SEED conference

BOOK OF ABSTRACTS

4th International Conference on the Sustainable Energy and Environmental Development

October 13-15, 2021 | Krakow (Poland)

Institute of Sustainable Energy

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PREFACE

Nowadays the actions related to environmental protection and energy production have to be lead with respect to sustainability. The balance between environmental effects or energy resources has to be maintained. The topics of energy production and storage, simulations in modern energy systems, alternative and traditional fuel production, environmental causes of these actions, waste management, environmental policies, and many others were discussed during the 4th International Conference on the Sustainable Energy and Environmental Development (SEED2021 Conference) on October 13th-15th, 2021. The Conference was dedicated to Scientists from around the world representing academic institutes, research, and development institutes as well as the industrial fields from energy and environmental sectors. This book presents the abstracts of topics presented by the participants at the SEED2021 Conference.

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THE CONTENT

EXPERIMENTAL INVESTIGATION OF THE PROTOTYPICAL MICRO SCALE LINEAR CONCENTRATING SOLAR POWER COLLECTOR WITH PV CELLS

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Typical linear concentrating solar power collectors reflect sunlight with mirrors and focus it onto a linear receiver tube. Sun's energy heats the fluid, that flows inside the receiver and is used to heat a traditional power cycle that spins a turbine connected with a generator to produce electricity. This paper presents the experimental works carried out on the prototypical micro-scale solar concentrator equipped with solar cells located on the linear receiver tube. The main goal of these investigations was to determine the possibility of increasing solar cells efficiency by placing them in concentrated solar radiation. The first part of the paper describes the solar concentrator construction, resulting e.g. from the use of the Ray Tracing method for determining proper geometry. Then, front-contact and back-contact monocrystalline solar cells were tested. Obtained results showed, that it was possible to increase the efficiency of solar cells using concentrated sunlight compared to solar cells efficiency measured in direct sunlight. It was demonstrated that the use of solar radiation concentrators is justified in the case of solar installations and confirmed the potential of this solution soon. The necessity of proper cooling of cells used in such conditions was also confirmed.

APPLICATIONS OF ISOTOPIC TECHNIQUES FOR ENVIRONMENTAL RESEARCH

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The review of the applications of nuclear methods in environmental research related to the identification of sources of air pollution will be presented. The research relevant to the Baltic Sea region will be presented during the lecture. Stable isotope ratio and radiocarbon mass spectrometric methods are increasingly used to solve the problems of pollution source identification. Based on the property that the course of a chemical reaction depends not only on the chemical properties of the substances, but also on the isotopic "fingerprints", the primary sources of the substances involved in the reactions can be restored. Stable isotope ratio mass spectrometry can be useful when the materials in the mixture differ in the isotope ratio, e.g. biomass combustion products can be distinguished from fossil fuel combustion products. The combination of stable isotope methods with the radiocarbon measurements also reveal a good result in air quality studies. In order to better understand the origin of particles in the air, the research is related to the generation of particles of different sizes, determination of isotopic characteristics. Various biomass samples, brown and black carbon, fuels with different bioadditives are combusted in controlled experiments in order to create database for these constituents.

LEGITIMACY OF THE SEZO AM OPTICAL METER (WIRAN) USE FOR THE MEASUREMENTS OF PARTICULATE MATTER IN THE ATMOSPHERE

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Various methods are used to determine air quality in terms of PMx pollution. The most common is the manual gravimetric method, which consists in determining the mass of the particulate matter from the difference in the weight of the filter before and after its exposure. A modification of this method is the automated gravimetric method, performed without the need to manually weigh the filters. Automatic methods based on the optical properties of PMx have also been widely used in recent years.

From March 1, 2021, comparative studies of PM2.5 and PM10 concentrations are carried out in Gdynia, on station belonging to the ARMAAG Foundation. For intercalibration, a device operating on the basis of non-reference methodologies and without proven equivalence to the reference methodology (SEZO AM, WIRAN) and EDM180 analyser (GRIMM) with certificates and approvals: US-EPA, UK-MCERTS, CN-CMA are used. The aim of the research is to estimate and later on eliminate the measurement error for PM2.5 and PM10 concentrations obtained for the SEZO AM device.

The SEZO AM method uses the phenomenon of light scattering by particles. The degree of scattering of the light beam is converted into an electrical signal, the intensity of which is determined by the size of the particles and their concentration. This method requires the use of complex mathematical algorithms, allowing for the expression of the final result in µg/m3. The SEZO AM enables direct transmission of results to the server in real time, as well as monitoring, eg. daily changes in the concentration of PMx in the air with high frequency.

Two-month measurements allowed us to state good agreement of the results obtained with both methods. The coefficient of determination obtained by the SEZO AM and EDM180 methods (after rejecting outliers, 10%) amounted to R2 = 0.90 (PM2.5) and R2 = 0.85 (PM10). Further research will be enriched with meteorological parameters in order to determine their influence on the method error.

Keywords: *PM10, PM2.5, intercalibration, WIRAN SEZO AM , GRIMM model EDM180*

AIR POLLUTION CAUSED BY FIRES AT WASTE STORAGE SITES: ANALYSIS OF SELECTED EPISODES IN POLAND

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The fires of stored waste may have a significant impact on the deterioration of air quality in a given area, which may implicate among others adverse health effects. In recent years there have been many fires at storage sites of flammable wastes in Poland. The impact on the air quality of waste fire episodes can be assessed using data derived from public air quality monitoring (AQM).

In this study the impact on air quality of selected waste fire episodes in Poland in the last few years was examined. The concentrations of air pollutants such as: particulate matter PM10 and PM2.5, nitrogen oxides (NOx), carbon monoxide (CO) and benzene (C6H6) were treated as characteristic substances of waste fires. The analysis was complemented with some meteorological data. Taking the wind direction into account enabled to assess whether the concentrations increase at particular station and in a given period might be related to the occurrence of the fire in the vicinity of the measurement point or coincidental. For the stations situated at a greater distance from the fire locations the forward trajectory modelling using Hysplit (Hybrid Single-Particle Lagrangian Integrated Trajectory) was conducted. In order to validate the obtained results, the study was reinforced by aerosol optical thickness (AOD) data analysis and the use of satellite imagery.

In the situations where the wind was blowing from the place of the fire occurrence to the AQM station, the significant concentration peaks of the analyzed substances were observed. The study showed that the fumes from large waste fires spread over a long distance, so that the increase in air pollutant concentrations can be recorded in AQM stations located further away from the fire site. In the layer of the atmosphere where the smoke is transported, its influence on the AOD data from satellite observations is also visible.

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WASTE FIRES – WASTE OF ENERGY, WASTE OF MATERIALS

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In 2018, there were 243 fires in waste management facilities in Poland, and in 2019, the number of waste fires amounted to 176. During the uncontrolled incineration of waste, the environment is significantly polluted through the emission of toxic substances to the air, water and soil, and various compounds are leached out of the combustion residues. In addition to the negative environmental aspects, waste fires cause enormous losses of materials, that could be recycled or recovered. Therefore the waste fires directly affect the depletion of natural resources. According to the waste hierarchy, if the recycling is not feasible, waste should be recovered, for example for energy generation purposes. Considering that fires burn waste with high calorific value, there is a loss of energy that could be obtained from waste in incineration plants or in cement plants fuelled by RDF (refuse derived fuel). In the paper detailed data on waste fires in recent years in Poland has been summarized, taking into account the location and size of fires, type of waste management facilities in which fires occurred. The paper also shows types of waste that were fired. Moreover the an estimation of amount of waste that was burned was done and thus their material and energy value was irretrievably lost

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HYDROTHERMAL CARBONIZATION CONVERTING SEWAGE SLUDGE INTO CARBONACEOUS BIOFUEL

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Sewage sludge is a type of waste which can present many difficulties because it contains not only organic and inorganic compounds or bacteria, but also dangerous compounds, e. g. heavy metals, hormones, pharmaceuticals, or pathogens. One innovative method of sewage sludge utilization and its conversion into a potential energy source is hydrothermal carbonization. This is the process of converting wet biomass into bio-oil, biogas, or hydrocarbons. Since there is no requirement for prior drying, this process works extremely well on sewage sludge. The resulting solid product (hydrochar) is structurally similar to natural lignite. It has a similar chemical composition and type of chemical bonds. The main aim of this study is to determine the potential for the production of a high carbon content fuel from sewage sludge using the hydrothermal carbonization method. In this study unfermented sewage sludge was used. The hydrothermal carbonization process was performed at temperatures of 200 and 220 °C and at 2 h of residence time. The effect of the selected process parameters on the properties of the resulting hydrochar for energy application was investigated using advanced instrumental methods. The results indicated that this process compacts the energy contained in the waste. Hydrochar has a calorific value higher than raw sewage sludge. The results depicted better energy properties in hydrochar than in raw sewage sludge (improved chemical composition, higher fixed carbon content and fuel ratio). This suggests the hydrothermal carbonization process is an efficient way to produce biocarbon. Additionally, the heavy metal transformation from raw sewage sludge to hydrochar and postprocessing water will be assessed.

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TECHNICAL AND ECONOMIC ASSESSMENT OF SELECTED HEATING SYSTEMS FOR A SINGLE-FAMILY BUILDING BASED ON LCC (LIFE CYCLE COST)

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The article presents a technical and economic analysis of the use of the most popular renewable energy systems for heating and preparing domestic hot water for a selected free-standing building residential. The analysis was carried out for selected variants of heating systems and compared with the selected ones conventional heat sources. For each of the systems, the investment and operating costs were determined and costs incurred over the entire life cycle of the product. Heat pumps are enjoying more and more interest of the owners of single-family houses. Around 40% of investors are considering the possibility use of the heat pump in your own home. The national and international energy policy forces investors to include renewable energy systems in their newly built house designs. At the same time, there is a great awareness of relatively higher costs at the investment stage in the case of heating systems with the use of heat pumps, with relatively lower operating costs of these systems. In view of the constantly rising cost of carriers energy, the ability to perform a technical and economic analysis use of heat pumps in construction in relation to conventional ones heat sources is of great practical importance that it translates directly into the costs of thermal energy for heating and domestic hot water. The basic criterion for selecting a specific system heating is an economic bill. Based on the detailed energy characteristics of the analyzed facility, the main parameters for the selection of the assumed heat sources were determined. At work the LCC (Life Cycle Cost) method was used. This method allows you to determine the estimated, total investment and operating costs of the system in the adopted cycle of its life.

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UNMANNED SOLAR POWERED PLANE – DEVELOPMENT AND APPLIED TECHNOLOGIES

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AGH Solar Plane is a student science club aiming at creating an unmanned aircraft powered by photovoltaic cells installed on both wings of the model. The energy obtained from sun during daytime flight is used to operate the engine and to charge lithium-ion battery packs used as a power source during nighttime flight making it able to work for the whole day under favourable conditions. The most important success factor is to achieve proper power, weight and structural strength of photovoltaic cells. Initial attempts to use a plastic laminate and attach the panels to the wings using acrylic tape proved unsuccessful due to aerodynamic drag and low structural strength. Newest method developed by the team involves fabricating wings from composite and integrating them with PV cells during lamination process to make them an integral part of wings, which significantly improves all key factors. Currently, new models are being created to test new technologies and enhance current ones. So far several models with different sizes and configurations have been created – amongst others the one with wingspan of 3.8m with 48 photovoltaic cells or a test model with wingspan of 1.5 m and 12 photovoltaic cells. Several more technologies are being developed, such as all the systems necessary to ensure full autonomy in energy management and tracking of the maximum power point of PV cells.

THE APPLICATION OF MODERN MATERIALS WITH SORPTION AND CATALYTIC PROPERTIES FOR MICRO-CONTAMINANTS REMOVAL

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In modern world the air-quality is one of top priorities in the environmental protection research and legislation. The BAT conclusions, EURO Emission Standards or recent EU Fit For 55 program implements severe retractations in case of the exhaust gasses emissions from heavy, automotive and other branches of the industry. Beside main pollutants such as solid particles, heavy metals or oxides of the carbon, nitrogen and sulphur the exhaust gasses from stationary and mobile sources contain micro-contaminants.

The micro-contaminants are a group of pollutants present in the exhaust in low concentration. This includes Polycyclic Aromatic Hydrocarbons, their nitric and oxygenated derivatives, inorganic ions, metals and metalloids from the combustion processes. Some of these compounds e.g. Sulphates cause acidic rain, degrading the quality of the soil, while others, especially Nitro-PAHs and Oxy-PAHs are even ten times more carcinogenic than benzo[a]pyrene. Due to immense volume of the exhaust gases produced every day even seemingly insignificant amount of the micro-contaminants is a serious concern

The increasing prices of the platinum group metals such as Pt, Pd and Rh commonly used in exhaust aftertreatment systems compel the researchers to focus on the alternative materials. There are several conditions that these materials should meet, such as reasonable price, environmental friendliness, high micro-contaminants reduction level, sufficient thermal resistance and mechanical strength. Studies show, that use of the metals such as Cu, Co, Fe, Ni or Mn improves oxidation of PAHs and their derivatives, thus it might be a valid solution for the micro-contaminants emission control. The work is to review the possibilities of application of new materials with sorption and catalytic properties for removal of microcontaminats generated in combustion processes.

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MICRO-SCALE BIOMASS FUELED RANKINE CYCLE HYBRIDIZED WITH WIND AND SOLAR ENERGY

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The proposed study deals with the investigation of a trigeneration system involving more than one energy source. The hybrid system adopts biomass, wind and solar energy to provide energy to the user. The motivation of the study consists in the rising interest about micro- and small-scale systems running using a combination of renewable energy sources and to the lack of literature studies dealing with systems like the one proposed here. In particular, the investigation concerns the performance and operation analysis of a novel trigeneration system based on a biomass fired steam cycle, wind turbine, photovoltaic panels and adsorption chiller.

In the proposed system, the thermal energy produced is used directly to cover thermal demand of the user during winter, and indirectly to match the cooling loads by means of an adsorption chiller. driving the adsorption unit during summer. The steam and wind turbine and the photovoltaic field electrical energy production is linked to a bidirectional connection with the electric grid, working also as a virtually storage. are considered The case study regards a zootechnical farm and a residential building.

The TRNSYS software is adopted to model and to carry out dynamic simulations of the proposed system. Through this software, the system operation and the energy and economic performance is investigated. The analysis of the results shows that the system achieves a primary energy saving beyond 70 % and its Simple Pay Back period is near 10 years in case of a reference system based on the use of natural gas, electrical chiller and grid. The system technical and energy performance is satisfactory, although the reference system that is adopted by the used has substantial impact on the economic profitability of the proposed system In case of absence of incentives.

TREATMENT OF MUNICIPAL WASTEWATER BY ELECTROCOAGULATION AND NATURAL ZEOLITE – INFLUENCE OF INITIAL pH VALUES

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Treatment of municipal wastewater prior to discharge into the environment is necessary to prevent pollution. In order to obtain satisfactory effluent quality, integration of two or more physical, chemical or biological process operations after primary treatment is needed. In this paper, the municipal wastewater is treated with electrocoagulation integrated with sorption on natural zeolite. Experiments are performed in an electrochemical cell with aluminium electrodes under conditions of I = 0.1 A, U = 29.9 V, with the addition of zeolite at the solid/liquid ratio of 20 g/l, and contact time of 60 min. The influence of initial pH values on removal efficiency has been investigated. The pH value, el. conductivity, temperature, turbidity, chemical oxygen demand (COD) and total Kjeldahl nitrogen (TKN) were used for the evaluation of removal efficiency. Results show that reductions in el. conductivity and COD are independent of adjustment of the initial pH values of wastewater. However, the initial pH of wastewater does have a significant influence on the reduction the turbidity and TKN. The increase in solution temperature is higher in acidic medium, which is connected with higher electrode consumption and operational cost. Results confirm that the initial pH of wastewater has a significant impact on municipal wastewater treatment by electrocoagulation integrated with zeolites.

Keywords: *municipal wastewater, integrated process treatment, electrocoagulation, natural zeolite*

STORAGE OF HYDROGEN AND/OR BIOGAS WITH HYDROGEN IN UNDERGROUND GAS STORAGES (UGS) -BENEFITS AND THREATS, PERIODIC MONITORING USING THE DEVELOPED TRAP METHOD

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For many years, Underground Gas Storage (UGS) Facilities have been used around the world to store various types of fuel. In the era of current technology, an idea has emerged to use the existing tanks to inject various types of high-energy mixtures, such as natural gas with hydrogen or pure hydrogen, intended to be obtained from alternative energy sources. One of the basic problems in the process of underground storage is to ensure the safe operation of these large-size facilities. Years of experience have shown that underground fuel storage in salt caverns is one of the safer types of reservoirs. Despite their size, do not interfere with the landscape and the natural environment, also thanks to the properties of salt rock formations, are geologically stable. Unfortunately, we cannot clearly rule out circumstances in which slight leaks of the Underground Gas Storage (UGS) may appear. The physical properties of the stored gases especially hydrogen, due to its lack of sorption properties and its high permeability, will migrate directly to the atmosphere without enriching the soil air in the surface layer. The proposed method of monitoring Underground Gas Storage (UGS), filled with a medium as an admixture of hydrogen or pure hydrogen, has been divided into two stages. The first of them is to determine the value of the gaseous background before gas injection. It is the so-called primary background, which determines the content of light hydrocarbons in the soil gas from soil samples, taken from the surface layers at a predetermined depth. The further part of the method consists in taking air samples from specially made and located at the sampling places to the primary background of gas traps, the so-called hydrogen traps, tested periodically in a systematized methodological manner. The data collected in this way and the use of the research method which is being developed, will allow to fully characterize the hazards and to monitor the exploitation deposit.

INFLUENCE OF VARIOUS AMOUNTS OF SUNFLOWER HUSK ASH ON TIRE CHAR GASIFICATION

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The dynamic development of the automotive industry along with the growing number of vehicles in use results in a large number of used tires, the responsible and effective management of which is still problematic. The use of tire waste in the pyrolysis technology is prospective; however, the management of solid residue from pyrolysis is still challenging. Considering the above, the aim of this study was to perform steam gasification measurements of char from used tires in the presence of 5, 10, and 15 wt.% of sunflower husk ash, added as a source of catalytic components. Measurements were made at three temperatures - 800, 900 and 1000 °C using the thermovolumetric method. On the basis of the performed measurements, the formation rates of main gaseous products (CO, H2, CH4, and CO2) were determined. Moreover, the effect of sunflower husk ash on tire char reactivity was analyzed using half-time conversion τ0.5 and rate constant k of conversion reaction, as well as resulting gas quality was designated based on CO/H2 ratio. Finally, kinetics parameters, i.e. activation energy and pre-exponential factor were calculated using grain model. Based on the obtained results, the catalytic effect of various amounts of sunflower husk ash on the gasification process was assessed, and the optimal temperature and amount of catalytic additive was selected, ensuring the most effective course of the process.

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VARIANT ANALYSIS OF RECEIVER GEOMETRIES DEDICATED TO THE PARABOLIC DISH CPVT

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Concentrated Photovoltaic-Thermal (CPVT) installations are one of the most efficient energy systems based on renewable energy sources, One of the available technologies uses parabolic dish mirror as an optical element, which collects the incident solar radiation and focuses it onto a relatively small receiver where photovoltaic cell is installed. Generally, the cogeneration efficiency of this system is determined by effectiveness of heat transfer from the PV cell to the working medium flowing through the internal channel of the receiver.

In this study a variant analysis of heat receiver geometries was conducted with usage of Computational Fluid Dynamics (CFD) methods. Obtained results indicated that the most beneficial shape of the receiver absorber is a flat one, due to the heterogeneous distribution of the radiation intensity on absorber surface, which provides a high rise of fluid temperature and also a high thermal efficiency. The heating rate of working medium in flat receivers depends mainly on the internal channel shape and flow parameters. The best thermal parameters were observed for receivers characterized by a low liquid-to-solid volume ratio, but with a relatively large liquid-solid contact area. Simultaneously, these geometries provided unfavourable conditions for photovoltaic cells operation. Based on these results it may be concluded that the geometry of two-stage receiver should be designed and tested to achieve the maximum production of heat and electricity at the same time.

THE COMPARATIVE ANALYSIS OF THE SHORT-TERM LIQUIFIED CO_2 STORAGE TECHNOLOGIES FOR THE PURPOSES OF THE FOOD INDUSTRY

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The food industry, i.e. the carbonated drink industry, needs the CO2 supply. According to the well-known and widely used practices, carbon dioxide is being produced in the gas engines (used for electricity and heat production). The CO2 is captured from the flue gases by the absorption process to be then cooled down and liquefied. These units consume a significant amount of electricity. In the following step, the liquefied carbon dioxide is stored. When the production line reports the CO2 demand, the external heat is used to make it gaseous again. The CO2 storage technology has to be applied in the system due to production fluctuations, which are not compatible with the demand. The paper presents a new approach to the technology, which can be called integrated CO2 management. In the developed technology, first, electricity is used to compress the carbon dioxide. Then the gas is cooled down by the cooling medium, which works in the cycle between the cooling stage and the evaporator. In the second step, the CO2 is cooled and partially liquefied by the expansion in a throttling valve due to the negative Joule-Thomson effect. After that, the liquid carbon dioxide is stored at the near-ambient pressure and the temperature of -80°C in an insulated tank. When the CO2 is needed, the liquid is pumped and heated up by the refrigerant, which cools down and is stored. The cooling cycle medium keeps the low temperature and can be used again to cool down the CO2 (gas) after the compression stage. The CO2, after being heated and evaporated, goes to the expander, in which gives the part of the energy, which can help to reduce the total energy expenditures of the storage. The proposed solution contributes to limit the energy expenditures of the short-term CO2 storage. To assess the technology, the mathematical model was created and applied to the Aspen Hysys numerical environment. Various operating conditions were considered to optimize the whole system operation efficiency.

AEROSOL SOURCE APPORTIONMENT USING STABLE SULFUR AND RADIOCARBON ISOTOPE ANALYSIS

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Atmospheric aerosol is generated by various natural and anthropogenic activities. Man-made emissions include power plants, vehicular traffic, domestic heating, waste and biomass burning, and other industrial emissions. Although radiocarbon methodology is most widely practiced in archaeology, it has found useful applications in environmental sciences as well and notably in source apportionment studies [1]. A combination of stable isotope and radiocarbon analyses allows us to differentiate between natural and anthropogenic aerosol emissions in greater detail [2].

In this study, the main goal was to characterize sulfur and carbon aerosol sources. PM1 aerosol particle samples were collected in Vilnius, Lithuania from November 11, 2020 to March 16, 2021. In such inland urban location, anthropogenic pollution is expected to be the dominant source of atmospheric sulfate and carbonaceous aerosols. It is often difficult to characterize pollution sources using stable isotope analysis alone, due to overlapping ranges of δ values. Usefully, radiocarbon analysis allows a more rigorous distinction between fossil and non-fossil fuels due to fossil fuels virtually having no radioactive 14C.

Sulfur and carbon stable isotope measurements were performed using stable isotope mass spectrometer and radiocarbon measurements were done using single stage accelerator mass spectrometer. Measured δ34S and δ13C values and 14C were compared with local air monitoring data and related to atmospheric air parcel trajectory models. Such an approach allows for a detailed characterization of sulfur and carbon aerosol pollution sources.

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AN ANALYSIS OF THE PERIODIC COUNTERFLOW HEAT EXCHANGER FOR AIR-TO-AIR HEAT RECOVERY VENTILATORS

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The proper functioning of the ventilation system under very low air temperature is still a big challenge. Due to the ventilation unit icing maintaining appropriate air parameters in rooms during the winter period typically requires additional energy for the unit. In this research work, a unique system with a periodic counterflow heat exchanger was developed which resolve the problem of heat exchanger icing. The proposed system characterized by high efficiency of heat and moisture recovery is operating continuously, regardless of the prevailing external weather conditions. The prototype solution eliminated the need to use additional security systems while maintaining the required air parameters and significantly reduced the building's demand for primary energy used for ventilation and heating, thus contributing to the reduction of carbon dioxide emissions.

In this research study, an experimental and numerical analysis of the periodic counterflow heat exchanger for air-to-air heat recovery ventilators was carried out to verified and determined the key parameters of the system operation. It has been shown that relatively simple modification of a typical counterflow heat exchanger allows for moisture recovery from extract air. The developed model of the proposed solution allowed for a detailed analysis of the system operation depends on weather conditions. The Eulerian Wall Film model in conjunction with the Species Transport model was used for the analysis. As a result of simulations, the impact of temperature, flow velocity and air humidity on the operation of the ventilation unit and its heat and moisture recovery efficiency were determined.

THE DEVELOPMENT OF GAS ENGINE DRIVEN HEAT PUMPS

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Gas engine-driven heat pumps are commonly used for heating and/or cooling based on compressor heat pump technology. However, unlike heat pumps with compressors supply by an electrical motor, gas engine-driven heat pumps are driven by gas internal combustion engines. The solution is an alternative to classic heating systems and is characterized by high efficiency of the systems where efficiency is related to the conversion of the energy contained in the fuel into mechanical and thermal energy. Mechanical energy through the shaft gear system is used to drive the heat pump compressor while thermal energy can be recovered from the engine jacket, chamber or exhaust gas.

Due to the complexity of the system and the wide range of applications, the technology has been the subject of detailed analyses and optimizations over the past 30 years in order to improve the efficiency of devices and their adaptation to market parameters. The presented paper shows recent development and current application of gas engine-driven heat pumps. investigated.

HYDROTHERMAL CARBONIZATION OF THE WET FRACTION MECHANICALLY SEPARATED FROM MUNICIPAL MIXED WASTE: TGA AND FTIR ANALYSIS OF HYDROCHARS

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One of the by-product of mechanical-biological waste treatment plant is under-sieve fraction which has to be separated prior further processing of municipal mixed waste. This stream usually follows the fate of landfilling. Instead, it may be introduced to hydrothermal carbonization (HTC) process to improve its fuel properties and become solid recovered fuel. Organic fraction and high moisture content of under-sieve fraction are favourable properties for HTC process. In this study, hydrochars, solid product of HTC, were produced at 200 and 220 °C and residence time of 1, 4, and 8 hours. The main aim of this investigation, was to establish influence of the different process parameters on hydrochars' fuel properties. Thermogravimetric analysis (TGA), Fourier-transform infrared spectroscopy (FTIR), and scanning electron microscopy (SEM) supported by electron dispersive spectroscopy (EDS) were used. The results confirmed positive effects of hydrothermal carbonization on under-sieve fraction of municipal mixed waste properties. The determined key combustion parameters as well as identified structural changes indicate that hydrochars may be successfully used in energy production.

ENVIRONMENTAL PROTECTION AGAINST VIBRATION IN THE CONTEXT OF HUMAN PERCEPTION OF VIBRATION

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Environmental protection has several aspects from the most popular like air or water pollution to landscape protection. One of the aspects of pollution which is often neglected is protection against vibration. Meanwhile, vibrations are a pollution not only in accordance with Polish legislation but also in EU directives. One of the most subjective parameters to judge this level of vibration pollution is the human perception of vibration. Vibration excitation in buildings comes mainly from external sources such as: industrial machinery (building machines during building process) such as vibration road rollers, pile driving etc. or transport excitation from roads, railway, subway or trams. Vibrations that are transmitted through the ground to building may influence on the building structure but more often can result in discomfort of the occupants. Humans are more sensitive to unexpected low- frequency vibrations and to provide vibrational comfort in buildings could be the basic element for buildings design criteria. In this article, on the example of a building located close to a railway line, it is shown how to assess the impact of vibrations on people receiving vibrations in a passive manner. This example shows the RMS procedure which is the basic method of human perception of vibration. The RMS method gives an advantage over the other methods (VDV or MTVV) that by using the division in 1/3 octave bands, we obtain information not only about exceeding the comfort level, but also about the frequency band in which this was exceeded. Ways to protect people in buildings against the harmful effects of vibrations were also shown.

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INFLUENCE OF RAILWAY VIBRATION ON BUILDING AND PEOPLE

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According to the construction law, railway vibrations are classified as environmental pollutants and should be taken into account when designing buildings. The Design of buildings in modern times seems to be a fully recognized topic. There are many national and international standards and guidelines, which should be taken into account. For these reasons designers could have some problems, especially when there is a problem with vibrations in the surrounding area. They do not know which standard should be used and there are problems in guidelines themselves- there is many imprecise definitions in standards regulations. This may result of not many mistakes made during dynamical analysis of the structure. For example in ISO standard there is a definition of duration of vibration: "the recorded signal should be sufficient to ensure rational statistical accuracy", which means nothing. According to Polish code (PN-B-02171:2017-06) duration of vibration is the range in which the value of vibration acceleration amplitudes does not fall below 0.2 of the maximum amplitude value in the recorded waveform – this definition is more precise. It is worth noting that in the seismic areas and in the relation to the slender structures the dynamical design is much better recognize than for transport vibrations, especially in relation to buildings. Differences in the regulations and ignorance in the aspect of dynamical design of the buildings. They often lead to errors in the design of buildings subjected to transport influences for example coming from railways. In this paper an example of such situation is analysed and the recommendations are given.

MERCURY REMOVAL FROM FLUE GASES FROM RDF COMBUSTION USING TYRE CHAR AS A SORBENT

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The amount of rubber waste generated is increasing, which poses a significant threat to the environment. This applies in particular to the used car tires. One of the methods of utilizing this type of waste is the pyrolysis process. The products of this process are gas, pyrolytic oil and a solid residue - char. These products are valuable feedstock for energy production as well as they can be used in other industry sectors. One of the directions for tyre char utilization is its use as a sorbent to remove pollutants from gases generated from fuel combustion, among others, mercury.

In the paper, a study of mercury sorption from flue gases generated from the combustion of waste-derived fuel using tyre char was investigated. The combusted fuel was RDF (Refuse Derived Fuel). RDF fuel is characterized by a higher mercury content than coal. Its use in the power sector can contribute to a significant increase in mercury emissions. The research was conducted on a laboratory scale using a horizontal tube furnace equipped with a quartz tube. The combustion process was carried out at 1200 °C in a flow of oxygen. A sorbent (tyre char) was placed at the end of the quartz tube. The heating of the sorbent was performed to obtain the appropriate temperature (95, 125, 155, 185 °C). The mercury contents in the fuel, ash obtained from its combustion, as well as in tyre char before and after the sorption process were measured. Based on the results, the mercury balance and the amount of mercury adsorbed were determined. Up to 94% of the mercury was captured by the analyzed sorbent at 185 °C.

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THE IMPACT OF COVID-19 ON NATURAL GAS DEMAND AND SECURITY OF SUPPLY IN POLAND

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The first case of COVID-19 infection in Poland took place in March 2020. Two significant waves of infections have passed through the country during the last 19 months. First of them at the turn of October and November 2020, and the other from February to April 2021. It is worth noting that the first wave coincided with the beginning of the 2020/2021 gas winter season. The second, was in line with its ending. The work attempts to find the answer the following question: how did the pandemic affect the consumption of natural gas (NG) by end users in Poland and did the plans for the development of the Polish transmission networks presented before the pandemic change significantly? The work also touches on the aspect of guaranteeing the security of supplies by using UGS. In order to answer the aforementioned questions, a study of the daily consumption of NG by end users connected to the transmission and distribution network was conducted. The analysis covered two groups of natural gas transported by the transmission network operator, i.e. low-methane gas - Lw and high-methane gas - E. The observed results indicate an increasing demand and undisturbed development of the NG sector in Poland, in particular for large high-methane NG end users connected to high pressure transmission network. The extremely frosty months like: March and April 2021 had the crucial impact on the largest ever consumption of distribution networks. Despite the lower consumption in 2020, compared to the assumptions from before the pandemic, at the end of 2021 the level of NG consumption from both groups will approach the published optimal development scenario. Historically based forecasts confirms the high probability of the implementation of one of the 3 development plans presented in 2019. In the UGS at the end of the withdrawal season, more fuel was stored than in the previous 4 years. Higher inventories of storage facilities allowed to accelerate the injection process during the summer season.

CHEMICAL MECHANISM OF THE FORMATION OF CHLORINE COMPOUNDS DURING THERMAL CONVERSION OF PLASTIC WASTE

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Silicon In the era of the consumer society, plastics are the most commonly used materials, due to a number of advantages such as low production costs and versatility. Unfortunately, this type of material, due to its complexity, makes material recycling difficult. Additionally, the COVID-19 pandemic has caused a significant increase in plastic waste, which is very difficult to manage. Most of them are hazardous waste that cannot be landfilled. Thermal processing of plastic waste, in particular the pyrolysis process, is an effective alternative. As a result of the process, it is possible to recover three fractions: liquid, gas and solid. However, chlorine compounds (e.g. HCl) are problematic, causing, among others, the phenomenon of pitting corrosion in thermal processing plants. The aim of this article is to present how chlorine compounds are formed during thermal processing of plastic waste.

The key premise for conducting this type of research is the fact that so far few analyzes have been carried out on the thermal behavior of chlorine. There are also no specific measures to prevent problems caused by the presence of this element.

THE ENERGY POTENTIAL OF BIOMASS OF POST-MINING SPOIL HEAPS (SOUTH POLAND)

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Nowadays, the main biomass sources are energy crops, forestry and partly agriculture. In order to limit intake of land intended for food cultivation while striving to increase the percentage share of biomass in RES production (EU Policy 2030), biomass resources from industrial wastelands may be used as an alternative local solution. In such areas, there are often single-species, extensive fields of wild-growing invasive species, such as the goldenrod Solidago gigantea (Sg)., which produce, on average, 1,01-4,5 kg · ha-1 biomass - comparable to 4,9 kg · ha-1 of maize crops. Therefore, it is important to study the potential and energy parameters of these species and to assess the possibility of using them in the production of renewable energy.

The main goal of the research was 1) determining the parameters essential for the use of SG biomass in the energy sector and 2) giving the areas transformed by man new functions within the concept of circular economy. Solidago gigantea, which forms a monoculture on a hard coal heap, was selected for the research. The methods of classification of the time series of multispectral images WorldView 2, covering various phases of vegetation, were used to locate biomass on the studied objects. Sg biomass was collected in accordance with the guidelines of PN-EN ISO 18135: 2017-06. Then, the combustion characteristics, humidity, volatile matter content and ash content were determined. The analysis of the energy potential of the model species was also enriched with a petrographic assessment.

The conducted research allowed to compare the properties of the energy parameters of the model plant's biomass to the parameters of native plants and other standard species used for energy purposes. Determining the energy potential of the invasive species – goldenrod Solidago gigantea, allows for the recommendation of the species' biomass to begin work on using it in distributed energy installations. the main biomass sources are energy crops, forestry and partly agriculture. In order to limit intake of land intended for food cultivation while striving to increase the percentage share of biomass in RES production (EU Policy 2030), biomass resources from industrial wastelands may be used as an alternative local solution. In such areas, there are often single-species, extensive fields of wild-growing invasive species, such as the goldenrod Solidago gigantea (Sg)., which produce, on average, 1,01-4,5 kg · ha-1 biomass - comparable to 4,9 kg · ha-1 of maize crops. Therefore, it is important to study the potential and energy parameters of these species and to assess the possibility of using them in the production of renewable energy. sources.

ARTIFICIAL NEURAL NETWORKS AND MACHINE LEARNING AS METHODS FOR IMPROVED AIR POLLUTION CONTROL

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The environmental protection issues have been still gathering more and more attention of governments, scientists and society. Atmosphere and water pollution, climatic changes, and natural disasters are the effect of continuous industrial and municipal development and of human interference into natural ecosystems. The progress in science and technology is observed almost everywhere in the world and currently, most of new advanced technical solutions are mainly targeted to protect human lives, to protect the environment and to face the ecological effects of industrial development. Recently, advanced methods have been sought to improve and to predict the mechanisms processing while exhausts producing and pollutants releasing to the atmosphere. Artificial intelligence (AI) find more interest among researchers. The artificial intelligence has already found its interest almost in every area of technology. At the same time, it is continuously improved to fully replace a human in the near future in such activities, like cooking, telemarketing, or driving a cab. In this work, the application possibility of artificial intelligence (artificial neural networks – ANN, and machine learning – ML) in some environmental aspects has been reviewed. On the basis of the reviewed papers, it was concluded that the artificial intelligence, both ANN and ML using the proper computational algorithms and matrices, may be successfully applied for the optimisation and control of polluting mediums (like stoves, or internal combustion engines) and for the forecasting of emitted pollutants depending on chosen factors.

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FUEL VAPOR CANISTER AS AN ENVIRONMENTALLY ESSENTIAL ELEMENT OF GASOLINE CARS

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The carbon canister or just canister is one of the vital components of the fuel system of gasoline cars. It consists of a plastic housing filled with adsorption material and is designed to absorb and store the excess of gaseous hydrocarbons generated by gasoline during various evaporation processes. Hydrocarbons originating from fuel vapours pollute the air, are toxic to living organisms and take an active part in the formation of photochemical smog.

Emission standards are being still lowered in the automotive industry, which forces the optimization of canisters in terms of design, e.g., changing the number and shape of the chambers and different arrangement of adsorbents in the chambers, or the introduction of innovative solutions using new adsorption materials. Another challenge is hybridization or partial electrification of vehicles. The designed part must meet the emission as well as the durability requirements throughout the expected lifetime, assuming canisters as non-replaceable element. The common tests: BWC (butane working capacity), GWC (gasoline working capacity), SHED diurnal, BETP tests are performed to assess the correct/target performance of carbon canisters. The parameters of the test procedures are described in the emission standards and strictly depend on the region where the canister is used.

As part of doctoral dissertations conducted in cooperation between AGH UST and BorgWarner, actions are taken to optimize fuel vapor canisters. Work on the subject required the launch of a research laboratory. Scheduled work includes refinement and development of methods for analysing emissions from different canisters. The use of specially constructed test stands in conjunction with gas chromatography (GC) with MS/FID detection and headspace analysis, will enable the emission measurements of the adsorptive materials as well as the quantitative and qualitative evaluation of emissions from the canister under simulated operation in the fuel system of a vehicle.

A REVIEW ON MATHEMATICAL MODELING AND INTERCONNECTION ASPECTS OF KEY SOLAR THERMAL SYSTEM COMPONENTS FOR INDUSTRIAL HEATING AND COOLING PROCESSES

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The review presents the key solar thermal system components for solar heating and cooling (SHC) applications in the range of low to intermediate temperature in industries that have been largely ignored in existing reviews. Special attention is given to stationary (no and low concentration) solar thermal collectors and water based sensible heat storage systems. A summary of mathematical modeling for the purpose of performance analysis and system sizing as well as the possible interconnections for more than one collectors and storage tanks has been provided.

GEOTHERMAL ENERGY: AN EFFECTIVE LOW-CARBON SOLUTION FOR INDOOR HEATING AND COOLING

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Nowadays, climate change and environmental damage are serious problems that must be solved. Europe needs to develop all the available energy strategies to become a modern, resource-efficient, and competitive economic system, and in which net greenhouse gas emissions are no longer generated by 2050. These are the assumptions of the European Green Deal, providing the actions to be carried out in order to efficiently use energy resources, to move towards a circular economy, to restore biodiversity, and to reduce pollution.

In recent years, probably mainly due to the above reasons, the interest of the scientific community towards low and medium enthalpy geothermal energy sources has significantly increased. These types of renewable energy sources are an effective option to heat and cool indoor environments. Different technologies can be used, such as energy piles, geothermal probes and down-hole heat exchangers (DHE).

Energy piles consist in special heat exchangers obtained inserting probes inside foundation piles which, in addition to the structural function, exchange heat with the ground, by means of a heat transfer fluid flowing in the probe. The probes are connected to the steel frame of the pile and positioned before the concrete casting. The main advantages of these systems are due to excavation costs saving and space saving with respect to classical geothermal probes.

DHE are special heat exchangers inserted inside boreholes, that can solve the problem of re-introducing the geothermal fluid into the reservoir, as requested by environmental and legislative restrictions. This technology can be used to exploit both low and medium enthalpy geothermal energy. However, the amount of heat withdrawn from the aquifer with DHE may be limited due to the interaction between the heat exchanger, the well and the aquifer. Therefore, a careful design is needed for this type of geothermal systems.

In this keynote, the main scientific results obtained from two research projects related to geothermal energy (GeoGRID and REGGAE), carried out in Campania Region, in Southern Italy, are presented. In particular, the outcomes related to GeoGRID project, described in the keynote, concern the low enthalpy geothermal energy applications successfully tested on site at the new underground station of Piazza Municipio, in Napoli. The experiments carried out regard: (i) a set of energy piles with different geometrical configuration of the probes (U, double U, triple U, spiral); (ii) the recovery of the probes employed for artificial ground freezing to be re-used as geothermal heat exchangers. Finally, the outcomes related to REGGAE project concern the experimental activity aimed at the analysis of the heat transfer performance of an innovative DHE, designed and produced ad hoc for the project, inserted in a hole, realized on the island of Ischia, interacting with an aquifer at medium enthalpy.

Keywords: Geothermal energy, low and medium enthalpy, indoor heating and cooling

MULTI-OBJECTIVE APPROACH FOR DESIGN OPTIMIZATION OF LOW AND MEDIUM-TEMPERATURE POWER GENERATION SYSTEMS

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An increased energy consumption combined with a progressive depletion of fossil fuels has forced the scientific and engineering communities to develop energy technologies which are based on renewables (biomass, solar, geothermal) and waste energy sources (flue or exhaust gases). In this regard, the low and medium-temperature power generation systems based on such technologies as organic Rankine cycle (ORC), thermoelectric generator (TEG) or Stirling engine (SE) have been extensively studied in the last decade. Currently, the interest is growing in a system design which considers several performance aspects, including thermodynamic effectiveness, economic viability, sustainability, environmental impact, installation size etc. To include all desired aspects, the system design should be optimized by means of a multi-objective approach. Once the thermodynamic model of the system is developed, a multi-objective optimization (MOO) can be performed. In practice, it boils down to specifying several (at least two) mathematically defined objective functions (criteria). In addition, the appropriate constraints need to be defined to provide a feasible design. The final outcomes of a MOO procedure are presented in a form of the set of optimal solutions, known as the Pareto front. These optimal points represent possible design solutions and the decision on the final design point is as essential as the MOO process itself. Overall, the design optimization of power generation systems with the use of a multi-objective approach is a comprehensive and responsible task. In this respect, the entire design procedure is discussed in detail in this work. Moreover, the selected findings of the author' research team studies related to this topic are presented as well.

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