12th NATIONAL CONFERENCE ON RENEWABLE ENERGY SOURCES

BOOK OF ABSTRACTS

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PREFACE

The Institute of Solar Technology has the pleasure to present the volume with the abstracts of the papers presented at the 12th NATIONAL CONFERENCE ON RENEWABLE ENERGY SOURCES, which was co-organized with the Department of Mechanical Engineering of the Aristotle University of Thessaloniki and under the auspices of the Faculty of Engineering of the Aristotle University of Thessaloniki.

The joy is twofold as the conference took place in an unprecedented and difficult period for all of us, demonstrating that where there is will and perseverance everything is possible. Unfortunately, it was not possible to hold the conference live, which would allow further osmosis between colleagues.

The volume includes the abstracts of 79 scientific papers, which were presented at the conference from the 107 papers submitted in total, as well as the presentations of the invited speakers.

In addition, selected papers will be published, following a review, in special sections of the international journals "International Journal of Sustainable Energy" and "Energy Sources, Part A: Recovery, Utilization, and Environmental Effects" by Taylor Francis and in a "Special Issue" of the scientific journal "Green Energy and Sustainability with an extension of their content.

The Organizing Committee expresses its warm thanks for the affection with which all colleagues embraced the conference once again both morally and scientifically, leading to another successful conference and we hope to see you in person at the next conference.

Special thanks to the Department of Mechanical Engineering and the Dean of the Faculty of Engineering of the Aristotle University of Thessaloniki for their financial support, as well as the Research Committee of the Aristotle University of Thessaloniki for its intention to provide free conference venues in case the conference was held live.

Thessaloniki, September 2021

On behalf of the Organizing Committee
G. Martinopoulos
D.Eng, Mechanical Engineer, MSc.
General Secretary of the Governing Board of IST

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CERTIFIED PELLETS FOR HOUSEHOLD USE

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ABSTRACT

Wood is one of the most important renewable energy sources (RES) and it has been used as fuel since fire was discovered by mankind. Pellets are a modern form of energy utilization of wood. In the last decades, due to the strict policy to reduce greenhouse gas emissions and the effort to prevent climate change, we have been noticing an increase in the use of pellets, which has created the need to classify them into quality categories. Product standardization and establishment of standard quality ensures consumers in choosing the right quality for optimal and safe use. The most important body involved in the issuance of standards for solid biofuels is the Technical Committee TC 238 of the International Standardization Organization ISO. The pellet certificates used on a large scale are the European ENplus™, the American PFI and the Canadian CANplus™. In the last decade production of ENplus™ certified pellets has increased by 69%, exceeding 13 million tons of certified products. The purpose of this paper is to review the standards for pellets as well as the analysis and comparison of the certificates used in the production of pellets for household use.

Keywords: *ENplus™, ISO 17225:2014, standards, renewable energy sources, biomass*

WOOD BIOMASS PRODUCTION FROM A FIVE YEAR-OLD FOREST PLANTATION OF THE FAST GROWING SPECIES *PAULOWNIA TOMENTOSA* KAI *P. ELONGATA* IN N. GREECE

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ABSTRACT

A forest plantation of the fast growing species *Paulownia tomentosa* and *P. elongata* was established (planting space 4 x 4 m, experimental design - single tree plot) in 2012 (end of the year) in Mesimeri area of Thessaloniki (Greece), aiming at wood biomass and timber production. The soil had medium-heavy mechanical properties/CL(Clay Loam) with pH = 7.5. In January of 2018, the following biometric parameters were measured: total tree height (H), height of crown start (Hκ), diameter at stem base (DB), diameter at the middle of trunk (Dm), diameter at breast height (DBH), diameter before crown start (Dk) and trunk volume (V). Following, the wood biomass (fresh weight/FW) of the mean tree for each species was measured, and then converted to ha. Based on the moisture content – which was found 40% of the fresh weight - the dry weight (DW) was calculated. The analysis of results showed the following: significant differences between the two species were found for the parameters DB (*P. tomentosa* 16.8 cm - *P. elongata* 19.5 cm), Dm (*P. tomentosa* 11.0 cm – *P. elongata* 12.0 cm), DBH (*P. tomentosa* 13.6 - *P. elongata* 15.3 cm), Dk (*P. tomentosa* 7.6 cm – *P. elongata* 8.6 cm), V (*P. tomentosa* 0.062 – *P. elongata* 0.075 m^3) and the dry weight (DW). No significant differences were found for the parameters H and Hκ (due to the competition among trees). Based on the mean tree, the wood biomass (dry weight) was calculated for both species. It was found 2,543 kg/0.1 ha for *P. tomentosa* (62 trees x 68.35 kg/mean tree x 0.6) and 3,065 kg/0.1 ha for *P. elongata* (62 trees x 82.4 kg/mean tree x 0.6). Assuming that 1 kg wood (air dried) has a mean heating value 19 MJ (1kg wood = 19 MJ, 1MJ = 0.278 kWh), the energy content of the wood biomass produced for *P. tomentosa* was estimated to 48,310 MJ (2,543 kg x 19MJ) and for *P. elongata* 58,240 MJ (3,065 kg x 19MJ). The analysis of correlations (Pearson correlations) between biometric parameters depicted that the stem volume (and therefore wood biomass) is better correlated with diameter at the middle of the stem (Dm) (r >0.95) in comparison to the other parameters. Assuming that the plantation had had a denser planting space for example 3 x 3m (111 trees/0.1 ha – a pure energy plantation) the wood biomass would be much higher (almost double). However, on the other hand, the combination of production of different products such as wood biomass for energy use, timber production (of different sizes) and the use of *Paulownia* in agroforestry systems, can provide alternative solutions to the producer/ investor in the face of variations in the market values of wood biomass.

Key words: *Paulownia* spp., forest plantation, wood biomass, energy, timber.

ENVIRONMENTAL IMPACT ASSESSMENT AND SUSTAINABILITY FROM THE PRODUCTION AND USE OF OLIVE RAPESEED BIODIESEL IN GREECE

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ABSTRACT

In an effort to break free from fuel imports while at the same time reducing greenhouse gas emissions, the European Union has focused on the use of Renewable Energy Sources. Biofuels, whose blending in oil has been mandatory for years, play an important role in this effort. In Greece, the production of biodiesel is based on the Distribution Program, which determines each year the quantity for mandatory mixing with conventional fuels.

Biodiesel is defined as a fuel derived from vegetable oils or animal fats, consisting of long carbon chain fatty acid esters which are produced by the process of low chain alcohol transesterification. Biodiesel has similar physicochemical properties to conventional ones, retaining some comparative advantages, most notably in the absence of SO_x emissions, reduced CO emissions, non-combustible hydrocarbons and soot, while its disadvantages include the production of by products like glycerin during its production.

There are 22 biodiesel production units in Greece. Of these, 9 companies have a refining unit while 13 are supplied with raw materials either from abroad or from domestic refining units. Most companies process vegetable oils with sunflower and rapeseed oil, accounting for the largest share of all processed oils.

In this study the sustainability and the environmental effects from the production of biodiesel from oilseed rape are determined. To that end the methodology of Life Cycle Analysis is used, according to the ISO14040-4 standards. As input data for the calculations primary data from the existing production process of one of the companies operating in Greece are used. For the analysis of the environmental impact, two different methodologies are used (CML2001 and Impact2002 +) which confirm the sustainability of biodiesel while identifying the main stages with the greatest participation in the environmental burden (fertilizers, use of agricultural tractor).

Keywords: Life Cycle Analysis, Sustainability, Biodiesel

UTILIZATION OF THE BARK IN ENERGY PRODUCTION

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ABSTRACT

Large amounts of forest bark biomass accumulate in wood processing and wood composites production industries each year, or remain inside the forest area after debarking process, where it decomposes releasing trapped carbon dioxide into the atmosphere. In the terms of materials saving, the proper utilization of natural resources, the effort of gradual detachment from non-renewable energy sources, the utilization and contribution of the bark to energy production, as well as other residues or low quality forest biomass, acquires special importance. The present study deals with the potentials and perspectives of utilization of bark of softwood and hardwood forest species in energy production, with the aim of increasing the amount of biomass utilized today, with emphasis on the natural composition of the bark of forest species as a raw material in energy sector. Successful cases of industrial energy production that rely strongly on the bark utilization, in Greece, Europe and around the world are presented. The natural and thermal properties of the bark, its chemical composition, as well as the way in which its components affect its possibilities of integration as a raw material in the production of various types of solid, liquid or gaseous biofuels are analyzed. The high availability of bark as raw material, its energy efficiency, the cost of its harvesting, transport and processing, the sales networks, the necessary equipment for its processing and conversion into energy are examined, in order to evaluate the value chain of the bark holistically from harvesting to its energy conversion, concerning domestic and industrial applications.

Keywords: Wood composites, natural resources, biomass, energy, raw material.

SUSTAINABLE MANAGEMENT OF ENERGY RESOURCES IN URBAN COMMUNITIESQ: PRODUCTION OF BIOENERGY AND BIOPRODUCTS

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ABSTRACT

Lately, the model of circular economy has gained worldwide interest. Within its concept, biowaste is viewed as a beneficial resource that needs to be re-introduced in the supply chains, which also requires the use of raw materials, energy, and water to be minimized. Undeniably, a strong link exists between the bioeconomy, circular economy, bioproducts, and bioenergy. In this light, in order to promote a bioeconomy business model, a range of alternative options and technologies for biowaste exploitation are currently available. In this paper, we propose a generic methodological scheme for the development of small, medium, or large-scale units of alternative biowaste treatment, with an emphasis on the production of bioenergy and other bioproducts. With the use of multi-criteria decision analysis, the model simultaneously considers environmental, economic, and social criteria to support robust decision-making. Towards validating the methodology, the latter was demonstrated in a real-world case study for the development of a facility in the region of Serres, Greece. Based on the proposed methodological scheme, the optimal location of the facility was selected, based on its excellent assessment in criteria related to environmental performance, financial considerations, and local acceptance. Moreover, anaerobic digestion of agricultural residues, together with farming and livestock wastes, was recommended to produce bioenergy and bioproducts.

Keywords: *sustainable management; bioenergy; decision support system; multi-criteria analysis; bioeconomy.*

DESIGN OF AN INTEGRATED PROCESS OF SYNTHETIC NATURAL GAS (SNG) PRODUCTION VIA RES-DERIVED H_2 AND CO_2 CAPTURED FROM INDUSTRIAL PROCESS

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ABSTRACT

Responding to the global efforts towards climate change mitigation, the European Union announced recently the “Green Deal”, a strategy that aims to valorize the emissions of greenhouse gases by 2050. The mitigation of atmospheric CO_2, the main greenhouse gas, can be achieved either by extensive use of renewable energy resources instead of fossil fuels or by capturing and reusing CO_2 emitted from power stations or industries such as cement production or iron and steel industries. The most common pathway for CO_2 activation and th subsequent production of chemicals and fuels is its reduction via H_2, ideally produced by water electrolysis from renewable energy resources such as solar and wind. Afterwards, renewable H_2 interacts with the captured CO_2 to yield synthetic natural gas (SNG) in a process generally denoted as “Power-to-Gas”.

In this paper, an environmentally friendly process of synthetic natural gas production from emitted CO_2 from a Greek cement industry and hydrogen generated by solar/wind energy is examined. In more detail, CO_2 is directly captured from the gases of a cement plant via scrubbing with monoethanolamine, MEA, while H_2 is solely produced from wind or/and solar-powered water electrolysis. The two high-purity gases are then transferred to the catalytic reactor system, where SNG is produced. The final product is designed to fulfil the criteria for its insertion into the national grid. The produced SNG may partly replace the fossil fuel in the cement-making process, satisfying the energy demands and improving the carbon footprint of the process.

In light of the above, the present work examines the preliminary design of flow chart diagrams and the mass and energy equilibrium calculations (using the Aspen Plus and HOMER software) for all the main segments of the process, i.e., a) CO_2 capture unit, b) H_2O electrolysis unit and c) reactor system. Subsequently, the economical evaluation and the feasibility assessment of the proposed scheme in the case of Greece considering present and projected future costs is conducted.

Keywords: H_2O electrolysis, CO_2 capture, SNG production, Feasibility study

EFFECT OF THERMAL TREATMENT AND CATALYST ADDITION DURING THE GASIFICATION OF GREEK LIGNITE AND OLIVE KERNEL USING PURE CO_2 AS GASIFICATION AGENT

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ABSTRACT

Recently, efforts toward clean energy transition to combat climate change are accelerated. Toward this direction, fossil-based conventional power production technologies are gradually being replaced by efficient energy conversion processes using alternative fuels. The gasification of fossil solid fuels and biofuels using captured CO_2 emissions as gasifying agent constitutes a very promising approach. The main aim of the present study is to explore the effect of heat treatment of Greek lignite and olive kernel on the physicochemical characteristics of as produced chars and their gasification performance using pure CO_2 as gasifying medium, in the absence and presence of an eutectic mixture of carbonates under non-isothermal (300 – 900 ^oC) and isothermal (700 and 800 ^oC) operation. The produced synthesis gas consisted mainly of CO via the Boudouard reaction, followed by minor quantities of H_2 and CH_4 attributed to the devolatilization process. The superior performance of chars was ascribed to their improved textural properties (higher porosity and BET surface area), higher fixed carbon content and lower volatile matter content compared to primary fuels. The addition of carbonates led to an increase in the production of syngas.

Keywords: Lignite, Olive kernel, thermal treatment, CO_2 gasification, syngas

ELECTROCHEMICAL REDUCTION OF GLYCEROL TO HIGH-VALUE ADDED PRODUCTS

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ABSTRACT

Electrochemical processes are used to produce high value products (with prices usually above 1 €/Kg) due to the fact that transformers and rectifiers are needed to produce direct current (DC). Photovoltaic cells generate direct current (DC) that can be used in the electrolytic system resulting in a significant cost reduction.

Biodiesel, one of the main biofuels, is produced by transesterifying vegetable oils (such as canola oil, sunflower oil, palm oil and soybean oil) with methanol in an acidic environment. In this process it is produced 1 kg of glycerol (as a by-product) per 10 kg of biodiesel. The amount of glycerol that enters the market annually exceeds two million tons resulting in a decrease in its commercial price. For this reason, the conversion to higher value-added products, such as 1,2 propanediol and 1,3 propanediol, is of great economic interest.

To date, many efforts have been made to reduce glycerol by catalytic methods. Catalytic processes require high pressures and temperatures (between 200 and 250 °C) resulting in increased operating costs of the units. To address these disadvantages, the electrochemical method has been proposed as an alternative approach. The main advantage of electrolysis is that it can be performed in ambient conditions and consumes less energy compared to chemical methods.

In the present work was studied the electrochemical reduction of glycerol at various metallic electrodes. The effect of potential, the nature of the working electrode and the glycerol concentration were studied. The main products of its reduction were 1,3-propanediol, 1,2-propanediol and hydroxyacetone. Smaller amounts of ethylene glycol (EG), propanol-1, propanol-2 and propane were also detected. The highest % selectivity in 1,3-propanediol (90%) was found in the platinum electrode (Pt) with correspondingly high % conversion of glycerol (81.5%). The highest selectivity for 1,2-propanediol was 21% at Au electrode and for hydroxyacetone was 5.6% at Pt.

Keywords: bio-glycerol, electrochemical conversion, propanediols

ANAEROBIC DIGESTION AND ECOTOXICITY OF PRIMARY SLUDGE

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ABSTRACT

The aim of this study was to investigate the anaerobic digestion of primary sludge, in order to evaluate a) the amount of the produced biogas and b) the quality of the solid residues produced after the anaerobic digestion in terms of its suitability for potential downstream resource recovery, through land application. The anaerobic digestion of primary sludge was studied using the Biomethane Potential Test (BMP) for various volatile solids, VS primary sludge/VS inoculum ratios. The results showed that the maximum methane production was achieved at a ratio of 2:1 g VS primary sludge/g VS inoculum. A 20% w/w mixture of solid residue from BMP and reference soil was subjected to a up-flow percolation test (EN 14405). The application of the BMP residue to the soil contributed to the pH regulation of the soil and to its enrichment with organic and inorganic ingredients, while at the same time in the initial stages of leaching high toxicity was recorded in *Vibrio fischeri*, due to the high organic load. On the contrary, leaching fractions for liquid/solid ratio greater than 1 L/kg showed a low toxic effect (<35%) on both *Vibrio fischeri*, and *Daphnia magna*. Finally, coagulation tests of primary sludge with the addition of polyelectrolyte showed that the coagulation process can increase the content of VS of the primary sludge and thus it could be applied as a pretreatment step during anaerobic digestion.

Keywords: anaerobic digestion, primary sludge, *BioMethane Potential (BMP), ecotoxicity*

ENVIRONMENTAL ASSESSMENT OF BIOGAS VERSUS COMPOST TREATMENT OF SEWAGE SLUDGE

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SUMMARY

The establishment of the Urban Waste Water Treatment Directive resulted in an immense increasing quantity of sewage sludge produced from waste water treatment plants. Various legislations and strategies, with most recently the "Ex-post evaluation of certain waste stream directives", were derived in order to fulfill the requirements resulting from this directive appropriately, in an economical and environmentally acceptable way.
This work focuses on the assessment and comparison of the environmental impact of the sewage sludge exploitation, which is produced during the treatment of municipal wastewater, for the production of compost and the use of anaerobic digester for the production of biogas. Support for public funding for energy waste processes (including proposals for landfill reduction and higher urban recycling and waste packaging targets) should be in line with the upward shift in the implementation of the European Union waste hierarchy. These processes, whether at national or European Union level, could focus on maximizing the contribution of the circular economy, both environmentally and economically. According to this, the prevention, reuse and recycling of waste are the main priorities. They are also key objectives of both the action plan and the waste legislation, in line with the Energy Union strategy and the Paris Agreement (European Commission, Communication 2017/34). The environmental assessment of the two alternative routes, following the treatment, will be carried out using the life cycle assessment (LCA) methodology and in accordance with the ISO 14040 Standard (EN ISO, 2006). As part of this work, a targeted presentation of the sewage sludge treatment of the two processes will be attempted, according to the Best Available Techniques (BAT) reference document for waste treatment.

Keywords: Sewage sludge; Wastewater; Life Cycle Assessment; Biogas; Compost

CO-COMBUSTION OF FOREST RESIDUES WITH LIGNITE FOR ENERGY PRODUCTION. THERMAL BEHAVIOUR AND SLAGGING/FOULING PROPENSITY.

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ABSTRACT

The combustion characteristics of lignite and forest residues from N.Greece, as well as of their blends, were studied by thermal analysis technique. Ignition, reactivity, peak and burnout temperatures, combustion time and interactions between blend components were determined. Slagging and fouling propensities of ashes were assessed through their mineralogical and fusibility analyses. Combustion of lignite occurred between 220°C and 730°C, while that of forest residues, which were rich in volatiles (83%), between 200°C and 520°C at a much higher rate. Lignite/forest residues blends presented some synergy during combustion. An increase of biomass percentage in the mixture improved reactivity as compared to lignite. Initial deformation temperature of ashes is considered low for most combustion processes, especially that of forest residues due to their content in arcanite mineral. However, the fluid temperature of forest residues ash was about 100°C higher than that of lignite and the induced fouling rate was reduced. When the two fuels were mixed, the slagging/fouling propensity was lowered with respect to lignite.

Keywords: *co-combustion; lignite; biomass; ashes*

PRODUCTION OF LIQUID FUELS FROM BIOMASS

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ABSTRACT

In recent decades, the increasing use of conventional energy and fuels continues to cause severe problems in the environment and fossil fuels reserves. In the context of countries' intense commitments to reduce greenhouse gas emissions, the utilization of alternative energy sources has steered the interest in the production of biofuels from high availability raw materials. The present study provides a record of the evolution of biomass liquid fuels production methods and processes, emphasizing on the main types of liquid biofuels, those of bioethanol and biodiesel, which belong to 1st generation biofuels. Their characteristics, the main raw materials such as forest biomass, biomass from energy crops and agricultural crop's residues are analyzed, as well as their production process, restrictions on their widespread use and the prospects of these methods in the near future. Today, about 60% of ethanol is produced from maize, 25% from cane, 7% from molasses, 4% from wheat and the rest from other seeds, cassava or sugar beet, with 77% of biodiesel based on vegetable oils (30 % soybean oil, 25% olive oil, 18% rapeseed oil) or recycled cooking oils. European and international standards with the certification system for liquid fuels are under review, while a brief reference is implemented to the most important agreement documents that the last two decades keep motivating and increasing their utilization. Additionally, the production of these biofuels in Greece and Europe is analyzed, highlighting the growing research efforts to shift to low-risk biofuels.

Keywords: *biomass, biofuels, biodiesel, bioethanol, energy crops*

PHOTOVOLTAICS

SIZING METHOD FOR OFF-GRID PHOTOVOLTAIC – BATTERY – GENERATOR SYSTEMS

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ABSTRACT

Distributed energy resources like photovoltaic modules can replace the electricity grid supplying power to non-electrified areas. One disadvantage of these systems is the unpredictable nature of solar irradiation. Furthermore, the temporal distribution of solar energy may not match that of energy demand. Power systems that combine photovoltaic modules with electrical energy storage systems can eliminate the above disadvantages. However, the adoption of such solutions by non-electrified areas is often financially prohibitive. Therefore, in the design phase of such systems, all those parameters that lead to a functionally reliable, efficient and low-cost power generation system should be taken into account. In the present work an attempt is made to dimension non-interconnected Photovoltaic Systems with Battery that meets the above criteria along with an auxiliary power source in the form of a generator to achieve total grid independence. The effort is based on the synthesis of the equation expressed by the Levelized Cost of Energy and is defined as the estimation of the system cost over time per unit of energy. The aim of the methodology is to select the appropriate combination of the number of photovoltaic panels and the nominal energy of the battery so that the cost of the system per unit of energy for a period of 25 years is minimized.

Keywords: Photovoltaics, Batteries, Generator Set, Levelized Cost of Electricity

DEVELOPMENT OF A COMPUTATIONAL TOOL FOR THE DESIGN OF RO DESALINATION SYSTEMS POWERED BY PV FOR CROP IRRIGATION

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ABSTRACT

Global population growth leads to an increasing demand of food, feed and nutrients. Water is an essential element of life on the planet and at the same time for the development of nutrients. According to the World Health Organization, 844 million people today lack even the most basic fresh water services, and this number is expected to increase by 2025 due to population growth and growing food demand. Hence, it is imperative to find new solutions for a sustainable production of fresh water aiming at the improvement and increasing of crop production with zero environmental impact. Desalination, powered by Renewable Energy (RE), seems to be a successful and sustainable solution of this problem, producing fresh water for the irrigation of crops. The current paper presents the development of a computational tool for the optimum (economically and technically) design of RO desalinations systems aiming at the sustainable production of water for crop irrigation. In addition, in order to further reduce the cost of water produced, an energy management and control system was designed to ensure the optimal operation of the desalination plant. The system enables the variable load operation and determine the operating point of the desalination unit by using a computational intelligence algorithm (Fuzzy cognitive maps). The results of this study will contribute to economic development at national and international level, as they aim to minimize the cost of product water in a sustainable way.

Keywords: RO desalination, PV systems, computational intelligence

INCREASE OF PHOTOVOLTAIC GENERATOR EFFICIENCY THROUGH SURFACE FLOW WATER FILM

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ABSTRACT

Photovoltaic generator technology is a method of converting solar radiation into electricity. During this conversion, part of the energy is spent on increasing the temperature of the PV resulting in a decrease in its energy efficiency. This side effect can be avoided by using a cooling system. Modeling and simulation play a very important role in the development and design of photovoltaic systems. The purpose of the present work is the theoretical investigation of heat dissipation by a photovoltaic generator through surface flow of water film. The system studied consists of a photovoltaic system and a water spray device. The water actively cools the front surface of the generator in order to increase its efficiency. The simulations were performed at three different ambient temperatures (22, 32, 42° C) and with three different heat fluxes (600, 800, 1000W/m^2) and the temperature variation of the photovoltaic with and without the cooling system is observed. The simulation results show that the fluid dissipates heat and significantly reduces the temperature of the photovoltaic generator and the maximum temperature drop is observed in conditions with both higher temperature and heat flux.

Keywords: Photovoltaics, Photovoltaic Cooling, Active Cooling, Surface Water Film Flow, Computational Fluid Mechanics

EFFECT OF GREENHOUSE INTEGRATED PHOTOVOLTAICS ON SOLAR RADIATION AND PLANTS GROWTH

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ABSTRACT

A solution to the problem of reduction of available Photosynthetically Active Radiation (PAR) inside greenhouses due to the coverage with conventional photovoltaic (PV) panels could be the use of semitransparent PV. The question is to what extent the semi-transparent photovoltaic can cover the greenhouse so as not to cause problems in plant growth. The present article assesses the influence of integration of semi-transparent PV on the cover of an arched greenhouse to the available PAR at the plant level. For that reason the propagation of solar radiation through the cover and inside the greenhouse is simulated using Computational Fluid Dynamics (CFD) with the model Discrete Ordinates (DO). A 2D section of an 8 m width greenhouse was studied. Three combinations of semitransparent PV/cover were examined which correspond to normal PAR transmittance of 30%, 45% and 60%. This determines the percentage of roof coverage with PV. The radiation transport was simulated for 8 indicative solar days of the year. The results are given in terms of available PAR at plants' level and of crops photosynthesis rate. These values are compared with the results of a 'bare' polyethylene cover (without any PV integration) for the same climatic conditions. Finally the yearly power production from the PV was calculated for the three examined cases. PAR transmittance of 30%, 45% and 60% compared to bare PE cover is 77%, 66% and 52% respectively while the reduction to average daily photosynthesis rate is 33%, 21% and 12%. The yearly power production by the examined greenhouse section per greenhouse length meter for normal PAR transmittance of 30%, 45% and 60% is 323, 242 and 158 kWh/(m·y) respectively. Present results can be used for the optimization of available PAR at the plant level in conjunction with power production to cover the greenhouse energy needs.

Key words: photosynthetically active radiation, Computational Fluid Dynamics, semitransparent photovoltaic, greenhouse, photosynthesis rate

ANNUAL ENERGY PRODUCTION COMPARISON BETWEEN TWO PV SYSTEMS IN A GREEK NOT INTERCONNECTED ISLAND BASED ON REAL DATA. THE EFFECT OF DIFFERENT TILT AND AZIMUTH ANGLES

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ABSTRACT

The specific research presents the results of a detailed study on the comparison of the annual performance of two photovoltaic (PV) systems, which are installed on the isolated, non-interconnected island (NII) of Tilos. The two under study systems were installed during the springtime of 2019 in two buildings on the island and they are interconnected to the local electrical grid through the net metering scheme. Both systems are of similar technology, while except from their difference on the nominal installed power, they also differ from each other in the selected PV panels' angles of inclination and orientation.

The first system, with a rated power of about 5kW$_p$, is located on the roof of a municipal building in the settlement of Livadia, very close to the coast and the municipal coastal pedestrian street of the port. Due to several shading problems from nearby obstacles, and due to the consideration for the minimization of possible visual impacts, non-optimal angles of inclination and orientation were used. The second system, with a nominal power of about 3.5kW$_p$, is located in the settlement of Megalo Chorio, and is installed on a residential roof. Since in that case there were no installation constraints, the theoretically optimal angles of inclination and orientation were selected, making this installation a standard one and suitable for comparison with other installations.

The energy comparison is performed using real data describing the production of the two plants for a whole year of operation in 15-minute and hourly time steps. Due to the different installed power of the two systems, specific energy values (kWh$_e$/kW$_p$) are used for the above comparison. In this point of view, a detailed comparison is made on a daily, weekly, monthly and annual basis, covering the cases of differentiation of the operation of the two PV systems during all time periods of the year. It should be emphasized that despite the differences recorded, the energy production of both PV plants is satisfactory, exceeding the initially estimated values. Finally, the results of the comparative energy behavior of these PV plants, based on real annual measurements, are very informative, pointing out the important role of inclination and orientation angles in PV installations.

Keywords: *Tilt angle, azimuth, shading, capacity factor, specific energy*

RECOVERY OF RENEWABLE ENERGY CURTAILMENTS IN SATURATED ISLAND GRIDS VIA WATER AND ENERGY NETWORK COUPLING AND VIA THE APPLICATION OF AGGREGATE DEMAND RESPONSE STRATEGIES

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ABSTRACT

Island systems presenting high shares of RES capacity normally imply significant curtailments of RES power generation, negatively affecting the economic performance of similar installations. To address this issue, presence of appreciable storage and/or interconnection capacity provides a way forward, but at the same time adds considerably in terms of costs. On the other hand, exploitation of already existing assets at the demand side offers the opportunity for low-cost demand response schemes. These may first concern pools of highly-deferrable loads engaging fleets of sufficient flexibility. Such demand response pools may be limited strictly to the electricity sector, but may also extend to capture vector-coupling aspects, such as with the integration of transportation and/or heating/cooling means. In addition to the latter, an increased interest is recorded over the last years concerning the investigation of the water-energy nexus, which in turn introduces the notion of combined management for the electricity and water networks. Acknowledging the above, the specific work focuses on the development of high-level, aggregate demand-response strategies, looking at the exploitation of water network assets (water pumps) in order to address the issue of increased curtailments in RES-saturated island systems and minimize the use of thermal power generation, while also achieving the integration of the water and energy networks.

Keywords: Island systems, water-energy nexus, network coupling, RES curtailments, aggregate demand response

BUILDINGS PHYSICS

INVESTIGATING THE EFFECT OF URBAN MICROCLIMATE ON THE ENERGY PERFORMANCE OF TYPICAL BUILDING UNITS. APPLICATION IN URBAN AREAS OF THE CITY OF THESSALONIKI

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ABSTRACT

Predicting buildings' heating and cooling needs through dynamic simulation methods requires the input of hourly weather data, to represent the typical meteorological characteristics of a specific location. Hence, the so called 'typical weather years' (TWY), mainly deduced from multi-year records of meteorological stations outside the urban centres, cannot account of the complex interactions between solar radiation, wind speed and high urban densities which lead to the formation of the urban heat island effect and to higher ambient air temperatures.

As the assumption that climatic parameters at a reference location of a meteorological station are similar for a densely built up area can lead to miscalculations of the heating and cooling needs, the aim of this study is to present a computational method for the generation of typical weather data for dynamic energy calculations that do capture the particularities of the urban microclimate as a function of the morphological and geometrical characteristics of the respective case study area. The proposed simulation method, here applied for the energy performance analysis of generic building units, located inside four different urban sites of Thessaloniki, is based on three tools: (a) The ENVI-met v.4 microclimate model, (b) the Meteonorm weather generator and (c) the dynamic BEPS tool Energy Plus. More precisely, microclimate simulations with the ENVI-met model are initially performed for all study areas and for 12 representative days (one for each month), especially defined through a detailed statistical analysis of long-term climatic records. At a second step, the major microclimatic parameters are extracted from the ENVI-met and are then introduced in Meteonorm weather generator to stochastically create the site-specific, annual climatic datasets, henceforward entitled 'urban specific weather datasets' (USWDs). The created, hourly weather datasets are thus representative of the microclimatic conditions of each one of the 4 urban sites.

Finally, the generated USWDs are used as an input boundary condition for the building units' dynamic energy performance simulations with EnergyPlus, enabling the consideration of the microclimatic conditions of the four case study areas, not only for a limited time period, but for an entire representative weather year. The analysis indicated that the urban warming and the higher urban air temperature during winter can be beneficial for the annual heating energy demand of the examined building units, an effect that is however counterbalanced by the considerable rise of the summer cooling energy needs.

Keywords: urban microclimate, weather datasets, energy performance simulations, ENVI-met, Energy Plus

COMBINED INDOOR ENVIRONMENT AND ENERGY PERFORMANCE ANALYSIS OF AN OFFICE BUILDING IN NORTHERN GREECE

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ABSTRACT

The building sector represents a significant portion of total energy consumption globally, noting that this share for the EU is around 40%. Nevertheless, energy saving potential in buildings is high, indicating that for building offices, which is the case of this work, the largest amount of energy is spent on heating and cooling spaces, as well as for lighting uses. In the present work, the analysis of the energy performance of an office building is presented; the selected building is the Commercial and Industrial Chamber of Kozani, in Northern Greece. The investigation aims to improve indoor environmental conditions, and reduce energy losses through the building envelope, as well as conventional energy consumption, while also generating energy from renewable energy systems, thus achieving an overall reduction of the corresponding CO_2 emissions.

Dynamic simulation is implemented for the analysis; more specifically, the building under study is represented in Revit Autodesk, while the building performance simulation is run in the Green Building Studio (GBS). Firstly, the building envelope is examined with regard to the restrictions of KENAK, that is the responsible regulation for the adoption and implementation of the European Performance Building Directive in Greece, regarding thermal insulation. Moreover, experimental equipment was placed in the building, to evaluate the actual thermal comfort conditions, indoor air quality, namely CO_2 concentration, and lighting performance. The required, for the analysis, technical characteristics of installed HVAC systems were determined through inspection. The results of the developed model were validated with regard to actual energy consumption data.

The investigation concludes on energy interventions that improve thermal insulation, HVAC systems performance and after all the energy efficiency of the building. The renovated building will save considerable amounts of energy, on reduced operating cost, will offer improved indoor environmental conditions, while contributing to environmental protection, as verified by the estimated reduction of CO_2 emissions on a level of 41%. The proposed combination of indoor measurements and energy analysis offers the possibility of an integrated approach to the conditions and performance of the building. The presented methodology combines individual validated methodological tools, in terms of simulation, measurements and inspection, achieving a reliable assessment of the current condition of the building, as well as of the benefits of the adopted interventions on an energy, economic and environmental level.

Keywords: *Office building, Energy analysis, Indoor environmental conditions, Dynamic simulation*

INVESTIGATION OF THE IMPACT OF THERMAL TRANSITTANCE OF THE ENVELOPE ON THE ENERGY EFFICIENCY OF RESIDENTIAL AND OFFICE BUILDINGS UNDER TYPICAL CONDITIONS

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ABSTRACT

A goal of the society nowadays, is the reduction of the energy consumption in all sectors, and therefore in the building sector, which is the most energy-intensive. Globally, it has prevailed that the more thermal insulation a building has, the more energy efficient it is. However, lots of scientists, based on researches, argue that on regions where cooling demands are increased for long periods during the year, very low thermal transmittance coefficient U of the building envelope may result in building overheating, since excess heat is trapped inside the building, causing increased air-conditioning demands. This paper investigates whether and under which circumstances, the idea that a highly insulated building is more energy efficient, is accurate in Greece, a country with Mediterranean climate, i.e. mild winter and hot summer, where cooling period lasts for approximately six months, or whether the validity of this opinion seems to be limited in northern countries. A typical building storey is examined, for residential use and office use, in the four climatic Zones of Greece, for the thermal insulation thicknesses of the two extreme Zones, A and D. Additional examined parameters are the existence or not of dynamic thermal insulation during the cooling period, the type of thermostat used, conventional thermostat or operative thermostat for better approaching the thermal comfort feeling, and the building material of the filling masonry, consisting of conventional perforated clay bricks and thermal insulation bricks, with the thermal conductivity coefficient λ being the only difference between them. According to the obtaining results, the increased thermal insulation protection seems to reduce significantly the annual cooling demands of the building for the local climatic conditions, while it is clear that the dynamic thermal insulation is beneficial during summer months, especially in certain climatic Zones, where the temperature conditions are more favorable.

Keywords: thermal insulation protection, dynamic thermal insulation, cooling period, residential building, office building

THE INFLUENCE OF EN17037 REQUIREMENTS ON THE ENERGY BALANCE OF OFFICE BUILDINGS

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ABSTRACT

In the last decade there has been a significant change in the assessment of daylight conditions in building interiors. This change is also affected by the increase of computing power, which allowed the estimation of daylight levels on an hourly basis using typical meteorological years. Thus in 2013 in the USA the IES directive LM-83-12 was introduced while in Europe in 2018 the standard EN 17017-2018 "Daylight in buildings" came in force. The latter proposes a series of criteria that allow the evaluation of the basic parameters related to daylight. For each of these criteria, the standard defines three performance categories: minimum (Cat.1), medium (Cat.2) and high (Cat.3). This criterion related to daylight provision is satisfied either by calculating the spatial distribution of the daylight factors (static method) or by estimating the spatial daylight autonomy resulting from hourly simulations (sDA, dynamic method). Obviously the inclusion in the above performance categories depends on the properties and size of the opening in relation to the space, the shading systems and the orientation. Any change of these can affect energy consumption for heating, cooling and lighting. In this work we use a typical office space and by changing the characteristics of the façade, the daylight provision category is estimated with both the static and the dynamic method. At the same time, the energy consumption is calculated in order to assess the impact of each category on the energy balance of the space under consideration. This effect is catalytic for the national methodology for calculating the energy efficiency of buildings. The conclusions are:

• In an urban environment, both static and dynamic have similar effects except in cases where the lighting levels inside the space are significantly affected by the reflection of electric radiation in front of the opening obstacles. This is the case for Window to Floor Areas (WFR) > = 35%. On a practical level this means that the dynamic method, which is very demanding in the calculation, does not differ significantly from the static one, ie the distribution of daylight factors, the calculation of which is easier.

• In the middle category (Cat. 2), without obstacles, the dynamic method offers better results because the requirements for this category can be achieved with a smaller size of opening and therefore lower energy consumption.

• The standard EN 17037 “pushes” the design teams to achieve a better category of dalighting provision. Of course this is accompanied by an increase in consumption and this should be emphasized. Can the highest category of daylight provision be achieved together with a reduced energy consumption? In cases such as the one examined, a dynamic shading system can contribute in this direction. However, a change in the national calculation methodology is needed so that this dynamic shading can be assessed.

Keywords: Daylighting, spatial daylight autonomy, daylight factors, EN 17037.

ANALYTICAL MODEL FOR THE SIMULATION OF TROMBE WALL OPERATION WITH HEAT STORAGE

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ABSTRACT

Passive solar systems, such as the Trombe wall, are cost-effective ways to reduce the energy consumption of buildings for heating, cooling and ventilation. The operation of these systems can be simulated either with Building Energy Simulation Tools – BES like TRNSYS, EnergyPlus etc either with Computational Fluid Dynamics – CFD. In both cases purchase of special software is required. In parallel analytical calculating tools are being developed, which also require some programming to solve an implicit system of non-linear equations but with less software requirements. The majority of analytical models concerns energy balance models for steady-state conditions with the result that heat storage is not taken into account, which in the case of a Trombe wall has a significant effect on the developed transport phenomena.

In the present work an analytical energy balance implicit model was developed for the simulation of the transient operation of a Trombe wall taking into account the heat storage.

Using this model, the operation of a Trombe wall for 7 typical days of the year was simulated. The results are presented in terms of daily evolution of the temperature with which the air enters the room served by the passive system, of the temperature of Trombe wall surface adjacent with the served room and of the air flow rate inside the air gap. These results are compared with the results that a system without heat storage would give. Both systems are assessed on the basis of annual performance as calculated by a quasi-steady explicit model.

The developed model can be used to calculate the operation of a Trombe wall as well as to supply explicit semi-stable models with values for air flow rate air inside the air gap air for Trombe wall operation without mechanical ventilation.

Heat storage offer better utilization of Trombe wall heat gains by 35% in yearly base.

Key words: Trombe wall, heat storage, energy balance model, analytical model

2D SIMULATION OF TROMBE WALL OPERATION INTEGRATED IN CHAMBER USING COMPUTATIONAL FLUID DYNAMISCS

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ABSTRACT

Trombe wall is a passive system for buildings' microclimate control. The aim of this work is to develop a 2D Computational Fluid Dynamics (CFD) model to study the operation of a Trombe wall section in order to study the heat transfer mechanisms between the passive system components and to calculate the relevant coefficients as well as the flow rate in the air gap.

For the study of transport phenomena in the simulated 2D geometry in steady state condition the partial differential equations of continuity and momentum, energy and radiation conservation were solved with the finite volume method. Turbulent was modeled with the k-ε high Reynolds model and radiation with the Discrete Ordinates (DO) in four wave length bands (UV, VIS, NIR and IR), while radiation equation is also solved inside the participated solid materials too. The radiation equations are coupled with the energy equation through a source term. The transparent cover was considered as a sandwich of two semitransparent surfaces optically and thermally coupled to the solid material of the cover and the air in the gap between cover and storage/absorbing wall. The collection surface of the storage/absorbing wall was treated in a similar way.

The vertical section of a Trombe wall 2.8 m high with as distance of 2 m between the ventilation openings, an air gap of 10 cm and a storage wall 10 cm thick of unisulated bricks serving a room 2.8 m high and 3 m long was simulated. The results are given in terms of temperature inside the air gap, and the storage wall surfaces, the flow rate through the air gap and the heat transfer coefficients.

The developed computational tool can be used to calculate the flow rate within the air gap for any relative geometry of the Trombe wall and any outdoor climatic conditions. In this way it can be used to compile table for the flow rate in the air gap and for heat transfer coefficients in order to feed with these information quasi-steady explicit models. It can also be used to validate analytical models regarding the type of flow and the use of heat transfer coefficients. Finally it can be used to optimize the design of the storage wall absorbing surface and the geometry of the ventilation openings.

Key Words: Trombe wall, Computational Fluid Dynamics, heat transfer

EXPLICIT MODEL FOR THE CALCULATION OF SUMMER OPERATION OF A TROMBE WALL AS SOLAR CHIMNEY

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ABSTRACT

Towards to zero energy consumption buildings, designers need an easy tool to assess in a first stage of the design the performance of passive heating and/or cooling systems. Trombe wall is a passive system which can be used for heating during the winter and for cooling during summer operating as solar chimney when external climatic conditions allow it.

Although calculation methods for passive elements performance have been developed by many researchers, there is a small gap in user-friendly computing tools that can guide design teams through the early stages of design. The today available models can be categorized if four classes: a) Quasi steady models based to ISO13790(2008) which are designed for mechanical ventilation, b) Analytical energy balance models which are implicit and so require programming for the simultaneous solution of the equation set, c) Building Energy Simulation (BES) models which require purchase and learning of software and d) CFD models that require specialized computational skills. It is obvious that of the above described models only quasi-steady state models could be developed into explicit models that can be easily used in the first stage of a building design.

The aim of the present work is the development of an explicit model for the calculation of energy saving offered by the summer operation of a Trombe wall like solar chimney that will be consisted by a set of equations able to be solved sequentially without the need for special software and programming knowledge

For that reason a monthly quasi-steady explicit model was developed for the calculation of Trombe wall performance as solar chimney adopting the model of equivalent electrothermal analogy according to ISO13790. However, a prerequisite for the use of the model is the knowledge of the air supply in the gap which for this model has been obtained from an energy balance analytic model developed and adequately modified by the authors.

The developed model was applied to a chamber equipped with a Trombe wall and it was found that the wall in question in the geographical location for which it was studied cannot operate as passive cooling system, as solar chimney, contributing positively to the coverage of cooling during the examined months. During May, June and September it should operate with some automation system able to close the ventilation openings and shade the Trombe wall at intervals during which the thermal solar gains through it exceed the losses (mainly through ventilation). Finally in July and August the wall should be fully shaded and the ventilation openings closed as the outside temperature is higher than the design temperature and so ventilation cannot contribute to the reduction of cooling loads. However, the same Trombe wall in areas with lower temperatures can contribute positively to meeting the cooling needs in May and September even without any automation system , while with automation it can operate even during the summer months (June – August).

Key words: Trombe wall, solar chimney, quasi-steady model, monthly step, explicit model

PHOTOVOLTAIC GLAZING IMPACT ON THE ENEGY BALANCE OF AN OFFICE SPACE

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ABSTRACT

Glazing in modern building structures servs a dual role, since on the one hand, it allows user's visual connection to the environment and on the other hand it can significantly impose an impact on the building's energy balance. Using STPV (Semi Transparent Photovoltaic) glazing which produce power is of a great importance. This analysis which was divided into two phases, was carried out with the software "DesignBuilder", while the electricity generated by the STPV glazing with the software RETScreen EXPERT. Initially in the first phase, the contribution of an STPV glazing to the energy balance of an office space in Athens was investigated. For this purpose, the building's energy balance was studied for different proportions of openings (WWR, Window to Wall Ratio) with different visual transmittance every time. The analysis was carried out with South orientation searching for the one STPV glazing that lead to the lower primary energy consumption and maximum annual saving rate. In the second phase the same analysis was carried out for the 4 climate zones of KENAK (Hellenic Building Energy Efficiency Regulation). The goal was to further investigate the relationship between W.W.R, visual transmittance and thermal gains (g-value, solar heat gain coefficient) in terms of heating, cooling and lighting loads for the office space. The present analysis initially concluded that an STPV glazing could lead for South orientation and high WWR value in Athens, in annual energy savings from 19% to 31%. Phase two, showed that the annual energy savings for the other three cities analyzed, with response to their Climate Zone by KENAK resulted similar values.

Key Words

STPV glazing, energy balance, thermal gains(g-value), optical transmittance, W.W.R, energy saving.

INTERVENTIONS FOR THE ENERGY AND AESTHETIC CITY REGENETATION

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ABSTRACT

Urban form and urban geometry have been proved to affect in a great extent the energy efficiency of buildings. Parameters such as the density of the urban tissue, the orientation and width of the streets and the building heights can significantly affect solar gains which can be decisive for the overall heating and cooling energy demand, especially in Mediterranean climates, where there are large periods of solar availability. On the other hand, energy renovation strategies are mostly targeted on individual buildings or building units neglecting the advantages of a larger scale intervention approach which, except from the almost obvious economy of scale, it could also take into account urban form and urban geometry in order to apply passive solar interventions in a more efficient way, which would promote at the same time urban aesthetics. It is suggested that several aesthetic issues created in a long-term degradation process of the built environment could be faced through larger scale interventions fostering energy efficiency as well.

Under this perspective, this research examines urban block energy efficiency interventions in the Greek city climatic conditions, taking into account different urban form and geometry parameters in order to define optimum solutions in terms of energy, aesthetic and economic impact on the city's footprint. For the scope of the research different urban block representative typologies are taken into account.

First, a base case scenario is analysed representing the existing situation of the urban block. Second, different scenarios of upgrading interventions are examined including: 1) the conventional thermal insulation of the building shells and 2) the installation of attached sunspaces on the building facades,

The analysis includes energy performance simulations in order to define the energy demand for heating and cooling at the existing and at each upgraded intervention scenario and the analysis of aesthetic parameters as well. The results of the research indicate that parameters affecting the density and geometry of the urban tissue, such as the road width, the building height, and the geometry and density of the urban blocks can, not only be decisive for the energy profile of the urban blocks, but they can give different directions on how to decrease the energy demand by applying different design of similar interventions that can optimize energy efficiency and the city's aesthetics.

Keywords: energy efficiency, urban form, passive solar renovation interventions, passive solar systems

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EVALUATION OF THERMOPHYSIC PROPERTIES OF CONVENTIONAL AND VENTILATED FACADES

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ABSTRACT

The need to improve the indoor climatic conditions, without the energy burden on construction, is now of great importance. As described by the current national and European legislative framework, levels of energy consumption of buildings, accounting for 39% of final energy consumption, thus it is urgent that it must be reduced. In this context, a number of measures and policies must be implemented focusing on improving both the energy profile of construction and the prevailing indoor environment conditions.

In particular, shell has a central role in shaping the energy balance of the building, as all the studies are directly related to its thermophysical characteristics. In this sense, it becomes impossible to carry out any study without an in-depth understanding of the function of the shell, which cannot be achieved without investigating elements of thermophysical properties for the individual materials, details of geometry in relation to and orientation, color, but also the effect of exogenous factors, such as shading or exposure to winds, etc.

The use of systems where the external element (marble or stone plates, ceramic tiles, glass panes, metal, wooden or other artificial panels) is fixed to a frame or individual supports and does not come into contact with the external thermal insulation of the building element, is a construction approach often chosen particularly in the case of office buildings. In particular, this technical approach is described as the most effective for the application of external investment in the building. More specific, the existence of a gap between the coating material and the outer surface of the building shell has multiple advantages over the conventional application by welding or nailing the lining onto the frame. These advantages are: moisture control, protection of the thermal insulation material of the construction, control of internal temperature as well as sound insulation.

Taking into account all of the aforementioned elements, it is necessary to further investigate and evaluate the operation of conventional and ventilated facades. In this context, this survey was carried out with the initial aim of gathering the bibliographical research related to the operation of ventilated facades in cases of buildings in the tertiary sector as well as the evaluation and determination of the thermophysical properties of conventional and ventilated faces.

Keywords: indoor conditions, Mediterranean climate, ventilated faces, thermophysical characteristics

HYBRID SOLAR PHOTOVOLTAICS THERMAL SYSTEMS IN NEARLY ZERO ENERGY BUILDINGS: A CASE STUDY IN RESIDENTIAL BUILDING, 12TH NATIONAL CONFERENCE ON RENEWABLE ENERGY SOURCES

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ABSTRACT

Europe faces challenges in the energy and financial sector. Unstable economic conditions are a source of severe disruption and a brake on the continued development of European countries. The continuous increase in energy demand, despite the progress made in recent years, has led to the gradual depletion of fossil fuels and the corresponding environmental degradation. As a result, the implementation of energy efficiency measures, as well as the integration of Renewable Energy Sources (R.E.S.) systems, are a challenge on the road towards Nearly Zero Energy Buildings (N.Z.E.B.). In addition, even when all efficient building design tools are applied, such as sound protection, thermal insulation and the use of energy efficient heating and air conditioning systems, there is always an additional significant demand for domestic hot water (DHW), space heating and cooling, as well as electricity for the lighting of the buildings and the use of devices, which has to be covered. This can ideally be done by using Renewable Energy Sources with solar thermal systems and photovoltaics being the primary candidates, as the former meet the range of temperature requirements while both have proven efficiency, reliability and durability. In buildings with ambitious energy targets or limited space available for the installation of the collectors, solar thermal and photovoltaic systems could eventually compete with each other. A technology capable of satisfying both electrical and thermal needs is provided by hybrid photovoltaic / thermal cell units, which are characterized by a higher rate of conversion of absorbed solar radiation into thermal and electrical compared to conventional units.

Within the framework of this study, an extensive literature review was carried out on the existing Photovoltaic / Thermal cell technologies, their energy, environmental and economic efficiency. Furthermore, a solar combi system with a photovoltaic / thermal collector installed in a N.Z.E.B., and more specifically a detached house, was studied. The system was evaluated for its energy and environmental efficiency. Finally, the results in terms of thermal efficiency and carbon footprint were compared with those of a solar combi system with a flat plate collector.

Keywords: Nearly Zero Energy Buildings (N.Z.E.B.), Hybrid photovoltaic/thermal collector, Renewable Energy Source, energy efficiency, environmental assessment

FROM SOLAR TO SUSTAINABLE ARCHITECTURE. THE EXPERIENCE FROM THE DISSERATIONS OF THE NTUA SCHOOL OF ARCHITECTURE (1978-TODAY)

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ABSTRACT

The education of architecture students is a complex and interdisciplinary process, which advances their competences and their critical thinking, as they learn how to respond in design challenges varying from the large urban scale, to the building scale and down to the scale of individual objects and products. As such, the studying curricula consist of multiple subjects many of whom are obligatory and others are elective.

The design should be influenced and formed by aesthetic, functional, social, cultural, technological and ecological parameters. Among these parameters, the latter, namely the relationship between the built and the natural environment is defined as the most critical as it calls for a holistic approach in the design development at any scale. However, sustainable and bioclimatic design have not always been prioritized and equally implemented in architectural education. But the implications of the built environment to the escalating environmental problems in the last decades have reformed the undergraduate education of architecture and thus, a rather peripheral and secondary topic, is gaining a growing attention among students in the last decade.

At the NTUA School of Architecture, fifth year students are required to work on a research topic in the context of a 9th semester core course called "*Dialexis*" (Dissertation). This paper looks into the dissertations that were elaborated at the Department of Building Technology during the last 40+ years under the topics of sustainable and bioclimatic design, energy efficiency in buildings and renewable energy sources. The aim is to examine the association of the different dissertation topics with current architectural practice, as well as with the course agenda at the School during the different periods, separated accordingly into decades and also to identify the possible shift of students' interest in the various related topics throughout the years.

The results illustrate increasing numbers of relevant dissertations, as well as an amplification of topics that during the last decade cover multiple issues related to sustainability. This is most probably due to the general intensification of environmental problems, extreme natural disasters and degradation of living and environmental conditions. Moreover, the students are getting more aware and possibly intensively interested in the interaction of the built and the natural environment, as well as in the essence of sustainable design, construction and use of buildings.

Keywords: bioclimatic design, energy-efficient design, architectural education and training, dissertation, sustainability

EVOLUTION OF THERMAL COMFORT REQUIREMENTS IN THE BUILDING SECTOR

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ABSTRACT

The need to maintain and continuously improve the indoor climate in a building is more than ever appealing. In particular, people spend 60-90% of their daily lives inside buildings and it is expected that indoor conditions correspond to the higher possible considering their needs.

Nevertheless, these needs must be consistent with the pursuit of reducing of energy consumption on the one hand and improvement of the environmental footprint on the other. Both aspects are, or should be, pillars of development strategies in the construction sector. At the same time, the implementation of these goals must be set while maintaining both the initial investment costs and the operating costs in a context that does not confront them as prohibitive for building users. In this context, a number of institutional frameworks and regulations have been adopted in recent decades aiming to the reduction of energy consumption levels and the environmental burden giving emphasis on the construction sector. More specifically, special attention is given to the indoor conditions and specifically to the thermal comfort of the users, noting the indicators and the parameters that consider different models for determining the occupants' perceived comfort.

In this context, the object of the research is the recording of the European institutional framework but also of the scientific models followed for the determination of the requirements and the way of determining comfort, aiming on the evaluation of both the parameters that are taken into account in the scientific models and the approach and potential gaps that need to be filled and evaluated further on.

Keywords: indoor climate; thermal comfort; legislation framework; building sector

POLICY

ATTITUDES OF RESIDENTS OF WESTERN MACEDONIA AND MEGALOPOLIS ON THE DECARBONISATION AS THE RESULT OF THE EUROPEAN GREEN DEAL OF DECEMBER 2019

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ABSTRACT

This research aims to record the attitudes of residents of the regions of Greece which are expected to be strongly affected by the implementation of the European Green Deal of 2019. For the study, a questionnaire using random sampling was conducted during the summer months of 2020. The survey involved 150 people who live and work in the regions of Western Macedonia and Megalopolis have participated. The objective of the questionnaire is to analyze the respondents' prospects concerning the European Green Deal and the perspective of the lignite phase-out in their regions, its implications, and the beginning of the "new era".

The results highlight the fact that when the research was conducted, the European Green Deal left an uncertain future for the case of lignite in Greece. Furthermore, as the results of the research have shown, there was a fear of the new era. The participated residents of the lignite regions felt insecure in the beginning of the new era. They were not so willing to accept the construction of renewable energy facilities. Although, they realized that the lignite has caused many serious negative effects on themselves as well as on the environment.

Thus, it is perceived that, as we move forward, the clear and right information is required to resolve the vague issue that existed in the summer of 2020. Both the competent European institutions and the national initiatives which are about to contribute to the necessary transition to the lignite phase-out era had to take into consideration the socio-economic impact on local communities. The contribution of the local community, the information, and the education are essential for the recovery of the most severely affected regions in the next few years.

Keywords: Climate Change, European Green Deal, Lignite phase-out, Renewable Energy Sources

EXAMINATION OF FACTORS DETERMINING SOCIAL ACCEPTANCE OF CARBON CAPTURE, TRANSPORT AND STORAGE FACILITIES IN THE CONTEXT OF MOF4AIR EUROPEAN PROJECT

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ABSTRACT

Carbon Capture and Storage (CCS) refers to capturing CO_2 that has been produced through power or heavy industry processes, and redirecting it to long-standing geological storage structures (e.g. depleted oil deposits or saline aquifers). In this way, CCS can contribute to global efforts of combating climate change. However, it remains a controversial technology that often faces public resistance in terms of accepting specific projects. It should not be overlooked, therefore, that social acceptance of CCS is a prerequisite for the further development and diffusion of this technology.

In this context, the European project MOF4AIR (Metal Organic Frameworks for Carbon Dioxide Adsorption in Power Production and Energy Intensive Industries), which aims to highlight the efficiency of CO_2 capture technologies based on MOF (Metal Organic Frameworks), includes specific activities related to the examination of social issues related to CCS.

The present work, therefore, presents the results that have emerged during the initial stages of these activities. Based on the performed literature review, the factors influencing social acceptance of CCS were identified, as well as the relationships between them. A number of factors affecting social acceptance either directly or indirectly have been identified, with the most commonly mentioned in the literature being perceived risks and benefits, trust in stakeholders, and knowledge of related issues. Subsequently, a questionnaire was created for the implementation of a quantitative social survey, which will be conducted in 7 European countries. The creation of the questionnaire was based on the literature review and the definition of research gaps in the existing literature.

The results from this social survey, in combination with the results that will emerge from interviews that focus on specific stakeholders, will be utilized for the development of public engagement scenarios.

Keywords: *CCS, carbon dioxide, capture, storage, social acceptance*

ENERGY COMMUNITIES IN GREECE: PUBLIC AWARENESS, AND WILLINGNESS TO PARTICIPATE AND INVEST

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ABSTRACT

A key challenge of the current century is the transformation of societies into sustainable models of energy production and consumption. Apart from changing the behavior on an individual level, transformation at the systemic level through collective action is required, in order to address the challenges of the existing energy systems, as collective action has been a historically successful driving force for social transformation. In this regard, community energy initiatives can contribute to the efficient production and distribution of energy, and support the achievement of climate goals, by assigning new roles to citizens and local communities. In this context, Energy Communities were recently institutionalized in Greece through Law 4513/2018, defined as exclusive urban cooperatives with the aim of promoting social and solidarity economy.

The present work is part of a research which aims to investigate the views and attitudes of citizens regarding awareness, participation and investment in the Energy Communities, as well as related issues that have not been previously examined. Thus, the research will provide further empirical results and innovate by examining new research questions relevant to community energy initiatives.

In this light, the present work provides the findings of the initial stages of research, namely a) information on the current situation regarding Energy Communities in Greece, b) a literature review on the factors that affect awareness, participation and investment in community energy initiatives, as well as related barriers and motives, and c) the presentation of research questions, which will be serve as the next steps of the research.

The results of this research will assist decision-makers and policymakers to design effective support policies tailored to particular circumstances, in order to encourage active participation and investment at the community level, and developers to design strategies tailored to the goals and benefits of each project.

Keywords: *Energy community, participation, investment, motives, barriers*

ENERGY TRANSITION AND THE DIMENSION OF SPACE: THE SPECIAL FRAMEWORK FOR SPATIAL PLANNING OF RES AND THE CASE OF CENTRAL MACEDONIA

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ABSTRACT

Climate change combined with growing global energy demand highlights the need for energy transition, which is largely related to the transition to renewable energy systems. While increasing RES energy production is moving in the right direction to mitigate climate change, RES installations often face problems about their location, as they may have a negative impact on land, landscape, nature and generally the environment. In previous years, discussions about energy transition have focused on the temporal dimension based on the aimed energy targets, neglecting the way energy transition shapes the space as well as the fact that spatial parameters effects RES. Today, with the spread of RES, given the global call about carbon emissions, the spatial dimension of energy transition becomes clear, as it can be observed on the problems which arise from the sitting of RES. The different characteristics between RES and fossil fuels are related to the spatial dimensions of energy transition, i.e. the demand for land and the conflicts of activities on land in order to locate RES. Although the demand on land for energy production is small (about 2% of the total land area worldwide) the spatial dimension is important due to the possible negative impact on land, landscape and nature as well as due to the possible conflict with other land uses. Thus, the issue of land use and land occupancy and the relationship with the spatial dimension of RES, are essential criteria for their proper implementation. This issue has recently gained prominence worldwide. In Greece, the directions for the spatial organization of RES are provided by spatial planning with the “Special Framework for Spatial Planning of RES” at national level as well as with the “Regional Spatial Frameworks” on regional level.

In this paper, we are seeking to analyze not only the spatial dimensions of energy transition but also how they are being dealt through Greece’s spatial planning. In particular, it is investigated how the concept of energy transition is treated in the “Special Framework for Spatial Planning of RES” as well as the spatial characteristics of RES. Afterwards, the paper focuses on the region of Central Macedonia and examines how energy transition emerges and how the “Special Framework for Spatial Planning of RES” and “Regional Spatial Framework” face the spatial characteristics of RES and link them to the spatial planning characteristics of the region.

Keywords: Energy Transition, Spatial Planning, “Special Framework for Spatial Planning of RES”, “Regional Spatial Framework”

LOCAL AUTHORITIES AS A LEVER FOR IMPLEMENTATION OF EUROPEAN AND NATIONAL JUST ENERGY TRANSITION POLICIES

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ABSTRACT

Energy Poverty (EP) is a major social problem and a major challenge for both the leadership of the European Union (EU) and the Member States in the context of a fair Energy Transition (ET) to cleaner energy solutions. Unfortunately, the Energy Vulnerable Households (EVH) cannot access basic energy services with the result that almost 34 million Europeans are not able to keep their homes at a tolerable temperature in the winter of 2018. Respectively, 32.5% of Greeks in 2019, stated that they paid their energy bills late due to their financial situation.

The National Energy and Climate Plans (NECP), drafted by the EU Member States, should have provided for an action plan to tackle EP as well as actions to determine the number of households living in EP conditions. The European Commission, in its 14 October 2020 recommendation on the EP, makes clear the strategy for implementing EU policies in each Member State, highlighting the important role of local and regional authorities and civil society in achieving outcome of dealing with the phenomenon of EP. In addition, the need to record energy-poor households is highlighted in order to make the most of European funding programs, including cohesion policy programs, to address EP.

The outcomes of the present research on EP result from the dynamics of co-evolution that composes and utilizes the Quadruple Helix model between the research team of the Laboratory of Soft Energy Applications and Environmental Protection of the University of West Attica, the Municipality of Ilion, the local civil society and the companies involved (suppliers & distributors) in the energy sector. All these stakeholders participate in the sustainable strategy for the implementation of the necessary European Policies at national and local level for the reduction and eventual elimination of EP.

The result of the research is the specifications' definition and the creation of a Database including the Energy Vulnerable Households. Moreover, the on-site recording of the phenomenon is implemented in order to develop targeted actions to eliminate it, taking into consideration the recorded needs of the local community and more specifically for the Municipality of Ilion. Subsequently a description of the basic energy needs of the EVH and the corresponding distribution of public resources for the energy upgrade of their homes is presented. Finally, the production and management of energy by the local government within an energy community is proposed and documented in order to distribute the benefits of energy market liberalization, especially to those who need it most.

Keywords: *Energy Poverty, Energy Vulnerable Households, Local Authorities, Quadruple Helix, Energy Policy*

THE ENERGY FUTURE DURING A PERIOD OF CRISIS

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ABSTRACT

The recent global pandemic and the “shutdown” of the global economy have undoubtedly hit growth and in particular the prospects of renewable energy sources (RES). However, this crisis did not stand fortunately able to prevent the progress. Under these circumstances, the energy sector is now called upon to manage the current and future possible crises and imposes the need to update the priorities and objectives at both global and national level.

At the same time, over the last five years, the European Union (EU) has made significant progress in the electricity and gas markets, improving energy efficiency and promoting RES, achieving significant reductions in greenhouse gas emissions and 'pricing' of carbon with strong prices in the emissions trading system.

The present analysis aims to review energy policy in the light of recent developments and available data from the International Energy Agency (IEA, 2020). It evaluates the progress made in recent years and examines the opportunities for energy boost in the energy sector in the context of economic recovery and the promotion of climate neutrality. The need for organizations to address the uncertainty and risks to which they should be able to respond quickly and effectively in "turbulent" periods of crisis characterized by often lacking information and unknown conditions (CCSA, 2020) is also discussed. Equally important is the recording of new data and conditions in Environmental Management Systems in the area of risk analysis and management.

Finally, the recent crisis of “self-restriction” and social distancing can be a living example of dealing with and successfully managing crises and perhaps a useful tool for developing short-term and long-term actions for a clean, resilient and equitable energy recovery, but also the economy.

Keywords: energy, renewable energy sources, risk management

SOLAR THERMAL SYSTEMS

PERFORANCE ANALYSIS OF A PTC SYSTEM WITH CONCRETE THERMAL ENERGY STORAGE INSTALLED FOR INDUSTRIAL PROCESS HEAT APPLICATIONS

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ABSTRACT

After the 20th century, many countries have focused on renewable sources for thermal and electrical energy production. The general objective is to restrict the environmental impact due to the increased use of fossil fuels. The globally dominant renewable source is solar energy, and many technologies were developed to exploit this resource, such as thermal plants and photovoltaics. Cyprus is an island with an isolated energy system, highly dependent on fossil fuels. The second-biggest fuel consumer is the industrial sector with steam production demands. The Parabolic Trough Collector (PTC) systems could be applied in industries to cover a significant fraction of their steam load. The two primary criteria to apply this technology is firstly to satisfy the thermal needs of the industry and secondly the land availability. In this study, the performance of a PTC system is investigated, which is installed in the biggest juicing industry in Cyprus named KEAN. The system consists of eight collectors connected in two parallel rows of four, covering 288 m^2. The PTCs reflect the solar radiation in highly efficient (up to 95%) and absorb 94% of the solar rays. The heat produced is transferred to a steam generator that serves steam to the industry at 188°C, 10 Barg, and to a Concrete Thermal Energy Storage System (CTES). The scope of the CTES is to support the load in the early morning hours and when the solar radiation is low. For this purpose, two operation strategies have been developed that are automatically controlled by the central system processor. The first strategy is enabled when there is a steam demand by the industry, and the second, during the weekends where the heat is transferred directly to the CTES. Both strategies are evaluated, and it is revealed that the system can produce 940 L of steam at the demanded temperature and pressure, and the system can store 107.3 kWh_{th}. Both strategies are also evaluated during a week, proving that the system can continuously support the load, supporting its steam production by the CTES.

Key words: Parabolic trough collector, thermal energy storage, solar collectors

DYNAMICAL SIMULATION AND OPERATION STRATEGIES OF A PARABOLIC TROUGH COLLECTOR WITH THERMAL STORAGE

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ABSTRACT

In Cyprus in the context of the European research program „Editor“ an innovative parabolic trough collector with heat storage was developed. The installation is in the industry of KEAN, the largest juice industry in Cyprus and the plant uses concrete as a heat storage system.

The purpose of the concrete heat storage system is to provide the industry with a supply of steam throughout the day, without being affected by periods of low sunshine. Depending on the factory's seasonally varying capacity for beverage production, the solar system delivers between 5 and 25 % of the total steam demand.

Within the framework of the European research program „Editor“ a dynamical simulation model was developed and run for the solar plant in Cyprus. The simulation model features a deviation between the measured and simulated oil temperature at the collector outlet of only few °C. With this simulation model an energy calculation of the plant is possible for different operation strategies.

Keywords: solar energy, parabollic trough collector, simulation, heat storage

SIMULATION OF THE OPTICAL PERFORMANCE OF STATIC CONCENTRATOR SOLAR COLLECTORS

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ABSTRACT

The building sector contributes significantly to the world energy consumption, impacting negatively the environment via the related greenhouse gas emission. In order to face this problem, new technologies for the improvement of the energy performance of buildings are under development. These technologies include new solar energy systems. There are few solar systems covering intermediate and medium temperature applications while the commercially available ones are very expensive.

In the frame of the Hellenic – German cooperation project "SCoSCo" innovative solar thermal systems are developed and studied. Static concentrators combined with movable absorbers have been studied, with the aim to develop a high efficiency but low-cost thermal solar collector for intermediate and medium temperature applications, e.g. for industrial heat production or integration in buildings. The aim of this work is to present the optical simulation results of those concentrators obtained by two different software packages. The methodologies are described, and the results are compared.

Keywords: *solar energy, solar collector, simulation, mirrors, static concentrators*

DESIGN OF A SOLAR CALCINER FOR THERMOCHEMICAL ENERGY STORAGE IN CONCENTRATED SOLAR PLANTS VIA CALCIUM LOOPING

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ABSTRACT

Thermochemical energy storage via calcium looping technology (CaL) has been proposed as a means of addressing the intermittent solar energy supply in concentrated solar plants (CSP). According to this technology, solar energy facilitates the endothermic decomposition of calcium carbonate in a solar calciner, whilst the reaction products (CaO and CO_2) may be stored over a large timespan. The reverse reaction, being exothermic, takes place in a separate reactor (carbonator), releasing heat which may be utilised to generate power using conventional technology. The solar calciner is a fundamental part of the process and its optimal design will maximize the efficiency of the storage system. This work consists of the design of an entrained-flow solar downer reactor. The feed flow contains solid limestone fine particles (< 100 μm) and a gas mixture of N_2/CO_2, which both enter from the top of the reactor at the same temperature and at atmospheric pressure. The reaction takes place as the particles fall within the bed due to gravity and interaction with the carrier gas. A two-stage kinetic model in conjunction with the changing grain model (CGM) have been employed to thoroughly describe the calcination reaction. The reactor modelling entails the discretisation of the calciner across its axial direction, whilst considering homogenous conditions across the radial. The model assumptions include ideal 1-D plug flow, homogenous temperature in the cloud of gas and particles at any length and low bed density. It was concluded that the calciner should operate at the temperature range 925 – 950 °C to achieve near maximum calcination at pure CO2 atmosphere and maintain the heat flux per unit of length relatively homogenous. The model has been validated successfully with experimental data from the literature, carried out in a pilot calciner 6.5 m long and 80 mm inner diameter, in a broad range of CO_2 partial pressures and temperatures.

Keywords: Calcium-looping, solar calciner design, thermochemical energy storage, decomposition of limestone

MULTI-CRITERIA ANALYSIS OF AN INTEGRATED COLLECTOR STORAGE SYSTEM

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Abstract

The paper presents a design and operation analysis of an integrated collector storage (ICS) system, which consists of an asymmetric Compound Parabolic Concentrating (CPC) reflector trough, while the water tank comprises two concentric cylinders. The annulus between these vessels is partially depressurized and contains a small amount of water in the bottom of the outer vessel that contributes to the thermal transfer from the outer to the inner cylinder. The specific study evaluates the design specifications for the parabolic surface (which leads to the design of the entire ICS system) and predicts the number of the installed units aiming at the highest efficiency and the lowest fabrication cost in order to create environmental friendly systems. The design analysis was implemented using an optimization program that supports a multi criteria decision analysis technique for analyzing complicated geometries in CPC reflectors planning and manufacturing. The environmental footprint of the device highlighting through the Life Cycle Assessment (LCA), which contributes to the customization of the system to the mathematical pattern of the code. The second objective is to evaluate the thermal energy the designed ICS device produce in operation mode and to outline the environmental - economy profile of the system in that phase. The energy, environmental and economic results were evaluated using sub functions of the algorithm while the code analyzes different configurations of the water storage focuses on the mean solar radiation of the system's installation area and the total pressure inside annulus aiming to design new solar devices with different reflector's geometry. The general conclusions of this paper prove that the final redesign models are cost effective devices that can approach the energy performance of conventional type Flat Plate Thermosyphonic Units (FPTU).

Keywords: Integrated collector storage system, Multi criteria decision analysis technique, Life Cycle Assessment (LCA), Thermal energy and Environmental – Economy profile

A CIRCULAR ECONOMY APPROACH FOR THE DESIGN OF SOLAR THERMAL TECHNOLOGIES

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ABSTRACT

Although solar energy is considered a ‘‘clean’’ energy form, both processes of manufacture and final disposal of Domestic Solar Hot Water Systems (DSHWS) are associated with environmental burdens. This is due to the energy required for the raw material extraction and the final product formation and assembly, as well as the final disposal and/or recycle of the systems at the end of their useful lifetime. Therefore, it is necessary to evaluate solar technology accounting for the indirect environmental impacts caused by these systems over their whole life cycle. The objective of this study is an holistic evaluation of the energy and environmental profile of flat plate and vacuum tube solar thermal systems. The two technologies are widely commercially available and can substantially cover significant thermal demands in residential applications (especially for hot water production). The application of eco-design principles in solar thermal collectors is yet in initial stages and needs to be improved as their recycling potential is high due to the large quantities of metals included.

In order to validate the environmental hot spots of the studied systems a Cradle-to-Grave life cycle assessment (LCA) has been implemented from raw material extraction through manufacture use and end of life. From an environmental point of view, the application of eco-design principles in solar thermal collectors can contribute towards either increased adoption of recycling or extended reuse in selected components of a new generation of solar thermal systems.

The studied systems reveal hot spots during their production phase and through their operation they manage to mitigate significant amounts of emitted greenhouse gases due to the avoided use of fossil fuels. Furthermore, they exhibit similar environmental impacts in most life cycle impact categories but the vacuum tube collector, has highest values, in most cases. Eco-design aspects for solar thermal systems focus on new designs that allow the devices to be disassembled thus improving their recycling potential. Moreover, the storage tank can be made of stainless steel as steel and aluminium can be cleanly separated and reused. All the above mentioned results are helpful to distinguish the impacts of each solar system and can be used when installing such solar energy harvesting technologies.

The linear "take-make-consume-dispose" economic system practiced within Renewable Energy Systems will inevitably undermine their sustainable status without an effective end-of-life management strategy. Circular economy philosophy attempts to close the supply chain loop by reducing the need for virgin materials via the eco-design and with "Reduce, Reuse, Recycle" principles can minimize waste throughout a product's life-cycle. Therefore, eco-design and LCA are important and related tools that enable this perspective. The obtained results of the evaluation identify the products’ hot-spots and provide insights and drivers on choosing the most appropriate technology for optimized design based on the circular economy guidelines.

Keywords: Life Cycle Assessment, Circular Economy, Solar Thermal Systems, Eco-design

ENERGY SAVINGS

COMPARATIVE ANALYSIS OF AIR-TO-WATER HEAT PUMPS SEASONAL COEFFICIENT OF PERFORMANCE

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ABSTRACT

Air-to-water heat pumps (HPs) are a very good choice for the heating systems of the residential and commercial building sectors. Their technology is mature and reliable, they have high efficiency and they operate in a wide range of outdoor temperatures. In addition, they are able to provide both heating and domestic hot water, and they use renewable energy sources (air, water or ground). The HPs' efficiency is affected by various factors, such as: the local climate, the water outlet temperature to the heating system, the building design heat load, the HP's control system, and the compressor technology. Each of these factors has a different effect on the HP's seasonal performance and therefore on the use of primary energy and on CO_2 gas emissions.

The aim of this paper is to present a detailed comparative analysis of the seasonal coefficient of performance in heating (SCOP) of air-to-water HPs, which are available in the Greek market. The sample includes 100 models in total, offered by 12 manufacturers, in a range of HP's thermal capacity up to 50kW. The comparative analysis is based on: a) the technical specifications of the different models given in the data books of each manufacturer, b) the climate of the location where the HP is installed, c) the temperature of the water outlet to the heating system and d) the HP's control system. The calculation of SCOP values was performed according to the methodology proposed by the EN14825 standard with a special software, which was developed based on this methodology.

The results of this work indicate the effect of the local climate, of the supply water temperature and the control system, plus of the heating capacity on the seasonal performance of the various air-to-water HP models examined. Setting the SCOP≥3 value as a criterion, the analysis which was carried out in four representative cities of the climatic zones A, B, C and D of Greece, shows that there are many HP models that meet this criterion and in fact their number increases from the coldest to warmer climates, in combination with lower water supply temperatures to the heating system and a control system with compensation. Additionally, from this analysis is concluded that the reduction of the supply water temperature as well as the use of the compensation increase the seasonal coefficient of performance in a range of 2%÷27% depending on the supply water temperature, the climatic zone and the HP's compressor technology. The results can be used in energy studies and in the design of building heating systems, as they are based on climatic data from different regions of Greece.

Keywords: heat-pumps, heating systems, Seasonal Coefficient of Performance, energy conservation, European Standard EN14825

INTEGRATION OF A SOLAR-POWERED ABSORPTION CHILLER FOR THE PERFORMANCE ENHANCEMENT OF A CO_2 COMMERCIAL REFRIGERATION SYSTEM

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ABSTRACT

CO_2 refrigeration configurations are the most viable solution for the commercial refrigeration plants, which however accompanied with energy challenges due to their low energy efficiency during the operation under high ambient temperature. The objective of this study is to investigate the integration of a solar absorption chiller by means of subcooling to a CO_2 booster system that serves the refrigeration needs of a supermarket refrigeration system with an installed capacity of 80kW and 20kW for medium and low-temperature regimes respectively. The examined configuration is projected to the real refrigeration plant of a METRO S.A supermarket which lies in the region of Spata (Athens). The proposed solution includes the employment of an absorption chiller operating with LiBr-H_20 working pair of 60kW cooling capacity, which is driven by heat produced in 50 evacuated tube collectors installed in the store's rooftop with a total collecting area of 115m^2. The energy analysis is conducted with validated numerical models that are developed in MATLAB using the CoolProp library. Through parametric analysis the coefficient of performance (COP) of the proposed topology is compared to conventional booster system under constant low (450W/m^2) and high (800W/m^2) incident solar radiation for the temperature range 1÷40^{o}C, resulting in maximum COP increment of 26.44% και 47.34% respectively. Additionally, performance analysis in annual basis is conducted, by using the average hourly values of ambient temperature and solar radiation for each month of the year for the specific region of the examined supermarket. The results show that in comparison to the conventional booster system, the achieved subcooling rates reach maximum increment of COP hourly to 47.48% and monthly to 16.36% for August which is the warmest month of the year. Annual power consumption is decreased by 8.93% which leads to the energy savings of 30,185.82 kWh/year.

Keywords: CO_2 refrigeration system, absorption chiller, solar energy, energy efficiency, supermarket

SMART BUILDINGS FOR SMART CITIES: ANALYSIS OF THE SMART READINESS INDICATOR

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ABSTRACT

Subject of this study is the theoretical analysis of the Smart Readiness Indicator (SRI), as well as its application for a residential building in Greece. The indicator, which was firstly introduced in the revised EPBD in 2018, assesses the buildings' smart readiness through the examination of the presence and the evaluation of the functionality level of smart services. Its goal is the promotion of buildings that are *adaptive to their users' needs*, *energy efficient* and *flexible in respect of their electricity demand*, according to the three key - functionalities, as stated by the Directive.

A smart building is not only characterized by its sustainability but also by its adaptiveness to environmental conditions and its users' preferences. Smart buildings are a basic component of smart cities, which utilize a great range of smart technologies aiming at the improvement of their citizens' lives. The Smart Readiness Indicator as well as the sub indicators evaluate the smart buildings using a multicriteria assessment method, which is thoroughly described in this paper. Finally, the indicators' calculation is executed for a residential building in Greece leading to results, which are discussed along with identified methodology shortcomings and difficulties.

Keywords: *smart buildings, smart readiness indicator, energy efficiency, adaptiveness, energy flexibility*

ENERGY USE INTENSITIES FOR HELLENIC NON RESIDENTIAL BUILDINGS BASED ON DATA FROM ENERGY CERTIFICATES AND ENERGY AUDITS

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ABSTRACT

Based on the most recent buildings' Census, Hellenic Non-Residential Building Stock includes about 790,000 exclusive-use buildings, representing 21% of the national building stock, with the majority being wholesale and retail trade & offices. This work presents average primary energy use intensities for five selected non-residential building uses, namely Hotels, Indoor sports halls/swimming pools, Schools (primary and secondary), Hospitals and Offices. The analysis is based on data from two different approaches.

The first approach is the exploitation of data from about 2,800 energy performance certificates of whole buildings, included in the national EPC electronic repository (buildingcert) over a five-year period (i.e. from January 2011 to the end of 2016). After being screened in order to exclude outliers, the exploited information from the EPCs include the general characteristics of the building (i.e. building use, location, construction period, heated area), the calculated primary energy use per unit floor area (kWh/m^2) for the total consumption (EUIp) and for the different end-uses, i.e. space heating (EUIp,H), space cooling (EUIp,C), domestic hot water (EUIp,DHW) and lighting (EUIp,L).

The second approach exploits available information from about 490 energy audits of whole buildings that have been performed for issuing energy performance certificates. This data is used as case studies of real NR buildings located throughout the country. The relevant information retrieved from the input data files include general information about the building (e.g. location), construction characteristics of the building's envelope (e.g. area, U-value) and technical characteristics of the electromechanical installations (e.g. system types, fuels). A different quality control was applied due to the nature of available parameters. The energy audit files were used with the official calculation engine used in Greece for the energy performance of buildings to generate the primary energy use intensities for the total consumption (EUIp) and for the different end-uses.

The final step of this work was to compare the average primary energy use intensities between these two approaches. In order to investigate the significance of the observed differences between the specific indicators, two parametric and three non-parametric tests were performed.

Keywords: *non-residential buildings, energy use intensity, energy audit, energy performance certificates*

ENERGY CHARACTERISTICS OF HELLENIC NON RESIDENTIAL BUILDINGS' TYPOLOGY

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ABSTRACT

This paper examined the characteristics of building envelope and technical installations of existing Hellenic non-residential buildings, in an attempt to offset the lack of information about non-residential building stock. The work exploited data collected from about 2450 energy audits and submitted as input files to the official national register in order to issue an energy performance certificate.

The relevant information retrieved from the input data files include general information about the building (e.g. location, construction date, orientation, heated area), detailed construction characteristics of the building's envelope (e.g. area, U-value, shading factor) and technical characteristics of the electromechanical installations (e.g. system types, fuels, efficiency).

The data, after been screened to ensure better quality, was organized 239 types of the non-residential buildings; typology, in terms of different building uses, construction periods and climate zones. The data were clustered into a total of thirty-one building uses, according to the definitions in the national technical guidelines. About 45% of the audited buildings were constructed before 1980, 50% between 1981-2010 and only 5% post 2010. The buildings are distributed in sixty Hellenic cities, 35% located in southern Zone A, 47% Zone B, 15% Zone C and 3% in northern Zone D.

The main objective of this work was to define the average construction characteristics of the building's envelope and technical characteristics of the electromechanical installations in order to gain a better understanding of the existing condition for the various types of buildings.

On average, the building envelopes were typically without thermal insulation or they were only partly insulated. As a result, the average thermal transmittance of the various building elements was significantly higher compared to the current minimum code requirements. Specifically, the average U-value for external walls was 1.75 W/m^{2}K, for roofs 1.93 W/m^{2}K, for pilotis 1.35 W/m^{2}K, for slabs on floor 2.40 W/m^{2}K and for windows 4.51 W/m^{2}K.

Only 51% of the audited buildings were fully conditioned, while30% had no main heating and cooling system. The prevailing heating systems were central or local heat pumps boilers and oil-fired boilers with an average coefficient of performance 2.9 and thermal efficiency of 0.85 respectively. Heat pumps and chillers were used for space cooling with an average energy efficiency ratio 2.66. Unfortunately, the penetration of RES in non-residential buildings was low and depended on the building use. On average, only a negligible 0.5% of the audited buildings had photovoltaic panels, while 40% of the buildings with domestic hot water demand had solar collectors.

Keywords: *non-residential buildings, energy audit, building typology, building envelope, HVAC systems*

OPTIMIZATION OF MULTI ENERGY SYSTEMS FOR DOMESTIC HOT WATER USES

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ABSTRACT

The burden that has come upon the environment, combined with the ever declining fossil fuel reserves, has led to drastic decisions to reduce conventional energy consumption in buildings, including the growing admission of renewable energy systems. This paper deals with the optimization of multi energy systems, in order to cover the needs of hot water in domestic use. In particular, mathematical models of integer and linear programming are formulated and the optimal solutions are explored under an economic, energetic and environmental point of view, under the optimization of the grade of participation of the multi energy systems. As far as models are concerned, simple approaches are built such as linear objective functions, multiple objective functions with or without weights and structures based on goal programming. The modeling and problem solving is done with GAMS operating system.

The application is done in case of a residential building, with an area of 200 m^2, located in the A and D climate zones. As far as cover loads are concerned, both conventional and RES systems are selected (solar thermal systems with biomass boilers). The analysis step is 1 hour, for annual operation. According to the results, in the case of the energy criterion, biomass predominates or heat pumps when biomass is not included, with an increase in participation of solar panels when the environmental criterion factor is introduced. The participation of solar systems is also reinforced in the case of target programming, because of the possibility of divergence from the targets set in the beginning.

The analysis showed that the existing methodological tools of whole linear programming can be used for investigating problems of multiple energy systems or comparing subsystems. The investigation can be extended to different types of energy systems, or buildings for all climatic zones, but also to different uses, such as space heating and cooling. Finally, the reduction of analysis step time, can lead to the utilization of the proposed methodology and the findings in development problems of optimal control systems or energy systems.

Keywords: *optimization, multi energy systems, linear programming, domestic hot water, renewable energy systems*

INNOVATIVE PRECONSTRUCTED BUILDINGS VS CONVENTIONAL BUILDINGS: A COMPARATIVE ANALYSIS ON THEIR ENERGY AND ENVIRONMENTAL PERFORMANCE

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ABSTRACT

Despite of the multiple benefits of modern preconstruction methods, conventional buildings still prevail in Europe and particularly in the Mediterranean. Especially in Greece, the share of preconstructed buildings is still very low. In the past, preconstructed buildings were regarded as of inferior quality or designed for temporary constructions. However, today, the significant technological and industrial developments of the last decades have led to highly efficient preconstructed buildings that compete the conventional ones with regard to their structural, energy and environmental performance, but also due to their easier, faster and less resource demanding construction.

Within this context, the paper aims to analyze the energy and environmental performance of a building constructed with the conventional way (reinforced concrete and brickwalls) and with the use of preconsructed elements. For the latter, the preconstructed elements were developed within the research project SU.PR.I.M. with the objective of enhancing the hygrothermal, energy, environmental, acoustic and fire performance of the construction.

The building unit selected for this analysis is a single storey small residential building. For both construction techniques the energy needs for heating and cooling were calculated using the dynamic simulation tool Energy Plus, considering 4 different thicknesses of thermal insulation for the walls (5 cm, 10 cm, 15 cm, 20 cm) and the 4 climate zones of the country. Furthermore, the environmental impacts of the examined buildings are estimated through their life cycle, in order to reach the holistic performance through the whole building life.

The results of the energy calculations showed that the performance of the preconstructed building is better regardless of the climate conditions and the thickness of wall insulation. More specifically, it was found that the enhanced energy performance concerned mainly the annual heating needs. The analysis of the environmental impacts of the buildings indicated that for all examined building types the results were highly related to the climate context. Still, the preconstructed building had in general less environmental impacts than the conventional ones. However, from the study's findings it is indicated that through the proper design and selection of materials the performance of both building types can be further optimized not only in terms of energy but also in terms of environmental impacts.

Keywords: prefabricated buildings, building energy needs, environmental performance, life cycle analysis

STUDENT RESIDENCES' ENERGY COMMUNITY OPERATION ASSESSMENT IN DEMOCRITUS UNIVERSITY OF THRACE POLYTECHNIC SCHOOL

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ABSTRACT

Through Greek Law 4513/2018 and Government Gazette Issue No. 3154/B/31.07.2020 on Energy Communities, the integration process of energy communities in the existing energy market is accelerated. In this study, a first operation assessment of student residences' thermal energy production system in the energy community of Polytechnic School of Democritus University of Thrace (DUTH) is presented. The energy community utilizes solar thermal collectors, heat exchangers, thermal energy storage tanks, a biomass boiler and an absorption chiller, in order to meet the energy demand of DUTH Polytechnic School students' residencies. DUTh's campus, consists of eight (8) residential buildings, one (1) restaurant and one (1) amphitheater. The operation of the thermal energy production system is assessed through comparative analysis between field measured data and simulation results undertaken in selected software.

Keywords: *energy community, heat storage, renewable energy sources, simulation, TRNSYS, Dymola*

FROM ENERGY SAVINGS TO SUSTAINABILITY: INVESTIGATION OF THE ENERGY UPGRADE OF SCHOOL BUILDINGS

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ABSTRACT

Upgrading the building stock is one of the most widely accepted policies for tackling climate change and reducing greenhouse gas emissions, which is considered an integral part of sustainable development. A research question that has not been thoroughly investigated is whether the energy upgrade of a building is not just energy efficient, but also sustainable. This paper examines the energy upgrade of a school building, with the aim of converting it into an nZEB, quantifying the results of its energy upgrade for various examined sustainability criteria. Ten criteria are selected to describe the United Nations Sustainable Development Goals, the indicators of which are quantified through the TEE KENAK energy simulation software and respective calculations, while qualitative indicators are quantified through questionnaires to experts, as are also determined the weighting factors for each criterion. Eleven scenarios are examined, regarding building materials (conventional and environmentally friendly materials, as well as green roofs), the upgrade of the HVAC systems to ecolabel, as well as the installation of photovoltaic panels on the school roof. Six of these scenarios convert the building into nZEB. Through multi-criteria analysis, scenarios are ranked and the most sustainable ones are highlighted through sensitivity analysis.

Through this approach, it is found that the most sustainable scenario is not necessarily the most energy efficient one. The use of environmental-friendly materials and vegetation on the roof, in combination with the local production of electricity from photovoltaic panels is ranked as the most sustainable scenario for the energy upgrade of school buildings. Synergetic scenarios are generally more effective and sustainable choices, than focusing only on a single building component. The energy upgrade of the building with environmental-friendly materials is by far the most sustainable option than upgrading it with conventional materials that have higher embodied energy and, in some cases, harmful effects on the environment throughout their life.

Keywords: nZEB, embodied energy, sustainable building, school buildings, sustainability indicators, multi-criteria MAUT analysis

REVISED TECHNICAL INSPECTION PROCEDURES FOR BUILDINGS: THE CASES OF HEATING AND COOLING SYSTEMS

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ABSTRACT

The technical inspection process is necessary for ensuring the efficient operation of heating and cooling systems in buildings. Inspections of heating and cooling systems have proven to be insufficient in the years following the implementation of the provisions in place from 2002 to 2018. As a result, the European Commission's amending directive on building energy efficiency 2018/844 / EU calls for their revision in order to achieve better results. According to the new directive, Member States must take the necessary steps to implement regular inspections of the accessible parts of heating and cooling systems with or without ventilation that have a useful rated power greater than 70kW. Simultaneously, the European Committee for Standardization (CEN) revised the standards applicable to the calculation of critical energy performance parameters of buildings, including standards related to procedures followed during technical inspections of the buildings' heating and cooling systems, in accordance with European Commission mandate M / 343.

This work focuses on developments in the field of inspection of heating and cooling systems of buildings that arise through the revised European standards. A targeted presentation of the most important revisions in technical inspection procedures will be made as part of the work, and the methodology based on which they were adopted in the relevant procedures in Greece and Cyprus will be presented. The revised inspection procedures for heating systems based on the EN 15378: 2017 series of standards, as well as air conditioning and ventilation systems based on the EN 16798: 2017 series of standards, are highlighted. The paper also discusses the specific provisions of the new inspection methodology for technical heating and air conditioning systems, as adopted by Cyprus' revised inspection regulations.

Keywords: Technical inspection, HVAC, European standards

MODEL PREDICTIVE CONTROL PERFORMANCE ASSESSMENT OF ABSORPTION REFRIGERATION CYCLES UTILIZING DIFFERENT WORKING FLUIDS

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ABSTRACT

Under real operating conditions, absorption refrigeration (ABR) process performance is affected by uncertainties and exogenous disturbances, like ambient conditions variation, and by changes in operating points (e.g., partial cooling load operation). Additionally, the employed working fluid properties greatly affect the ABR performance, given the numerous temperature, pressure and phase change phenomena occurring through the cycle. Current working fluid selection approaches found in literature, are limited as they account only for the steady-state ABR behaviour. However, a highly performing working fluid based on steady-state operation, may be highly sensitive to dynamic variability (disturbances and cooling load demand alteration). In a case like this, the control system would probably require greater utilization of resources and eventually miss the desired cooling load specifications. As a result, it is important to evaluate the dynamic performance of the ABR - working fluid pair in addition to their steady-state performance, to fully evaluate the capabilities of an alternative candidate mixture.

In the present study, the evaluation of different organic working fluids for the single effect ABR process is performed through dynamic simulations, utilizing a model-predictive controller (MPC). Working fluid mixtures investigated in this study were previously identified as promising candidates based on steady-state operation. A MPC is designed for each working fluid - ABR system pair in order to maintain key process variables within the safety and operation specification limits, while a specific disturbance scenario that involves daily load demand variation is imposed to the system. Then, the closed-loop system performance is evaluated based on two comprehensive indices before being compared to steady-state performance criteria (coefficient of performance-COP). The first dynamic index is related to speed of response and deviation from the desired set-points, whereas the second one is related to control system resource utilization. The ultimate outcome of the proposed approach is the identification of working fluids that exhibit both low sensitivity to dynamic variability and good steady-state operation. The acetaldehyde/DMF mixture presents the best dynamic behaviour, followed by the commercially available mixture of NH_3/H_2O, which also presents the second best steady-state performance.

Keywords: Absorption refrigeration, dynamic modelling, model predictive control, working fluid assessment

EVALUATION OF METHODS FOR DETERMINING ENERGY FLEXIBILITY OF BUILDINGS

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ABSTRACT

The high rate of penetration of renewable energy sources leads to challenges in planning and controlling the production, transmission and distribution of energy. One possible solution lies in the change from traditional supply side management to demand side management. Buildings are good candidates for implementing a demand response model, as they represent about 39% of the world's final energy use, and in addition are firmly connected to all infrastructure networks, as opposed to vehicles. We therefore understand the potential of using buildings as "players" to provide energy flexibility in networks.

In recent decades, there has been a significant improvement in the thermal efficiency of the shell and the energy efficiency of the heating-ventilation-air conditioning systems in newly built and renovated buildings. However, despite the reduction in energy requirements for their air conditioning, buildings continue to be passive end users of the energy system. In order to ensure that they are capable of providing the necessary energy flexibility to balance intermittent energy production, a first step is to establish a formal, standard, and robust method of characterizing the energy flexibility provided on the demand side.

Energy flexibility can help avoid excessive energy production, increase grid stability, minimize congestion problems, and enhance the energy and economic efficiency of their use. The buildings can provide flexibility services in various ways such as, utilization of thermal mass, adaptation of the use of the heating-ventilation-air conditioning system, charging of electric vehicles and load transfer, through local storage of electricity and thermal energy. However, at present there is no quantified picture of the amount of flexibility that a building can offer to future energy systems.

In the context of this work, an overview of the literature related to the energy flexibility of buildings will be presented, emphasizing on office buildings. An introduction is made to the concept of energy flexibility of buildings and methods used to define and evaluate it are presented.

Keywords: interactive buildings, energy flexibility, demand side management, building energy efficiency, energy management systems

THE CONTRIBUTION OF HIGH EFFICIENCY COOGENERATION TOWARDS ENERGY TRANSITION FOR A GREEN UNIVERSITY

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ABSTRACT

Cogeneration technology stands out as one of the leading technological options for the European Union strategy for energy saving and rational energy use. Cogeneration units combine power generation with the simultaneous heat or cooling generation exploiting the same primary energy source, thus resulting to reduced emissions of gaseous pollutants and greenhouse gases by up to 80%, depending on the domestic fuel mix of the power generation sector.

The University of West Attica currently expands in three distinct campuses with a total electricity consumption that exceeds 7500 MWh_e per year, while the thermal energy demand is slightly higher than the electricity demand during the winter. During summer, cooling loads are covered either by central or autonomous air conditioning units, resulting in significantly increased electricity demand. As a result, about one million euros per annum should be spent by the University's budget, in order to meet its energy needs.

With the intention of providing an environmentally sound and economically acceptable solution of the problem, UniWA has adopted the gradual transition to a "greener" university, by utilizing the existing infrastructure, while investing in new environmental-friendly technologies. In the light of this, since June 2016, a modern Electricity-Heat Cogeneration Unit has been installed, operating periodically for self-generation purposes, covering exclusively the needs of University Campus of Ancient Grove. The unit presents high energy efficiency, has an electrical power of 600 kW_p and corresponding thermal power, depending on various parameters.

The present study investigates a dynamic utilization of the Cogeneration unit by adopting a virtual metering strategy, aiming to increase the full operating time of the installation ("CF" increase) while normalizing the production curve of the heat engine by maximizing its overall efficiency. By implementing this strategy, it is estimated that the unit can cover up to 70% of university's three campuses needs, while the rest of the demand may be covered by the installation of solar energy systems, after a strategic plan for the rational use of energy and energy saving in University facilities.

***Keywords**: Greenhouse Gases, Natural Gas, Solar Panels, Energy Saving.*

DESIGN OF A HEAT PUMP-ASSISTED SOLAR SYSTEM TO COVER THE THERMAL LOADS OF A SWIMMING POOL

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ABSTRACT

The energy consumption of buildings amounts to 40% of the total primary energy consumption of the European Union and is due to the growing needs for comfort and better quality of living indoors in recent decades. Thus, the issues of optimization and autonomy of the operation of heating, cooling, air conditioning and ventilation systems (Heating, Ventilating and Air Conditioning, HVAC) are raised. Building Energy Management Systems (BEMS) offer opportunities to address the above issues and therefore an interesting subject to explore.

This paper examines the operation and investigates the energy behavior of an indoor swimming pool. Emphasis is placed on the possibility of utilizing thermal solar energy, but also on the integration of the BEMS system.

The swimming pool under consideration is the one of the Liapeio Sports Center of Kozani, Greece. The existing system has two hydraulic devices One of them contributes to the heating, renewal and replenishment of water of the swimming pool and the Domestic Hot Water (DHW) tank of the locker rooms. The other covers the demanded heating loads of the interior space of the facility. The energy coverage of the required loads is achieved using a heat pump and a boiler. An automated controlling system is also installed and is responsible for the coordination and the operation of the heat pumps. The intervention proposal includes the installation of a solar collector system, in order to partially cover the required loads of the swimming pool and the DHW, in parallel with the already existing heat pump. Also, the alteration controller system is considered, so that it can autonomously optimize the system under proposition. More specifically, the proposed controller layout includes measurement sensors. Also, using optimization algorithms, it aims to properly control and operate of the individual components of the thermohydraulic network, namely valves, circulators, heat pump, boiler and solar collectors. As far as the controller application is concerned, the operating algorithms of the systems are also proposed. Finally, the annual energy savings are calculated.

According to the results of the calculations, the installation of solar panels and a device control system offers savings of up to 50% of the operating costs of the swimming pool heat pumps, while the payback time of the proposed intervention does not exceed 4 years. The proposed analysis on the alteration of the controller layout can be further extended by introducing the possibility of using self-learning algorithms and developing strategic operating decisions of HVAC systems. In other words, this could be an expanded framework for designing corresponding systems, considering the actual operating conditions, and utilizing the possibilities offered by modern optimization algorithms and of course information systems.

Keywords: Solar thermal system, Heat pump, RES, BEMS, Swimming pool

THE DEVELOPMENT PROSPECTS OF THE REGIONAL UNIT OF KOZANI IN THE POST-LIGNITE ERA

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ABSTRACT

The present paper investigates the development prospects of the Kozani Regional Unit during the post-lignite era. This area was chosen because it is the one that will be adversely affected most by the country's independence from lignite. According to the National Fund for Fair Transition, the selection of actions to be implemented in the target areas, which will be assisted in their transition to the post-lignite era, should be done in open consultation. Citizens, local authorities and productive sectors will be able to express their views at this consultation. In this context, the present paper aims to investigate the views of the residents of Kozani Regional Unit, regarding the transition of the region to the after-lignite era.

For the needs of the paper, a survey was conducted with questionnaires during the months of April and May 2020. The sample consisted of 354 citizens of the Regional Unit of Kozani. Given the restrictions on movement at the time due to the COVID-19 pandemic, questionnaires were sent and collected online. The organization and processing of the research results was done through the open free program google forms and for the needs of the present work are presented through descriptive statistics.

From the analysis of the data, conclusions emerged, which are summarized in a swot analysis of the research area. The field research also revealed conclusions and concerns, which orient to actions and interventions that should be made in order that the Kozani Regional Unit will be able to have a smooth transition to the post-lignite era and to achieve sustainable development.

Keywords: Energy, post-lignite era, lignite, Kozani Regional Unit

INVESTIGATION OF CONVERSION OF A HEALTH UNIT TO NEARLY ZERO ENERGY BUILDING

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ABSTRACT

In recent years, global energy consumption has increased disproportionately in relation to population growth, mainly due to economic growth and lack of social awareness in the most developed countries, where energy consumption per capita is increasing.

The building sector consumes about 40% of total energy consumption in EU countries and is therefore an important factor in global greenhouse gas emissions. Hospitals have been observed to have one of the highest energy consumptions in the tertiary sector. The main reasons why hospitals' energy consumption is so high are their continuous operation around the clock throughout the year and the special levels of comfort required for patient health as well as the special operation conditions of various spaces e.g. surgeries.

The energy upgrade of a Health Center in the Region of Central Macedonia (Greece) is investigated in the present work. It is a building built since 1954 and faces significant problems related to the increased energy consumption as well as the comfort conditions of the employees and the visitors. The Design-Builder energy model (Energy Plus) was used to simulate the current condition of the building and several improvement scenarios. After the completion of the design of the building model, data input in the program related to construction and operation of the building, simulations were performed both for the current situation and for improvement scenarios. The results were evaluated and ranked both in terms of energy savings and economic criteria and the possibility of converting it into a building with nearly zero energy consumption.

Keywords: Nearly zero energy buildings, health care units, energy saving in buildings, RES in buildings

GEOTHERMAL ENERGY

ENERGY SAVING SYSTEM ANALYSIS AND UTILIZATION OF GEOTHERMAL ENERGY IN INDUSTRIAL CO_2 REFRIGERATION UNITS

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ABSTRACT

The main objective of this paper is the theoretical analysis of an innovative ejector system, as well as the utilization of geothermal energy to enhance the performance of the conventional booster refrigeration system (CBR). The geothermal energy is incorporated in the primary cycle as a water-source (20°C) geothermal condenser and as a subcooler after the gas cooler. All systems are compared in terms of COP and total power consumption for ambient temperature range of 1 to 40°C. The analysis was conducted using the Engineering Equation Solver software. The results show that the simple ejector system (EBR) can achieve a decrease in power consumption up to 65% compared to the conventional one at 16°C ambient temperature, followed by a COP increase by 157%. At transcritical operation, the decrease in the power consumption reaches 40% at 27°C, while COP increased by 67%. Regarding the geothermal intergrations, the CBR system with the geothermal subcooler, results in an increase of COP up to 24% at 22°C and a decrease in the power consumption up to 19% in comparison with the initial CBR system. However, above 29°C the CBR with the geothermal condenser presents a constant energy lead, with a 22% increase in COP and an 18% decrease in consumptions at 29°C, while at 40°C the performance is enhanced by a maximum of 87% in COP and the consumptions are decreased by 46%. Similarly, for the geothermal-integrated EBR systems, the EBR with geothermal subcooler presents an increase of COP by 75% and decrease in consumptions up to 43% at 31°C comparing to the initial EBR system. However, above 32°C the geothermal condenser has a constant energy lead, with a 87% increase in COP and a 47% decrease in consumptions at 32°C, while at 40°C the performance is enhanced by a maximum of 206% in COP and the consumptions are decreased by 67%. Ejector systems generally present less water demand, specifically up to 20% less for the geothermal subcooler and 14% for the geothermal condenser in comparison with the matched CBR configurations. Moreover, the EBR system with geothermal subcooler presents a maximum of 230% increase of COP and 70% decrease in consumptions at 16°C compared to the reference CBR system, while the EBR with geothermal condenser presents with an increase of 241% and decrease of 71% respectively at 40°C.

Keywords: CO_2 refrigeration system, ejector, geothermal energy, subcooling, energy efficiency

MONITORING AND PRODUCTION CONTROL OF HIGH ENTHALPY GEOTHERMAL FIELDS

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ABSTRACT

Reserarch has shown that Greece hosts various sources of geothermal energy of both low (T < 90 ºC) and high enthalpy (higher temperatures) which can be proved to be economically viable. Many low enthalpy fields in northern Greece have been in operation for years while the exploitation of the high enthalpy ones has not been that mature despite the attempts to develop the fields in Milos and Nisiros islands.

Today, the industrial interest for high enthalpy fields aiming at producing electric power has gained attention with PPC Renewables sA being the major player and HELECTOR contributing as a strategic partner. The geothermal fields in Milos-Kimolos, Nisiros, Lesvos islands and Methana have concentrated the interest of those consortia aiming at the development of a 5 MW unit in Milos before 2025.

Given the size and importance of all projects exploiting geothermal energy to produce electricity new issues arise such as protection of the environment, risk assessment and management during the course of the project and, most important, sustainability of the geothermal field.

In this work we examine the application of procedures related to the management, monitoring and control of the production and exploitation of geothermal fluids from high enthalpy fields in Greece. Monitoring and control constitute the most important part of any geothermal field management program and their main objective is the optimization of the geothermal energy withdrawal from the reservoir, the minimization of the operating cost and of the environmental effects, the reduction or the elimination of operating problems such as scaling and corrosion, ensuring continuous and constant energy production rate and performing consistently so as to meet the requirements of the national energy policy.

Techniques involving the monitoring of wells level, enthalpy or temperature of the produced fluids, spatial and temporal distribution of pressure and temperature, chemical composition of the fluids, concentration of non condensable gases, scaling and the utilization of tracers are examined. Furthermore, we discuss the requirements related to the above specifications which are imposed by the recent national Regulations of Geothermal Exploitation.

Keywords: Geothermal energy, High enthalpy, Field monitoring, Production control

SIMULATION AND ANALYSIS OF THREE SOLAR ASSISTED GROUND SOURCE HEAT PUMP SYSTEMS

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ABSTRACT

The sector of households and services accounts for more than 40% of total final energy consumption in the EU Member States and has great potential for energy savings. Studies have shown that saving energy and integrating renewable energy sources to the heating and cooling of buildings is the most cost-effective method for reducing greenhouse gas emissions. In Greece, solar energy fits that role perfectly, given the high solar radiation potential of the region. Combining solar power with other renewable energy sources such as geothermal energy, further improves savings. In this study, three Solar Assisted Ground Source Heat Pump configurations comprised of Flat-Plate, Photovoltaic and hybrid Photovoltaic/Thermal collectors are designed as upgrades to the existing GSHP system installed in a university building complex in Volos, Greece. These systems were simulated with the dynamic system simulation tool TRNSYS and afterwards analyzed energetically as well as economically, to find the most suitable alternative that is cost- and environment- friendly. Results of the analysis showed that the PV system is the optimal solution due to its substantial energy savings and low cost compared to the PV/T system. The FPC configuration did not reduce energy consumption sufficiently

Keywords: hybrid systems, energy savings, system simulation, greenhouse gas emissions reduction, flat-plate collector

REVIEW OF GEOTHERMAL APPLICATIONS IN GREECE AND WORLDWIDE

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ABSTRACT

The installed geothermal capacity in Greece was 263 MWth at the end of 2020, manifesting a slight increase (4%) since 2018, mainly attributed to Ground Source Heat Pumps (GSHP). Geothermal energy is being exploited only in direct uses in our country, mainly in shallow geothermal systems, balneotherapy and greenhouse heating. The most important new investments regard the use of geothermal energy in agriculture and additional exploration of known geothermal areas in northern Greece. The country's largest geothermal greenhouse unit (Neo Erasmio, Xanthi), reached 20 ha in 2020, whereas the first geothermal district heating project is underway in Aristino (Evros). Despite some positive steps, power generation from geothermal energy remains a distant possibility. Worldwide, the total installed geothermal power capacity is 16 GWe (early 2020), increased by almost 30% during the last five years. Accordingly, the installed capacity from direct uses is 108 GWth.

Keywords: geothermal potential, power generation, direct uses, ground source heat pumps

CHARACTERISTICS OF GEOTHERMAL FLUIDS IN THE AKROPOTAMOS AREA

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ABSTRACT

The Akropotamos area constitutes a promising low enthalpy geothermal field located in the eastern coastal zone of the Strymonikos Gulf in Eastern Macedonia. This geothermal field belongs to the wider area of the Strymon basin, which is a typical post-orogenic graben. A systematic geothermal investigation was carried out in the area by I.G.M.E. between 2002 and 2006 with the drilling of six wells, revealing a relatively low-depth geothermal system with water temperatures reaching 90°C. Two geothermal aquifers were detected in this area, a shallow aquifer with saline waters reaching about 50°C and a deeper reservoir (at 240-515 m) containing hotter, brine waters.

The systematic production tests on the AKP-1 and AKP-3 boreholes revealed the rich geothermal potential of the lower and hotter aquifer. The tests were performed with artesian flow, which partly can be attributed to the presence of large amounts of dissolved CO_2. The water flowrates from the two wells exceed 230 m^3/h and 130 m^3/h, respectively. During the production test of both wells a strong tendency to form carbonate deposits was observed. The dominant crystalline phases are two polymorphs of $CaCO_3$, calcite and aragonite, constituting more than 98% w/w. The presence of silica, of iron oxides were also detected.

A mobile phase separation system was used to measure the flowrates of the two phases from the AKP-1 and AKP-3 boreholes. Carbon dioxide is the dominant gas of the non-condensable part of the gas phase (about 99.5% v/v). The CO_2 content in AKP-1 amounts to 5.0 kg/m^3 of water, a content that is the highest recorded in Northern Greece. The corresponding content in the AKP-3 well is 1.7 kg/m^3 of water.

The management of the fluids in the Akropotamos geothermal field is largely associated with the mitigation of the serious $CaCO_3$ scaling problem. Two approaches exist to deal with this problem: (a) by keeping the system at a high enough pressure so to avoid gas phase separation and (b) by using chemical additives, provided it is allowed by the environmental impact assessment. The way of utilization and management must take into account the special characteristics of each well and the final choice must be based on the lowest possible cost of operation (mainly cost of pumping).

Key Words: *Akropotamos geothermal field, fluid analysis, production tests, separation of phases, scaling formation and mitigation, scale analysis*

ENVIRONMENT

DEVELOPMENT OF A SYSTEM FOR FOOD WASTE MANAGEMENT IN THE FRAME OF CIRCULAR ECONOMY

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ABSTRACT

In the present work, the methods of food waste treatment and energy recovery utilization, in the light of circular economy, are investigated. First, the definitions of relevant concepts and the bibliography review that was carried out, are presented. Next, the pre-treatment stages of food waste anaerobic digestion are recorded, and process parameters and types of reactors used for the sustainable production of biogas and fertilizer, are analyzed. The trends in utilization of biogas as well as the importance, utility and benefits of circular economy in relation to anaerobic digestion are mentioned.

Then the proposed evaluation system for food waste management in the light of circular economy, is presented, and two scenarios for food waste management are formulated for the island of Thasos. The first concerns the upgrade of biogas, its storage and transport to a gas station, while the second concerns the utilization of produced biogas within the island. Their strengths and weaknesses are presented, while investment plans are evaluated through Net Present Value in the context of circular economy.

Keywords: *Food waste, anaerobic digestion, biogas*

FROM THE BUILDING TO THE BUILDING STOCK: INVESTIGATION ON THE TRANSFORMATIONS OF THE BUILDING STOCK FOR THE CONVERSION OF THE CITY OF ATHENS INTO CARBON NEUTRAL

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ABSTRACT

Under the Paris Agreement, cities are asked to become carbon neutral by 2050. This ambitious goal must be supported by competent actions, prioritised efficiently, in order to achieve the cities' independence from the carbon economy within a horizon of 30 years.

This paper examines what needs to be done and in what order so as to mitigate greenhouse gas emissions from the urban building sector. More specifically, the energy saving measures that should be taken in the building stock of the Municipality of Athens, in order to achieve the specific goal, are examined. Starting with the green house gas inventory of the building stock of the city and its energy consumption, energy saving scenarios for the various uses of buildings are examined and prioritised, depending on their technical characteristics, taking into account the reduction of the greenhouse gas emissions, energy saving, the payback period of the embodied energy of elements used for the energy upgrade of buildings (construction materials, both conventional and environmental friendly, HVAC systems and photovoltaics) as well as their impact on the heat island effect, the initial cost of the investment and its payback period.

Through a dynamic hypothesis on greenhouse gas emissions from electricity generation, cost-benefit analysis highlights the actions that can significantly reduce greenhouse gas emissions with existing low-cost technologies, so that they are easily reproducible and practically applicable on the city's building stock.

With the use of multi-criteria analysis, these actions are prioritised, offering a feasible timetable for the measures for the energy upgrade of the building stock of the Municipality of Athens, so that actions that offer high green house gas emissions reductions at low costs are applied first, with short payback period and small initial investment. Through this research, primary directions are given for financing strategies that should be followed for the energy upgrade of the building stock, in order to achieve this specific goal.

Keywords: zero energy building, embodied energy, carbon neutral city, multi-criteria analysis, Multi Attribute Utility Theory

ARCHITECTURAL – ENVIRONMENTAL DESIGN AND SUSTAINABLE INTERCONNECTION OF WATER FRONTS. THE CASE STUDY OF FALIRO BAY REGENERATION

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ABSTRACT

Regeneration projects on the water front of a city are convoluted issues, as they affect social, political, economic and environmental components. Their multidimensional character imposes the adoption of practices, based on the principles of sustainability. This research focuses on the "Complete Reconstruction of Faliro Bay", investigating the sustainable connection of Faliro Bay with the city. By creating three scenarios concerning the connectivity of the new park with the city and taking into consideration the influence of COVID-19 on transportation, the evaluation of the sustainability of the connection of the sea front with the urban fabric is attempted, with criteria from the three pillars of sustainability; environmental protection, social equality and economic growth. Ten criteria are chosen to describe these pillars, expressed from respective indicators, which are quantified in terms of the interconnection scenarios of the study area through: a) the existing design, b) mild interventions and c) large-scale, radical interventions. The indicators of the criteria are quantified through Life Cycle Analysis (ATHENA software), measurements on the proposed designs, while through questionnaires qualitative indicators are quantified and the weighting factor of each criterion is determined. Through multi-criteria analysis and sensitivity analysis, the scenarios are evaluated and prioritised, regarding the sustainability of each interconnection scenario. Conclusions are drawn on the sustainable nature of restricting car travel and enhancing the use of public transport and active mobility in the urban fabric, on the interconnection of the city and the sea front. This approach quantitatively demonstrates that if a prominent, bioclimatically designed seafront is not sustainably interconnected with the city, its interconnection could cause serious environmental issues, resulting from increased traffic. The most sustainable option is to radically transform interconnected areas into places that encourage walking, cycling and the use of electric public transport, despite its high initial costs.

Keywords: water front, sustainable interconnection, multicriteria analysis (MAUT), environmental design, “blue and green” infrastructure

Sustainable Planning for basic military installations

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ABSTRACT

The environment has always been one of the most valuable assets of humanity. Its preservation has always been duty of every state, and responsibility for all the citizens. Since the 90's, the concern of the mass about the subject of approaching the climate change and the protection of the environmental equilibrium was apparent, both in a national and in a European level. The preservation of the environment and finding ways for environmental energy saving measures through new ways of planning is a global requirement and a field of search for countries with significant power and size Armed Forces around the world.
In the context of this article, the criteria for a holistic approach to the design of key military installations with sustainability characteristics, considered on both the macro scale and the micro scale of an area, are explored and organized. The position selection factors are listed and the physical factors of the macro scale affecting the military installation are analysed. Design criteria are listed and the specific design criteria that must govern the basic military installation are presented. The aim is to organise, prioritise the criteria and planning guidelines for sustainability, which are suitable for military installations.
This is also verified through the examples of US Armed Forces mainly and the EU and the way they approach the design and implementation of environmental protection in their permanent military installations. In addition, a brief presentation and evaluation of the efforts of the Hellenic Armed Forces to implement sustainable planning in their buildings and facilities is made.

Keywords: Hellenic Armed Forces - Sustainability in military infrastructure - Military installation planning - Energy saving - Energy efficiency

ENERGY EFFICIENT REUSE OF INDUSTRIAL BUILDINGS WITH ENVIRONMENTAL CRITERIA. THE CASE OF A FORMER TOBACCO WAREHOUSE IN STAVROUPOLI THESSALONIKI

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ABSTRACT

In Greece there is a large number of inactive industrial shells that were abandoned after their closure. Given the importance of preserving the industrial-cultural heritage and recognizing the fact that the reuse of abandoned buildings is in line with the logic of sustainable development, the commitments involved and the means of implementing environmental design principles in industrial heritage buildings are examined. The various reuse methods and approaches are also examined.

The main object of the study is to investigate the reuse of the abandoned "red tobacco warehouse" in the area of Stavroupoli, Thessaloniki, in order to reintegrate it into the urban fabric, preserve its historical character and design the reuse proposal based on the principles of bioclimatic design. The energy performance of the existing former tobacco warehouse is investigated and evaluated using a special computer tool. A reuse proposal is made with a complete redesign of the building to satisfy the new use, which includes new architectural layout, other necessary interventions on the building envelope, implementation of energy upgrade measures, new mechanical systems and active solar systems. The reuse proposal of the tobacco warehouse and its transformation into a modern office building follows the principles of bioclimatic design, taking into account the morphological peculiarities and the commitments that arise from the historical value of the building. Also, using the special computer tool, a specific methodology is applied to evaluate the effectiveness of the proposal in relation to energy efficiency, energy savings, CO2 emissions, daylight conditions and thermal comfort conditions.

Keywords: Bioclimatic Design, Energy Efficient Reuse, Tobacco Warehouse, Industrial Heritage

CLIMATE

PREDICTION OF THE WIND SPEED IN RENEWABLE ENERGY ENVIRONMENTS

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ABSTRACT

The objective of this paper is the development of an algorithm that is able to provide near real-time predictions of the wind speed statistics (WSS) in renewable energy environments. The topic is clearly of interest since predictions of storms and extreme winds are important for decision makers and emergency response teams in renewable energy environments e.g. in places where wind turbines could be located including cities. The objective of the paper is reached through two phases: a) During the preparation phase, the construction of a large WSS database based on Computational Fluid Dynamics (CFD) is performed which includes flow fields of various wind directions in all numerical grid points, b) in the second phase, the algorithm is used on finding the records in the WSS database with the closest meteorological conditions to the meteorological conditions of interest. The validation of the CFD model (including both RANS and LES turbulence methodologies) is performed using the experimental data of the MUST (Mock Urban Setting Test) wind tunnel experiment.

Keywords: *Wind speed, Algorithm, Computational Fluid Dynamics*

SOLAR RADIATION FORECASTS BASED ON ALL SKY CAMERAS

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ABSTRACT

In recent years, several experimental and operational methods to forecast solar radiation at very short-term time scales (less than 20 min) have been developed based on the inspection of atmospheric conditions via all-sky imagers (ASIs). In this study, the preliminary results from a benchmark exercise, within the framework of IEA PVPS Task 16 (https://iea-pvps.org/research-tasks/solar-resource-for-high-penetration-and-large-scale-applications/) are presented in order to qualify the current ASI-based short-term forecasting solutions and examine their accuracy. For this reason, a 3-month observation campaign (from August to December 2019) took place at Plataforma Solar de Almeria in Andalusia, Spain, including a bouquet of ASIs and a network of high quality measurements of solar irradiance and other atmospheric parameters. Forecasted time-series of solar radiation are compared with ground measurements and a typical persistence model to identify strength or weakness of each approach, lower the uncertainty and define best practices of ASI-based forecasts.

Keywords: solar radiation, all-sky camera, solar radiation forecasting

FORECAST OF ENERGY PRODUCTION FOR RES PLANTS USING ADVANCED METEOROLOGICAL TOOLS IN GREECE

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ABSTRACT

For the RES area, the start of operation of the Target Model marks the transition period from "passive" market participation to "active" participation, from the "immaturity" of the fixed selling price to the "maturity" of variable pricing and continuous forecasting energy production. RES with the Target Model, acquire "balancing obligations", i.e. they are obliged to declare their hourly production program in the Day Ahead Market (DAM), to calculate the deviations from their actual production and to improve their declarations in Intraday Market (IDM). The remaining discrepancies finally participate in the final balancing market.

The participation of RES projects in the energy market can be done either directly or through the Cumulative RES Representative Bodies (FOSE) that have been established for this purpose, taking advantage of the possibility of a comprehensive declaration of production of a RES project portfolio of different technology and wider geographical distribution offering higher accuracy in the total hourly forecast of production of the projects within their portfolio and thus reducing the risk of deviations (consequently of the respective charges).

Power generation forecasting is based on the numerical input of multiple weather models. Extensive experience developing and operating numerical weather models combined with access to high-resolution weather data are key to producing accurate forecasts. In order to minimize the overall forecast error, to ensure the availability of forecasts and to accurately describe possible alternative weather developments, the use of at least three (3) meteorological models is recommended.

This paper concerns a comparative evaluation of forecasts and actual producers for a variety of photovoltaic and wind projects throughout the country in the context of providing forecasts to private RES producers as well as Cumulative Representation Bodies (FOSE) for a period of more than a full year.

The NMAE, MAPE, NRMSE, NBIAS evaluation coefficients are exported for six (6) wind farms and four (4) photovoltaic plants throughout Greece for a period of one year.

The study team evaluates the results, investigates limitations and causes of differentiation and provides useful conclusions for the improvement of the provided forecasts of energy production.

Keywords: weather conditions, target model, models, prediction.

ENERGY AUTONOMY SOLUTION FOR THE EUROEAN OBSERVATORY PANGEA OF ANTIKYTHERA ISLAND

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ABSTRACT

The island of Antikythera is an island of unique beauty, lying in the very position where the Ionian, the Aegean and the Myrtoan seas meet, in between Peloponnesus and Crete. According to the most recent data, the permanent population of the island does not exceed a total of 30 local inhabitants, while the total annual electricity consumption is in the order of 250-300 MWh_e, depending on the number of tourists visiting the island during the summer period. In the same context, the island peak demand, appearing during the summer months, does not exceed 100-120 kW and is so far covered by the Local Thermal Power Station (LTPS) operated on the basis of diesel oil, while, at the same time, the mean overall total production cost of electricity appears to be higher than 1400 €/MWh_e.

Recently, and due to its geographical location, the island of Antikythera was selected by the Greek State and the European Investment Bank in order to host the PANhellenic GEophysical observatory of Antikythera (PANGEA), developed by the National Observatory of Athens (NOA). The systematic operation of PANGEA is expected to more than triple the electricity consumption of the local electricity grid (the estimated energy consumption of the observatory when in full operation is expected to exceed 800MWh_e on an annual basis). In parallel, and in order to harmonize with the local environment and also limit the environmental footprint of the facility, use of fossil fuels is not welcome, avoiding in this way to aggravate the given research campaign with the emission of pollutants and greenhouse gases. Besides, one of the main reasons for the selection of Antikythera was the quite limited anthropogenic activity and impacts locally.

To that end, NOA, planning the development of the PANGEA facility and infrastructure in collaboration with the local Municipal Authority (Municipality of Kythera) and the research team of the Soft Energy Applications & Environmental Protection Lab (SEALAB) of the University of West Attica, examine the prospects of developing a Hybrid Power Station on the island. The latter will rely on the exploitation of the local solar potential and the deployment of energy storage systems, limiting the contribution of the LTPS to the minimum possible.

Acknowledging the above, the present study makes an effort to provide a realistic sizing of the proposed hybrid power station, building also on the recent experience of the TILOS-Horizon 2020 project. To strengthen the validity of the proposed solution, a series of simulation results are provided concerning the annual system operation and the value parameterization of the hybrid power station main components. Based on the evaluation of the proposed solutions, the conclusion is drawn that the satisfaction of the entire island needs is feasible under a minimum environmental footprint, improving also the resilience of the local electricity grid and compressing the electricity production cost by approximately an order of magnitude.

Keywords: *Greenhouse Gases, Thermal Power Station, Photovoltaic Panels, Energy Storage*

INTEGRATION OF RES - WIND ENERGY

THE HYBRID POWER PLANT IN SIFNOS. DEVELOPMENT PERPSECTIVES OF ENERGY COMMUNITIES

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ABSTRACT

Sifnos island has been declared as one of the six pilot islands of the European Commission within the frame of the "Clean Energy for EU Islands" initiative. This is due to the overall development of the energy transition plan with its major pylon the design and the licensing of a hybrid power plant of a wind park and a seawater pumped hydro storage system, accomplished by the Sifnos Island Cooperative. The objectives of Sifnos Island Cooperative is the approach of the rational and effective energy transition in the island, achieving energy independency and democracy and claiming the maximum possible benefits for the local insular community.

The article presents the essential technical and economic features of the hybrid power plant and the huge development perspectives which are created through its construction and operation. The pumped hydro storage system offers a storage capacity of 860 MWh, which imposes an autonomy operation period of 16 days. The economic feasibility of the project is ensured with a selling price for the produced electricity of 0,22 €/kWh, which can be reduced after the loans payback period. The available considerable electricity production surplus from the wind park, obtained due to the intensive seasonal power demand fluctuation, can fully cover new electricity loads for the transition to e-mobility, for doubling of the annual potable water production with desalination and for hydrogen production capable to guarantee daily maritime connection of the island with the major insular centres in the Cyclades complex through a small passenger ship.

The official Greek State owes to treat the Sifnos Energy Cooperative initiative as it really deserves as a pilot island for the European Commission, by declaring the required electricity selling price from the hybrid power plant which will ensure the project's economic viability.

Keywords: energy transition, wind parks and pumped hydro storage hybrid power plants, energy communities, clean energy for EU islands, energy independency and democracy

AGRICULTURAL USES IN A GREENHOUSE STRUCTURE WITH AN INTEGRATED SOLAR DESALINATION SYSTEM ON THE ROOF

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ABSTRACT

The regions of the Mediterranean and North Africa are characterized by intense sunshine with a simultaneous lack of rainfall resulting in a significant reduction in water reserves and limited agricultural activity. Today there are desalination systems that could support the production of water for agricultural uses. However, these systems are still characterized by relatively high installation and operation costs and are not particularly suitable for isolated areas.

The present work proposes the development and operation of an innovative and sustainable greenhouse structure that utilizes its roof for the production of irrigation water, with the method of solar desalination, and simultaneous utilization of the produced water in agricultural activity that can be developed inside and outside the greenhouse structure. The design and operation of this unit aims to produce irrigation water in arid areas, creating significant environmental and social benefits which focus on saving and protecting the water resources of these areas as well as the development of agricultural economic activity in drought conditions.

The main objective of this work is to study the agricultural uses and especially the livestock that can be welcomed by this greenhouse-solar desalination construction. Taking into account the internal environmental conditions (temperature, humidity, ventilation, lighting) that are created in the proposed unit but also those required for animal production, the uses that the specific construction can receive as well as the corresponding design techniques are proposed, in order to achieve the optimal growing conditions of productive animals. The operation of such an innovative greenhouse system for combined agricultural use and irrigation water production through solar desalination creates the opportunity for local communities to benefit from the increase of locally produced products at lower prices, and from the upgrading and utilization of arid areas that previously had no other use.

Keywords: *Arid areas, irrigation water, greenhouse, solar desalination, enhancement of agricultural economy*

2D OPTIMIZATION OF A SMALL HORIZONTAL AXIS WIND TURBINE WITH THE USE OF PASSIVE AND ACTIVE FLOW CONTROL TECHNIQUES

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ABSTRACT

In this work, the optimization of a Small Horizontal Wind Turbine (SHWT) is presented. SHWTs have usually a diameter of 1.5m to 3.5m and a height of 15m. These wind turbines operate at low Reynolds number regimes (up to $1.5x10^6$) and are placed completely inside earth's boundary layer. This environment is characterized by intense and volatile flow phenomena, creating early flow detachment over the blades. In order to counter this flow behavior, a set of flow control techniques is introduced and studied. These techniques can be categorized as passive or active, depending on the need of power to activate or not. Three Passive Flow Control Techniques (PFCT) and one Active Flow Control Technique (AFCT) will be studied. The passive techniques are based on the Vortex Generators (VG), tubercles and winglets. Vortex Generators are vanes or small airfoils positioned vertically on the lifting surface of the blade. Tubercles are a novel PFCT, inspired by the Megaptera Novaeangliae whale's fin, namely a sinusoidal blade leading edge. Finally, a winglet is a wing fence located at the very tip of the blade, a technology already widely used in aeronautical platforms. On the other hand, the AFCT is based on the Dielectric Barrier Discharge Plasma Actuator (DBD PA). This technique adds momentum in the local flow near the blade surface, by ionizing the air. The results from this evaluation are presented in this work. It is concluded that PFCTs and AFCTs can benefit the SHWT, by increasing the aerodynamic efficiency (Lift to Drag ratio) and therefore improving the efficiency of the SHWT. As a result, the performance efficiency factor of the SHWT can also be increased.

Keywords: Wind turbines, CFD, Renewable Energy

RENEWABLE ENERGY SOURCES CONTRIBUTION IN TACKLING WITH THE WATER SCARCITY ISSUE OF GREEK ISLANDS. THE CASE STUDY OF NISYROS ISLAND

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ABSTRACT

The rapid development of the touristic sector that occurred during the last years as also the absence of a central plan for the available water resources efficient and rational management, in combination with the usually low rainfall levels in the Aegean islands, have contributed to water scarcity issues that characterize the majority of the Archipelagos small islands. In an attempt to reduce the environmentally and economically problematic potable water transportation to these islands, originated from either the mainland or other adjacent islands, a significant number of seawater desalination units has been installed the last years, being generally based on the Reverse Osmosis (RO) process.

Nevertheless, the smooth operation of these RO units is strongly related with the consumption of vast amounts of electrical energy, mainly generated at the existing oil-based autonomous Thermal Power Stations (TPS) that have been already installed at the Aegean Archipelagos' small islands. The TPS operation is based on imported diesel oil, resulting in both an economic and environmental burden on the electrical energy consumers not only of the local society, but also of the entire Greek territory, via the pricing policies (Services of General Interest) that have been adopted.

A characteristic example of a small scale Greek island, whose water resources deficiency issue is also intensified by its volcanic origin, is Nisyros island. At the present time, three RO seawater desalination units are operating in Nisyros island, having a total capacity of 1,000 m^3/day. Their annual operation corresponds roughly to 25 % of the entire island's electrical energy consumption (approximately 6,000 MWh_e).

In this framework, the current research work investigates the economically viable and operationally optimum strategies for the exploitation of Nisyros island's Renewable Energy Sources (RES) potential, in an attempt to decrease the diesel oil consumption attributed to desalinated water production. Moreover, in collaboration with the local authorities that in essence support this work, the siting of the appropriate Photovoltaic (PV) systems that exploit the island's excellent solar potential for electrical energy generation is described. The first results that derived from this innovative research work are notably encouraging in terms of the benefits that the local society can attain and further enhance the stakeholders' decision for dedicated supplementary actions towards the accomplishment of the island's maximum electrical energy autonomy, based on the exploitation of the available RES potential.

Keywords: *Seawater Desalination, Electrical Energy, Photovoltaic Panels, Wind Energy, Geothermal Energy.*