that a combination of the byproduct coal-tar and porous hematite ($Fe_2O_3$) ore obtained from goethite (FeOOH) based low-grade iron ore can produce an attractive carbon-infiltrated/covered ore [1]. We have also revealed that the carbon-infiltrated/covered ore can be rapidly reduced in an oxygen atmosphere [1]. In this study, further experiments were conducted to know the optimum preparation and reduction conditions for the carbon-infiltrated/covered ore. Also, the system evaluation was conducted on the proposed ironmaking process to compare with the conventional one.

Experimental; goethite (FeOOH) based iron ore was firstly crushed into different particle sizes. Nanoporous hematite ($Fe_2O_3$) ore was produced from the goethite ore by mild-calcination at 300$^o$C via the dehydration reaction ($2FeOOH \rightarrow Fe_2O_3 + H_2O$). The porous hematite ore was then mixed with tar solution which was prepared from coal-tar and toluene. They were heated at 300-500$^o$C in an argon atmosphere to get carbon-infiltrated/covered ore. The carbon-infiltrated/covered ore was reduced by rapid heating experiment in an oxygen atmosphere. The phase composition of the ore was evaluated by XRD, as well as cross-sectional observation was conducted by SEM. The pore structure of the ore was analyzed through nitrogen adsorption/desorption measurements.

Results; higher amounts of coal-tar usage and lower tar-carbonization temperatures increase the deposited carbon content in the ore. Cross-sectional SEM-EDS image confirmed that the thickness of the carbon layer on the ore increase in the higher carbon contents. $N_2$ adsorption/desorption measurements revealed that the carbon content in the interior of the ore-pores also increases causing an improvement in the contact area between ore and carbon through the pores, contributing in a higher reduction degree. Ore particle size also affects the reduction degree in which the larger ore particle size was, the higher reduction degree obtained. During the reduction experiments, the surface carbon layer is combusted by oxygen for supplying the required heat to promote reduction inside the ore. Simultaneously, however, the re-oxidation of the ore also occurs, lowering the reduction degree, significantly in case of smaller ore particle size. In addition to the experiments, we conducted system

analysis in view of exergy using ASPEN Plus to show the proposed system was energetically superior to the conventional one.

**Keywords:** Coal, tar, ironmaking, reduction, exergy

# POSTER SESSIONS

## Id-196

## Nanopatterning of Cr Thin Films Using Low Energy Ion Beam for Selective Solar Absorber Application

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**Abstract:** Nanopatterned chromium (Cr) solar absorber coatings were deposited onto glass substrate using MBE technique at room temperature. Subsequently, the prepared samples were sputtered at 50° , 60° and 70° angle of incidence using low energy Ar+ ion beam. XRD analysis confirmed that the as-g rown Cr films showed highly crystalline bcc Cr (110) orientation, whereas the sputtered films showed a decrease in intensity and widening of the peak, which is typical of materials with small grain size. RBS analysis confirmed that the thickness of the Cr films was monotonically decreased with increasing the s puttered angle, which is due to removal of particles from the surface using ion beam. AFM indicated th at uniform distribution of micropeaks and microgrooves with well-defined nanopattern structures were a chieved for Cr films sputtered at 70° angle of incidence. High solar absorptance of 0.94 in the solar spe ctrum region and low thermal emittance of 0.16 was achieved for the Cr film sputtered at 70°, which is due to appropriate ratios of mean height deviation and the autocorrelation distance to the wavelength a s indicated from AFM.

**Keywords:** Textured surface, solar absorber, morphology, optical properties

# POSTER SESSIONS

## Id-201

### Hydrogeological Disasters and Risks Prevention and Management

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**Abstract:** After many years of experience together with PIDE SRL (Electrade SPA), Research and Development Department in Hydroelectric field and Crisis Prevention, we have analyzed some causes of hydrogeological instability in case histories of realized and not yet realized plants to reduce to minimum the potential collateral effect, taking into account the adaptation and the restoration works of the rivers, with the introdution of a volumetric turbine that consists in preventive geological analysis and the management of major works wastes.

As Security and Coordination Planning, we have considered one of the most used texts in major works, such as D.P.R. N. 320 of 20 March 1956, “Emilia Romagna and Tuscany Interregional Annotations”.

As technological result PIDE SRL Research and Development Department has created a portable component composed by a shelter container 3 m long, 2.4 m large and 2.2. m high and no more than 3 ton heavy. Inside of it, there is a volumetric turbine with reverse lobes, an asyncronous generator, a BT/BT trasformer and an electric and automation panel.

The production portable component will work simultaneously with the other working or ready to work hydroelectric plants (or fluent riverbed plants), using a minimum amount of water of the plant and producing further energy that we can use also from the major plant.

The production portable component works inserting purified water inside through an automatic or manual bypass and at the same time an adjustable time softstart opens the main conduit valve.

The production portable component will have the purpose also to filter the water that go inside and outside from impurities and wastes.

Technical features:

• Net head: 115 mt

• Maximum flow rate: 1550 lt/s

• Average flow rate: 725 lt/s

• Power Med.: 817,40 kW

Approximately volumetric turbine performances will be:

• Flow rate: 20 lt/s

• Speed of rotation: 500 rpm

• Expected power: 12.40 kW

**Keywords:** Hydroelectricity, energy, renewable, turbine, innovation, crisis prevention, risk

# POSTER SESSIONS

## Id-202

### The Determinants of Renewable Energy Consumption Infrench Regions

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**Abstract:** Energy transition tends to be at the heart of political and scientific agendas. Indeed, France has made national commitments such as National Strategy of Ecological Transition towards Sustainable Development and the energy transition law for green growth. This transition is also a matter of recent global concerns, as evidenced by recent redefinitions of international (Kyoto Protocol) and European (EU Energy-Climate Package) energy policies. However, this transition is carried out according to different rhythms and temporalities according to the territories; it therefore seems essential, as many studies have pointed out, (Bridge et al., 2013; Hansen and Coenen, 2014; Murphy, 2015), to pay more attention to territorial dynamics in order to better understand the diversity of energy policy configurations and trajectories.

In this context, we seek to study the factors that determine the regional consumption of renewable energies in France. We build an econometric model that explains the evolution of the share of renewable energy consumed at the regional level over the period 1990-2015 using a panel error correction model. Our sample is made up of the 22 metropolitan regions and the French overseas departments. Using panel data methods allows us to study simultaneously the dynamics and heterogeneity of regions.

The results of the unit root tests allow us to maintain the assumption that series are first-order integrated. The cointergration tests provide strong evidence that all panels are cointegrated. Like Apergis et al., (2010); we employ a panel cointegration and error correction model to infer the causal relationship. Short-term estimates indicate that there is a statistically significant positive relationship between the share of renewable energy consumption and its lags and between this variable and economic growth measured by the real GDP growth rate. The results also show that in the short term, nuclear energy is an obstacle to the promotion of renewable energies. In the long term, the results show that a positive shock on economic growth positively affects the consumption of renewable energy (Sadorsky (2009b), Marques et al (2010), Apergis and Payne (2011), Apergis and Danuletiu (2014)). Contrary to the results stated by Salim and Shafiei (2014), urbanization does not contribute in the long term to the growth of renewable energy consumption. Finally, on a regional scale, the weight of "green" parties positively influences the growth of renewable energy in the long term.

**Keywords:** Renewable energy, regional disparities, panel cointegration

# POSTER SESSIONS

## Id-213

## Design of a Solar Thermal Energy Accumulator Using PCM

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**Abstract:** The use of solar energy is recommended for the drying of agro-products due to its low cost and minimal environmental impact, using solar panels, although its availability is limited to the periods of the day when solar radiation is available. An option to continue the application of solar energy in the period of low or no solar radiation, is to accumulate thermal energy using phase change materials (PCM).

This paper presents a methodology to design an energy accumulator/exchanger to heat air, using solar energy, PCM and low-cost materials.

The proposed equipment uses aluminum cans from beverages, in which the PCM is contained. In order to increase the thermal conductivity of the PCM, 7.5% weight of aluminum sheets, also obtained from the cans, were added to the wax containers. The proposed exchanger, of rectangular section, considers a first stage in which it accumulates solar thermal energy in the PCM and then, in a second stage, delivers this energy to the drying air.

Using EXCEL spreadsheets, the energy requirement for a given application is determined through an energy balance in the air, which allows quantifying the mass of PCM required. Parameters determined in pilot equipment allow quantifying the rate of heat transfer to the air, average temperature of the outlet air, quantity of PCM, number of rows with the cans and the pressure drop in the exchanger. Once the exchanger is sized and using a polynomial expression of solar radiation as a function of time, it is possible to estimate the exposure time required to accumulate the necessary solar energy. Examples of some applications are included.

**Keywords:** solar energy, exchanger, PCM

**Acknowledgments:** The authors wish to thank the financial support of FONDECYT grant 1180028.

# POSTER SESSIONS

## Id-233

## Tungstates of the Type $Hf_{1-X}In_xW_2O_8$, (Ln = Eu, Tm, Lu) Studied by High Temperature X-Ray Diffraction

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**Abstract:** The data on the influence of different modifiers on the properties of cubic tungstates $ZrW_2O_8$ and $HfW_2O_8$ are rather incomplete but it has been found that small amounts of a modifying agent may influence their physical properties, such as the phase transition temperature, the coefficient of thermal expansion (CTE) [1]. The introduction of ions with different radius and charge can lead to a disorder in the crystalline structure of the tungstate and consequently to change their properties [2]. Recently it was proved by us that the modifying of $ZrW_2O_8$ with Eu(III) has an influence on the properties of the tungstate i.e. the unit cell parameters as well as the CTE decreased with Eu(III) content increasing [3]. In order to investigate the influence of Ln(III) on the properties of tungstates the work continued by using both Eu(III) and Tm(III) and Lu(III) ions for solid solutions formation on the base of $HfW_2O_8$. The hydrothermal method was applied to obtain the pure and Ln(III)-containing $HfW_2O_8$ samples. The amount of the Ln(III) ions in the range of 0.01- 0.15 mol with a step of 0.02 were used for $Hf_{1-x}Ln_xW_2O_8$. The samples obtained were phase homogeneous as shown by powder X-ray diffraction. The high temperature XRD was used to follow the temperature of the alpha-beta phase transition, as well as to observe the influence of the content of Ln(III) on the temperature of the transition and on the unit cell parameters of the samples.

**Keywords:** Tungstates, Lanthanoids, High temperature XRD

**Acknowledgements:** The financial support from the Bulgarian Fund for Scientific Investigations, Project DM 19/5 is acknowledged.

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# POSTER SESSIONS

## Id-250

## Boron-Oxygen Metastables Defects Degradation of Carrier Lifetime by Illumination In Cz and Multicrystalline p-Type Silicon Wafers

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**Abstract:** Light induced degradation (LID) of carrier lifetime and electrical performances were investigated in this study on Boron-doped silicon wafer and solar cells. Boron-doped P-type Silicon monocrystalline and multicrystalline wafers are used in this work. Measured Minority carrier lifetime before and after a prolonged illumination show a very fast degradation in the first few minutes and reach a complete degradation after four hours in Si-cm wafers and after 28 hours in Cz-Si one. The normalized effective density of the metastable Boron-Oxygen (BO) defects was calculated by means of the difference between the inverse of the measured lifetime before and after illumination and it is proportional to the boron concentration. Analysis of the lifetime minority vs. injection level □n using Shockley-Read-Hall theory shows that the prolonged illumination generate a deep BO defects Ec-Et=0.45 eV with a symmetry factor of cross-capture section k=□$_n$/□$_p$= 15. The obtained results show that the Cz-Si is more sensible to the electrical degradation properties under illumination than the Si-mc wafers and cells despite the higher boron concentration. The second phenomena related to the BO metastable defects saturation density $N^*_{tsat}$ is reached rapidly in the first 4 hours compared by the 28 hours in the Cz-Si samples. This can be explained by the predominance of the oxygen content in the creation of the $N^*_t$ concentration than the boron and the high density of the vacancy-sites in the Si-mc which accelerate the oxygen dimers ($O_{2i}$) diffusivity and their reaction with the substitutional boron atoms.

**Keywords:** Silicon, carrier lifetime, BO defects, Light-Induced-degradation, carrier recombination

# POSTER SESSIONS

## Id-251

## Design And Processing of $p^+/n/n^+$ Structure for n-Type Silicon Solar Cells

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**Abstract:** Solar cells based on *n*-type silicon (Si) have received growing attention over these last years. This is due to their higher efficiency potential compared to p-type silicon cells. In this study we designed, fabricated and tested a $p^+/n/p^+$ structure which constitute the basis and the main part of the n-type solar cells.

The process of fabrication is based on the co-diffusion of pre-deposited phosphorus (P) and boron (B). It consists of carrying out simultaneously in one single high temperature step the diffusion of both B and P of the $p^+$ emitter and $n^+$-BSF, respectively.

The first step is the pre-formation of the $n^+$-BSF using an optimized phosphorus pre-deposition process in a $POCl_3$ furnace system. The pre-deposition was carried out at 920°C for eight minutes. The process gas ratio $POCl_3/O_2$ was set at 1.

After depositing the silicon nitride film onto the wafers rear side as a diffusion barrier to protect them from being boron doped, the wafers underwent an alkaline bath to etch the phosphorus layer of the non-textured front side. Onto this latter we used a boron source paper sheets to create a $p^+$ emitter (preform source) simultaneously with $n^+$-BSF drive-in step. This co-diffusion process was carried out at 940°C for 30 minutes. The junction depths and surface concentrations of active dopants of the emitter and BSF were 0.45 µm – 1.17 E20 $cm^{-3}$ and 0.70µm – 2.93 E20 $cm^{-3}$, respectively. This $p^+/n/n^+$ structure was used to fabricate solar cells by passivating the emitter and screen printing the front and rear side metallic contacts.

An efficiency of 10.70 % was measured indicating that our non-optimized process and the resulting device were viable.

**Keywords:** n-type silicon, boron, phosphorus, solar cells

# POSTER SESSIONS

## Id-257

### Characterization of Solar Cells Used in First Algerian Satellite AlSat1

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**Abstract.** In this article we are about to exanimate the used double junction solar cells (DJSC) in the Algerian satellite AlSat 1. AlSat 1, an improved 90kg microsatellite, is the first Algerian national satellite for earth observation and disaster monitoring. It was designed and constructed by a group of British-Algerian engineers as a part of a collaborative program between Surrey Space Center (UK) and the Algerian National Space Agency ASAL (Algeria). Therefore, and for the reason to have a close look at the characterization of the used solar cells in the construction of this latter, we decided to test some cells under a sun illumination of about 1000W/m2 and investigate the results. Results of the tested cells are discussed and the compared to the those of the constructor.

**Keywords:** Double junction solar cell (DJSC), Microsatellite; AlSat 1, Surrey Space Center, Algerian Space Agency.

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