Institute of Solar Technology

10th National Conference
On Renewable Energy Sources

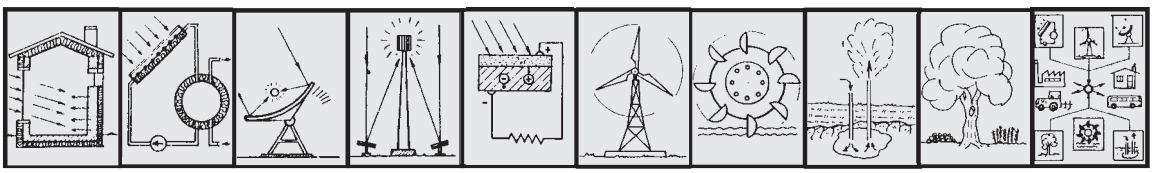
November 26 – 28, 2014

Thessaloniki, Greece

Book of

ABSTRACTS

Thessaloniki 2014



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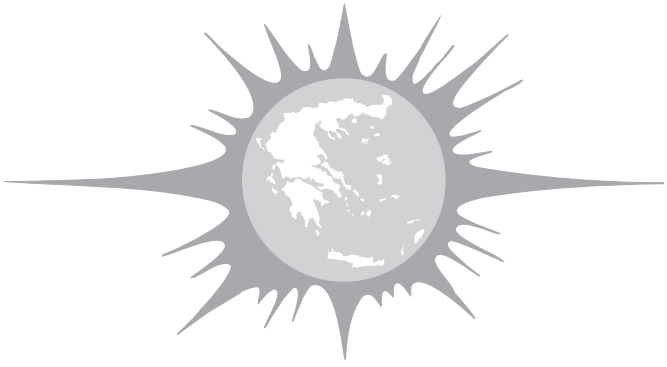

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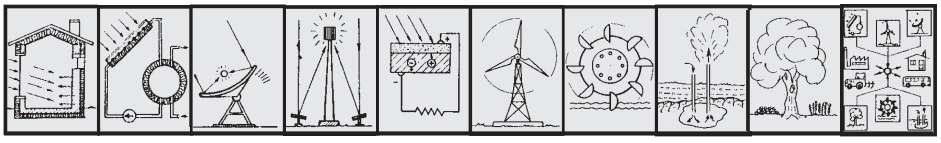

10th NATIONAL CONFERENCE ON RENEWABLE ENERGY SOURCES: BOOK OF ABSTRACTS

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INSTITUTE OF SOLAR TECHNOLOGY

The Institute of Solar Technology (IST) is a scientific and educational organisation established in 1980, in Thessaloniki.

Objectives of IST are:

- To encourage research, development, and use of Renewable Energy Sources (RES).
- To collect and disseminate information in the area of RES utilisation through conferences, seminars and publications.
- To establish international connections and to encourage the transfer of knowledge in the area of RES.
- To elaborate suggestions and energy policy alternatives aiming to promote the diffusion, utilisation and development of RES.

In promoting the above objectives, IST has already organised nine National Conferences on Renewable Energy Sources (in years 1982, 1985, 1988, 1992, 1996, 1999, 2002, 2006, and 2009), where the majority of Greek scientists active in all fields of renewable energies and energy conservation have participated, while more than 900 scientific papers were presented. The proceedings of the conferences present the state of research and work done in Greece in the field of Renewable Energy Sources and its development during the last two and a half decades.

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PREFACE

The present volume contains the abstracts in English of the 114 papers presented in the 10th National Conference on Renewable Energy Sources. The 10th N.C. on RES was organized in Thessaloniki, Greece, November 26-28, 2014, by the Institute of Solar Technology and the Mechanical Engineering Department of Aristotle University of Thessaloniki, in memory of Professor Nikolas Kyriakis, ex-president of IST.

The number of papers, as well as the number of participants, and the variety of the subjects demonstrate the vigour of the work carried out in Greece in the area of Renewable Energy Sources and Energy Conservation.

I hope that the present volume will give the opportunity to colleagues from abroad to assess the state of research and development work in Renewable Energy Sources in Greece, and that it may help the formation of fruitful collaborations.

Finally, on behalf of the Organizing Committee, I would like to thank the Mechanical Engineering Department and the School of Engineering of Aristotle University of Thessaloniki for their financial support.

Assoc. Professor George Tsilingiridis
President of the Board of Administration
Institute of Solar Technology

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AIR TEMPERATURE DATA ANALYSIS OF THE PERIOD 1983-2012 IN ATHENS AND THESSALONIKI CLIMATE CHANGE EFFECT IN GREEK CITIES

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ABSTRACT

Climate change has major influence on urban environment, and will continue to pose challenges in the future. The recorded observations on climate change is in line with the projected increase of the average annual temperature in Europe between 2-4°C until the end of the century, as well as the change of rainfall patterns and the prevalence of drier conditions in the summer months in the Mediterranean and wetter winters in the Nordic countries. The frequency and intensity of extreme weather events such as heat waves and floods are expected to increase in the coming years. The socio-economic impacts of climate change in urban areas are also very important. Demographic changes, such as the increase of the average life expectancy and the intense urbanization will increase the percentage of people who are vulnerable to conditions of high temperature and heat waves, with negative effects on health, productivity, social life and use of open public spaces. Furthermore, high temperatures can cause problems in fields such as transport, energy and water supply, along with an indirect effect on agriculture, tourism, urban microclimate and air quality. The current paper attempts to analyze the ambient air temperature in Athens and Thessaloniki for thirty years, namely the period 1983-2012, in order to explore trends in the two largest Greek cities. Based on hourly measurements of two meteorological stations, of the National Observatory of Athens and the Aristotle University of Thessaloniki, for the relevant period, descriptive statistics were calculated, analyzed and presented such as average minimum, average maximum and average monthly values of temperature, minimum, average and maximum daily values of the three decades (80s, 90s and 00s) and the cumulative frequency of hourly temperatures per decade. The number of days with maximum temperature above 25°C (summer day) and equal or greater than 35°C, in accordance with internationally agreed criteria and indicators, were calculated. The results prove a statistically significant raising trend in temperature values in the studied areas from decade to decade, in addition to the statistically significant increase in the number of days with average above 25°C and with a maximum equal or greater than 35°C. The conclusions drawn are particularly useful for planning and implementing policies of adaptation to climate change in different sectors in favor of environment protection and human well-being.

Keywords: climate change; ambient air temperature; temperature cumulative frequency; extreme temperatures.

HEATING AND COOLING DEGREE-DAYS AS A CLIMATE INDEX FOR CALCULATING ENERGY CONSUMPTION IN BUILDINGS. ANALYSIS OF THE PERIOD 1983-2012 FOR ATHENS AND THESSALONIKI

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ABSTRACT

This study presents annual values of heating and cooling degree-days of the period 1983÷2012, for the two main cities of Greece (Athens and Thessaloniki) and for two typical base temperatures, namely 15ºC for heating and 22ºC for cooling. Degree-days were calculated using hourly dry bulb temperature records from the meteorological stations of the National Observatory of Athens and of the Aristotle University of Thessaloniki. The general conclusion from the evolution of degree-days is that temperature shows a long-term warming trend which is more apparent in the last decade. The average value of heating degree-days in Athens, according to the base temperature, reduced 8%÷22% from 1983-1982 decade to 1993-2002 decade, and 0.5%÷8.5% from 1993-2002 decade to 2003-2012 decade. Also, in Thessaloniki the average value of heating degree-days reduced 4.5%÷9.5% from 1983-1992 decade to 1993-2002 decade and 5%÷10% from 1993-2003 decade to 2003-2012 decade. On the other hand the average value of cooling degree-days in Athens increased dramatically from 25% to 69% through 1993-2002 decade as compared to 1983-1992 decade, and 6%-14% from 1993-2002 decade to 2003-2012 decade, according to the base temperature. The increase in Thessaloniki was 10%-21% from 1983-1992 decade to 1993-2002 decade and 14%-44% from 1993-2002 decade to 2003-2012 decade. The higher percentage variation among summer and winter period shows that the temperatures increased more during the summers than during the winters. Also, the greatest reduction percentages during the heating period are for low base temperatures, therefore winters are milder, while during the cooling period the greatest increase percentages are for high base temperatures, therefore summers are hotter.

The temperature changes are affecting the energy demands of buildings for heating and cooling. In order to evaluate the effect of these changes, the energy consumption in a typical model residential building is estimated with the use of the variable degree-days method and the data sets of the three decades. As far as the rates of reduction in energy demands for heating is concerned, those are 12,65% for Athens and 2.58% for Thessaloniki, from the first to the second decade. Likewise, the rates of decrease in energy demands for heating from the second to the third decade are 3.57% for Athens and 11.63% for Thessaloniki. During the whole 30-years period the total reduction is 15.77% for Athens and 13.92% for Thessaloniki. On the other hand energy demands for cooling increased 32.11% and 8.19% in Athens, from the first to the second and from the second to the third decade respectively, while the corresponding increases in Thessaloniki were 12.23% and 20.36% respectively. The total raise in the 30-years period is 42.94% for Athens and 35% for Thessaloniki.

Keywords: heating and cooling degree days; energy consumption; climate change

PREDICTION OF THE DAILY TOTALS OF THE GLOBAL SOLAR IRRADIATION ON A HORIZONTAL PLANE USING HISTORICAL DATA AND ARTIFICIAL INTELLIGENCE

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ABSTRACT

Solar energy is one of the most promising natural resources, which raising increased interest due to its durability, abundance and cleanliness. Hourly solar radiation received at any location on the globe is very important with regards to solar power installations sizing, simulation of solar energy processes, sizing of thermal storage systems, etc. The aim of this work is the one day ahead forecasting of the daily totals of the global irradiation on the horizontal plane at two different locations within the greater Athens area (GAA), Greece. The two selected locations are Agios Kosmas with an altitude of 6m above sea level (south coastal region of the GAA) and Penteli with an altitude of 729m above sea level (north mountainous region of the GAA). For this purpose, artificial neural network (ANN) modeling techniques were applied. For the appropriate ANN training, hourly values of air temperature, relative humidity, sunshine duration and global irradiation were used, covering a five-year period, 2006-2010. For evaluating the potential of the prediction of the proposed ANN model, the 2011's dataset was used as a testing dataset. The aforementioned meteorological parameters have been recorded by the monitoring network of the Hydrological Observatory of Athens, operated by the National Technical University of Athens (NTUA), covering the six-year period 2006-2011.

More specifically, two different ANN models were developed for each one of the two examined locations within the GAA. The first ANN model predicts the daily sunshine duration (in hours) of the next day. Then, this prediction feeds as input the second ANN model. The second ANN, after the appropriate training predicts the daily total global irradiation, 24 hours ahead. Both models use as input data, during the training phase, local historical meteorological data of the three previous days.

For the evaluation of the predictive ability of the proposed models appropriate statistical indices were used, such as the Mean Bias Error (MBE), the Root Mean Square Error (RMSE), the coefficient of determination (R^2) and the Index of Agreement (IA). Results showed that the proposed ANN model's predictive ability is quite satisfactory at a statistical significant level of $p<0.01$.

Keywords: Prediction, solar irradiation, artificial neural networks

CLIMATOLOGY, MEASUREMENTS AND FORECASTS OF SOLAR IRRADIANCE IN GREECE

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ABSTRACT

This work presents the overall results of a series of researches related to climatology, measurements and nearly real time estimates and prediction of solar power in Greece. The results presented here are based on two on-going research projects: the «Greek Network for Solar Energy» (www.helionet.gr) and the «Direct Normal Irradiance Nowcasting Methods for optimized operation of concentrating solar technologies» (DNICast, http://www.dnicast-project.net) and are related to:

- The climatology of solar energy in Greece for the period 2002-2012 and its evaluation from ground measurements
- The clustering of Greece into areas with different solar energy variation characteristics
- The methodology for the assessment of the near-real time solar irradiance over Greece from satellite measurements with spatial and temporal step of 0.05^{o} and 15 minutes respectively
- The short-term (30-240 minutes) forecasting of the solar irradiance in Greece with the collaborative use of neural networks and satellite images

Keywords: solar energy, irradiance, climatology, forecast

GROUND TEMPERATURE VARIATIONS IN THE METEOROLOGICAL STATION OF NATIONAL OBSERVATORY OF ATHENS FROM 1999 TO 2012

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ABSTRACT

Ground temperature is a crucial factor in a variety of natural phenomena taking place in the ground and in the atmospheric layers close to ground surface. From energy point of view, ground temperature is an index of the thermal energy stored in the ground και its knowledge is a crucial factor for the evaluation of its energy potential as well as in the design and sizing of various thermal systems applications.

Factors influencing ground temperature variations are close related to ground composition, ground surface cover materials – grass, asphalt, other - ground moisture, existing gases, or they are factors close related to the environment, such as ambient air temperature, solar radiation, wind velocity or precipitation.

In this paper the variations of ground temperature at various depths in the Meteorological Station of National Observatory of Athens (NOA) are investigated, in order to evaluate and exploit the thermal energy potential of the ground. For this purpose the ground temperature variations in relation to ambient air temperature is examined, using a multiyear data set of ambient air and ground temperatures recorded in NOA, where time series of ground temperatures in depths up to 1,20 m are available.

Temperature measurements analyzed are hourly values of ambient air temperature and ground temperatures at surface (bare and grass covered) and at depths of 0.02 m, 0.05 m, 0.10 m, 0.15 m, 0.20 m, 0.30 m, 0.40 m, 0.50 m, 0.60 m, 0.90 m and 1.20 m, from 1999 to 2012. Average values for the whole period 1999-2012 are calculated and examined, as well as average annual and monthly values during the considered period.

Ground temperature variations in different depths are analyzed in connection to ambient air temperature. The influence of ambient air on ground temperature and its gradual decline increasing the depth is examined as well as average monthly ground temperature profiles up to 1.20 m. Moreover, time lag of ground temperature in various depths in relation to air temperature is examined.

Major aim of the study is to investigate the relationship between ambient air temperature and ground temperature in various depths, in the specific site, in order to propose simple equations for calculation of the monthly average ground temperatures, which could be useful in technical engineering applications, in conjunction with the air temperature, which is a physical quantity that can easily be obtained from existing meteorological stations.

Keywords: Ground temperature, ground-to-air temperature coupling, ground temperature profile

SIMULATION OF TRANSPORT PHENOMENA IN URBAN AREA

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ABSTRACT

According to the records of the European Union (EU), 40% of the energy consumed in the building sector and concerns besides covering needs heating and cooling. This due to the deterioration of the urban environment because of dense building and the technological means used to achieve internal thermal comfort conditions. The dense construction and lack of greenery are the main causes of the urban heat island effect which stresses large groups of the urban population during the summer periods. The improvement of the situation requires a city level treatment by making the urban free spaces regeneration, tools and means to upgrade the quality of life and living conditions of residents improving the microclimate in the immediate vicinity of densely populated areas.

A modern tool to assist in the investigation and assessment of the beneficial effects of a renewal is the application of computational fluid dynamics (CFD) mathematical models. This can be effective and reliable, depending on the extent of diligent application, which requires a thorough knowledge of theory. Based on the above, in the present work we use the CGF methods for the study of transport phenomena, developed within an urban area of Volos during the summer. It was developed a 3D model to solve the transport equations by the method of finite volumes. In modeling, the thermal buoyancy is incorporated by the Boussinesq approximation, the radiation is solved in two wavelength spectra by the Discrete Ordinate (DO) model, the energy balance model is determining the temperature of the free surface and diffuse radiation emitted therefrom, sources and sinks are taken into account for the heat, momentum and turbulence by the plants-trees evaporo-transpiration, the water elements and the building's heat gains.

Two days are examined; the hottest day of summer and a typical day of summer are steady state simulated at 1 hour intervals. From the produced flow and temperature fields and the calculation of thermal comfort index, cooling power (CP), it comes out that the area suffers from thermal stress due to low air velocities that fail to cool the examined urban environment during hot summer days. The low air velocities are due to the existence of a that deducts the area from sea breeze and due to the dense construction of buildings. This in combination with greenery and shadowed public areas lack and the using of dark colored materials for the ground covering, increase the air temperature levels during the day.

Key words: CFD, urban environment, thermal comfort, radiation

SOLAR ENERGY – THERMAL SYSTEMS

CASE STUDY OF SOLAR ENERGY USE FOR THE THERMAL NEEDS OF FERROUS CASTING INDUSTRIAL UNIT

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EXECUTIVE SUMMARY

According to the energy balance of the country, the participation of industry in total energy consumption is around 25.5%. From the energy consumed in industry, 24.4% is electricity, 71.2% comes from fossil fuels and only 4.4% from Renewable Energy Resources. The looming depletion of energy reserves of conventional fuels of our planet, combined with the ever increasing energy demand and the gradual deterioration of environmental and economic problems, led several companies in the field of industry to both technical conservation and rational use of energy, and the development of mild or Renewable Energy Resources (REC). In energy-intensive industries namely in the sectors of industry with the largest energy consumption, the Energy Management is becoming increasingly important.

According to the Eurostat data for electricity consumption in Greek industry for 2005, energy-intensive sectors are those of non-ferrous metals (mainly aluminum and nickel) and ferrous metals, as their participation in the total consumption of electricity consumption of Greek industry is 44% for non-metallic minerals (mainly cement) with 17%, as well as the sectors of food and tobacco with 13%.

Considering the above data of energy consumption, which was the reason for this investigation, lays as a problem to investigate the possibility of using solar energy for partial or complete coverage of the heat load required while running a casting unit of ferrous metals with the aim of final savings and rational use of energy consumed.

More specifically, examined the direct production of thermal energy by using REC systems to cover part of the thermal requirements of a foundry. For this reason the present research examines the solar systems with the use of concentrated mirrors which can direct heating than photovoltaic or other system where the generated electrical energy is converted indirectly into heat. More specifically, the energy coverage during the heating process of recovery is studied. The dimensioning of solar system and the determination of installation cost completed in accordance with the energy requirements of heating process. It follows the viability study and sensitivity analysis of the proposed investment. It is observed that, the system cannot cover the total required thermal energy for the process, as the maximum temperature of the transfer fluid extruded from the solar field is 390 ^{o}C. Therefore the temperature succeeded inside the furnace via the transfer fluid is even lower, therefore the extra energy required for the temperature rise until 550^{o}C (recovery temperature) will continue to be given from fossil fuel, in the particular case from propane.

Techno-economic assessment of a concentrating solar thermal system for steam production

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ABSTRACT

The 27% of the energy consumption in Europe is industry related. This amount of energy represents thermal energy requiring temperatures less than 100 ^{o}C by 30%, temperatures between 100 and 400 ^{o}C by 27% and higher temperatures by the rest 43%. Regarding Greek industries, heat is generated by the use of cost intensive and polluting fuels like oil and natural gas. Significant climate change and increasing trends in energy costs require sustainable solutions that build on domestic solar resources.

Solar thermal systems can be a reliable alternative for heat production. For temperatures up to 100 ^{o}C, systems made from flat-plate collectors are the most prevalent technology. At higher temperatures, such as up to 400 ^{o}C, solar thermal systems require concentrating collectors in order to reduce heat losses and at the same time to keep the index of utilization of solar radiation high, at the range of 40-60%. Despite the undeniably rich solar resources in Greece, no concentrating solar system has been installed yet.

This publication relates to the techno - economic study of a concentrating solar system for steam generation in an industry with annual and daily loads. The solar system consists of linear concentrating solar collectors, Fresnel type, with diathermic oil as the heat transfer medium. Initially, the potential systems are presented and then the optimal system is selected, for which the dimensioning of the components is implemented. An energy study is carried out using a dynamic simulations computational program. The parametric simulations of the system considered the most important techno - economic parameters, such as collectors' orientation, temperature level and collectors' area. Finally, the results of the energy study are presented in conjunction with a short financial analysis.

This study targets at assessing and promoting the sustainability of innovative solar thermal technologies that surprisingly have no application in Greece.

Keywords: Solar thermal system, Concentrating solar collectors, Fresnel technology, Energy saving, Steam production

SOLAR AIR CONDITIONING SYSTEMS AS A STEP TOWARDS NEARLY NET ZERO ENERGY BUILDINGS

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ABSTRACT

Heating and cooling accounts for a significant proportion of the world's total energy demand. In an effort to reduce CO_2 emissions and promote the use of renewable sources, the EU passed Directive 2009/28/EC. One year later, Directive 2010/31/EC set out minimum rules on the performance of building introducing energy certificates, taking into account external climatic conditions and defining the Nearly Zero Energy Buildings (NZEB). Furthermore, 2018 was set as the year that all new buildings occupied or owned by public authorities ought to be NZEB and the end of 2020 for all buildings.

In order for a building to qualify as a NZEB, it has to present a very high energy performance. Furthermore, the amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby.

Solar collectors for space and water heating have matured significant during the last decades providing a reliable alternative to fossil fuels or electricity and present not only a flourishing market for domestic hot water production and space heating, but also a viable solution towards NZEB.

In the present work, a feasibility analysis was performed concerning a solar combi plus system for a typical three floor residential building located in four cities (Heraklion, Thessaloniki, Athens, Kastoria) covering the four different zones of Greece. The buildings are designed according to the latest national Regulation on the Energy Performance which is in accordance with Directive 2010/31/EC.

For the energy calculations regarding the proposed solar systems and for the buildings heating loads, initially the TEE-KENAK software is used and then TRANSOL, a transient simulation software based on the engine of TRNSYS.

The system is composed of a Li-Br absorption chiller, selective flat plate collectors and a gas condensation boiler backup system. The power of both the absorption chiller and the backup boiler is selected so as to cover the peak heating and cooling loads of the building. The results obtained from the simulation system indicate that solar combi plus systems can contribute to the reduction of fossil fuel consumption in residential buildings, making them a viable solution towards nearly net zero energy buildings.

Keywords: Solar Energy, NZEB, Sustainable Building

HYBRIDE SOLAR TOWER SYSTEMS WITH BURNING OF NATURAL GAS AND FUTURE GROWTH POTENTIAL OF THIS TECHNOLOGY FOR GREECE

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ABSTRACT

The production of electricity in solar thermal power plants, like the solar tower system, is a long-term way for the saving of conventional fuels.

In Germany is since 2009 a solar tower demonstration plant of 1.5 MW for the production of electricity in operation.

In solar tower heliostats concentrate the sun rays to a solar receiver and achieve very high temperatures. This heat is then transferred in a conventional thermal cycle first to mechanical energy and then to electricity in a generator.

The use of air as a heat transfer fluid as well as of porous material as a solar receiver reaches high energy efficiencies.

The solar tower system in combination with hybrid systems like the burning of natural gas can achieve up to 8,000 operation hours a year. Greece has a good

Greece has a good, but until recently undiscovered hydrocarbon potential. In recent months the Greek market research and production of hydrocarbons become very active marking a new beginning in the field of exploitation of hydrocarbon deposits.

The possibility of the burning of conventional fuels or biogas with a solar tower enables the long-term cover of part of the energy needs of Greece from solar thermal concentrated technologies. In an intermediate medium term the installation of hybrid solar tower systems with burning of natural gas can achieve the saving of conventional fuels and the reduction of carbon dioxide in the atmosphere with a reduction of the energy cost.

Especially in Greece, with a significant solar potential the development of this competitive solar technology is imperative, since it is already in other Mediterranean countries and in America a top priority.

Keywords: solar tower, concentrated solar technologies, solar thermal power plants, hybrid systems

ASSESSMENT OF WORKING FLUID MIXTURES FOR SOLAR RANKINE CYCLES

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ABSTRACT

Organic Rankine Cycle (ORC) systems are receiving increased attention worldwide as a power generation technology from low enthalpy heat sources. In this context, solar ORCs are particularly interesting for the transformation of heat into power using different types of sun-to-heat equipment including flat plate collectors (FPC), parabolic trough collectors (PTC) or compound parabolic concentrators (CPC). Their operation is based on the extraction of the collected heat using an appropriate working fluid which is vaporized and subsequently expanded in a turbine to produce work. Clearly, the type of the working fluid and solar collector as well as their integrated operation are crucial decisions affecting the overall system performance.

To date solar ORCs utilizing pure working fluids have been widely investigated due to their simpler thermodynamic and operating characteristics compared to mixed working fluids. An important limitation of pure working fluids is their constant temperature profile during phase change leading to high irreversibility and low exergy efficiency. This results from a pinch point encountered at the evaporator and the condenser, giving rise to large temperature differences at one end of the heat exchanger. To increase power generation most investigated solar ORCs employ PTCs or CPCs as they facilitate the development of higher temperatures even at lower solar radiation. Such systems are of considerably higher cost than the widely available and less complex FPCs, which have received much less attention in solar ORCs due to the low outlet heat carrier temperature resulting in lower power generation. This may be considerably improved by the use of mixtures as working fluids in FPC-based solar ORCs to avoid the emergence of a pinch. This is possible due to the variable temperature profile of mixtures during phase change, avoiding pinches and resulting in lower irreversibility and higher cycle exergy efficiency.

The aim of this work is to investigate working fluid mixtures used in solar ORCs employing FPCs with heat storage. Several different mixtures are considered including conventional choices often utilized in ORCs as well as novel mixtures previously designed using advanced computer aided molecular design methods. The heat storage tank is a vital component of the system to help minimize frequent start-ups of the ORC and maintain a continuous power output, addressing solar intermittence. The proposed investigation considers solar irradiation using actual, hourly averaged data for an entire year, as opposed to the majority of published works mainly considering constant and high solar radiation values. A rigorous model is developed for the FPC system taking into account detailed heat flows and design equipment characteristics. This is complemented by a detailed ORC model emulating all heat transfer and power generation features, capturing the non-ideal mixture behaviour. The obtained results identify mixtures of optimum performance (e.g. maximum power output) in view of intense solar variability.

THERMODYNAMIC ANALYSIS AND PARAMETRIC OPTIMIZATION OF CONVENTIONAL IDEAL THERMODYNAMIC CYCLES SUITABLE FOR THE IMPLEMENTATION ON SOLAR THERMAL POWER PLANTS

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ABSTRACT

In Concentrating Solar Power (CSP) plants, mirrors concentrate sunlight and produce heat and steam to create electricity via conventional thermodynamic cycles. The thermodynamic process, on which the component design of the plant is based, plays a significant role in the optimization of the efficiency of the derived configuration. In the current study, conventional ideal thermodynamic cycles that are suitable for possible implementation in solar power plants are employed for investigation and parametric analysis. Although based on ideal cycles, the analyses are carried out in terms of non-dimensional variables which provide a platform for quick estimates of the effectiveness of free variable deviations from a given “reference” configuration with respect to the cycle efficiency and net work output. In addition, this kind of estimations provide a preliminary picture concerning the “size” and cost of the power plant for a given amount of heat input.

Keywords: Solar Thermal Power Plants, Thermodynamic Analysis, Solar Thermal Power Cycles

APPLICATION OF COMBINED OPERATION SOLAR SYSTEMS FOR THE HEATING, COOLING AND PRODUCTION OF DOMESTIC HOT WATER IN BUILDINGS

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ABSTRACT

The energy policies in Europe include the reduction in energy consumption of buildings along with the environmental impact (focusing mainly on CO_2 emissions). In this framework, various innovative technologies were developed to promote Renewable Energy Sources (mainly solar energy) use for heating and cooling of areas and for domestic hot water production.

The aim of the paper is to describe in detail the characteristics of combined operation solar systems for the heating and cooling of areas, as well as for domestic hot water production (Solar Combi and Solar Combi+ systems) in comparison to the existing technologies and highlight their applications in Greece and Europe. A thorough description of Solar Combi and Solar Combi+ systems, their respective components and their different types found in the market will be introduced. During this study, the applications that have already taken place in Europe will be identified and discussed, followed by the exploration of similar applications, or potential for applications, in Greece.

The main goal of this paper is to compare the technologies of Solar Combi and Solar Combi+ systems with the conventional technologies already applied in buildings. The comparison will be on the basis of structure and technical characteristics of the systems, the potential energy-saving achieved from their application and the economic and environmental efficiency.

Keywords: Solar Energy, Solar Combi Systems, Solar Combi+ Systems

DRYING OF HEAT SENSITIVE AGRICULTURAL PRODUCTS WITH SOLID DESICCANT MEDIA. POTENTIAL OF SOLAR THERMAL ENERGY UTILIZATION

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ABSTRACT

Conventional drying methods are not proven to be suitable for a variety of agricultural products which exhibit high sensitivity to the drying conditions. Aromatic and medicinal plants, seeds, cereals etc. constitute a large part of global agricultural production, which requires special treatment during drying.

Although the positive effects of the use of desiccant media in applications such as air conditioning have been investigated in the relevant literature, the same cannot be stated for their use in drying and especially in the drying of heat-sensitive agricultural products; the latter constitutes a field of high R&D prospects.

The use of desiccant media concerns the removal of moisture from the supplied hot air stream; in accordance with Fick's second law, the capacity of the air-stream on the removal of moisture from the drying product increases. Thus, it can be possible to implement drying at lower temperatures (or air-flow rates), while contributing, due to the reduction of drying time per cycle of operation, to the increase of productivity as well as to the potential replacement of the conventional heat source by solar collectors.

In this work, the design of the implementation of a silica-gel desiccant wheel to a dryer is presented. Operation of the dryer is studied with regard to an appropriately developed model. The case study of a heat-sensitive agricultural product, this of the seed of canola, is examined. The results are compared with those of a conventional dryer.

As the level of silica gel regeneration temperature allows the exploitation of solar thermal energy, the results by the connection of the desiccant dryer with a particular air collector are presented; the collector has been experimentally assessed for its ability to meet the requirements of the process.

Keywords: drying, heat-sensitive agricultural products, desiccants, solar energy, air-collector

ESTIMATION OF SOLAR PROCESS HEAT POTENTIAL FOR GREEK INDUSTRIES AND INDUSTRIALS PROCESSES

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ABSTRACT

In the future, the solar energy will be mainly used to directly meet the heat demand across the world. Industry represents a very promising application area for the utilization of solar thermal technology, since it accounts for 25.6% of the total final energy consumption in Europe. Greek industry accounts for 17.83% of the total final energy consumption of Greece. The head demand of the Greek industrial processes is estimated at 47.07% of the total final energy consumption of the Greek industry in 2011. Within this paper, the theoretical and technical potential for the utilization of solar process heat technologies in Greek industries is estimated. Additionally, the most promising industrial sectors and industrial processes of Greece are also identified. The Food, Drink and Tobacco industrial sector is undoubtedly the most important sector of Greek industry in terms of solar process heat technology utilization. The technical potential of total of 2.1 mio m^2 solar collectors that is estimated in this paper, indicates the particularly important future market for the development of solar thermal technologies in Greece.

Keywords: Greek Industry, Solar process heat, Industrial processes, Solar thermal technology

EFFECT OF A DIFFUSE POLYETHYLENE COVERING FILM ON GREENHOUSE AND CROP LIGHT ENVIRONMENT AND ON TOMATO CROP PRODUCTION

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ABSTRACT

High solar radiation levels occurring during summer in Mediterranean regions force greenhouse growers to apply shading usually from May to September. If no shading is applied the direct light entering the greenhouse may cause sunburn problems to the crop. Diffusing cover materials improve the uniformity of vertical light distribution in a crop; therefore decrease the energy load on the uppermost crop layer to the advantage of the underlying leaves avoiding light saturation in the upper leaves. These properties my lead to production increases of up to 10%. Diffusion, however, usually implies a loss of overall transmission. Thus, aim of this work was to study the effect of a diffuse polyethylene (PE) film on greenhouse light and crop microclimate and on leaf photosynthesis and crop production and the results where compared with those found in a greenhouse covered by a common PE film with no diffusion characteristics. The films were evaluated in the laboratory and experimentally in two similar arched roof greenhouses, one covered with a diffuse (D-PE) of a common PE film (C-PE). The greenhouse and outside microclimate parameters along with crop photosynthesis, growth and production were recorded. Experimental results show that the D-PE covering material reduces about 20% the solar radiation entering the greenhouse compared to the C-PE film. However, it results in a more homogeneous light distribution along the different levels of the crop. The photosynthesis rate measured at three different heights of the crop (bottom, middle, top) where found similar for the case of the crop grown under the D-PE film while under the C-PE film the crop had high photosynthesis rate for the top leaves and much lower photosynthesis rate in the bottom leaves. The different light distribution at the three crop levels affected also the quality of the fruit produced, since the fruit grown at the top of the plant during May and June under the C-PE greenhouse where affected by sunburn and blossom end rot, something that resulted in lower crop production under the C-PE greenhouse during the spring –summer experimental period.

Keywords: light transmission, light intensity, light quality, diffuse light, plant photosynthesis, crop development

SOLAR ENERGY – PHOTOVOLTAICS

PV PERFOMANCE IMPROVEMENT BY USING DIFFUSE REFLECTORS AND PASSIVE COOLING TECHNIQUES

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ABSTRACT

In this paper, some techniques for the improvement of electrical output of PV modules are presented. The suggested techniques are based on the increase of solar input to PV modules and of passive cooling. The increase of incoming solar radiation is achieved by using diffuse reflectors, combined with the PV modules installed on ground or horizontal building roofs. The passive cooling of PV modules is adapted with new arrangements of direct and indirect cooling. Regarding the PV direct cooling, a low cost cooling system consisting of a plastic pipe attached to the PV module back side, was performed. In addition, thermo-storage plates at PV module back side were mounted and tested. These plates can use their mass to store the extracted heat from PV module and keep it as cooler as possible. For the indirect PV cooling, the increase of thermal radiation from PV module rear surface to the ground or to the horizontal roof was applied, by cooling the ground or building horizontal roof, to keep a lower than ambient temperature. In addition to above, a hybrid PV/T system was tested as single as well as combined with a diffuse reflector. The experimental results showed that the applied techniques resulted to 5%-10% PV performance improvement, except the use of the thermo-storage plates, which contributed to PV module cooling only for the first part of the daytime and therefore some additional improvements are required. The application of diffuse reflectors was successful in all cases, resulting to a 30% performance increase of PV modules.

Keywords: Photovoltaics, Booster reflectors, PV cooling, Performance improvement

CONCEPTUAL DESIGN OF A SOLAR-POWERED UAV

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ABSTRACT

In the present paper the conceptual design of a hybrid solar-powered Unmanned Aerial Vehicle (UAV) is presented. Key features of this innovative concept are enhanced endurance, use of renewable energy sources and reduced emissions. It is capable of covering a wide range of applications, such as fire detection, sea-lane monitoring, border surveillance, sampling and analysis of atmosphere for forecasting and environmental purposes, rescue missions and communications. In this work, the aircraft's configuration layout, along with the main geometric parameters, is defined. The presizing procedure, including the basic weight and performance estimation methods, is presented and analyzed, focusing on power management and aerodynamics. CFD computations are employed as well, in order to analyze the flow field and calculate the aerodynamic coefficients. The hybrid propulsion system study, the sizing of the batteries and the selection of suitable solar cells, are also some important aspects of this work.

Keywords: Conceptual design, UAV, CFD, renewable energy, solar cells

DESIGN AND EXPERIMENTAL EVALUATION OF A LINEAR CONCENTRATING PHOTOVOLTAIC/THERMAL SYSTEM

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ABSTRACT

The design and experimental evaluation of a linear-focus Concentrating Photovoltaic Thermal (CPVT) system are presented in this study. The system under evaluation comprises three discrete components namely, a parabolic trough, which serves as the irradiation concentrator, an array of solar cells (module) and a heat sink for the extraction of the excess heat. The two latter components are in thermal bond through a heat-conductive epoxy resin (k=4.5 W/mK) and constitute the receiver of the system. The active aperture of the system module is equal to 1.0m^2, while the active area of the receiver is equal to (0.06 x 0.5) m^2 and thus the system geometrical concentration ratio results equal to 33. Two variations of the solar cell module were examined with cells of width equal to 40.0mm and 60.0mm, respectively, in order to illustrate the effect of the cell width on the system overall performance.In addition, two different heat-sink designs were considered as cooling devices, namely with fixed-width (FW) microchannels of constant hydraulic diameter (D_h=0.966mm) and with channels of stepwise-varying($D_{h,1}$=7.013mm, $D_{h,2}$=3.533mm, $D_{h,3}$=1.064mm) channel width (VW).Initially the concentrator optical quality was evaluated through experimental measurements and ray-tracing simulations. The irradiation distribution on the system receiver was measured through a custom-made device using photodiode sensors and the data were compared against ray-tracing predictions. It was established that due to distortion of the concentrator parabolic shape, the distribution exhibits two irradiation concentration peaks, while the receiver intercept factor was calculated approximately equal to 0.57. In reference to the solar cell performance, the effect of the operating temperature on the electrical output was examined and the temperature coefficient (β) was determined for two solar-cell modules.The heat-sink configurations were evaluated in terms of thermal resistance and pressure drop induced to the cooling fluid. The experimental results showed that the FW configuration attains lower values of the thermal resistance due to the larger overall area available for heat transfer in comparison to the VW design. An interesting finding of the evaluation was that the thermal resistance values obtained for the VW configuration remained relatively unaffected by the flow rate of the cooling fluid for the range of flow rates considered (20-40 mL/s). This distinct behavior was attributed to the transition of the flow and heat-transfer conditions within the device from forced to mixed-convection. At a final stage, the electrical and thermal performance of the system were measured for an extended range of operating conditions. The system obtained peak overall efficiencies are approximately equal to 50% for both variations of the receiver that were examined.

Keywords: concentrated solar power, photovoltaic/thermal system, cogeneration, active cooling, microchannels

EVALUATION OF PHOTOVOLTAIC POWER PLANTS IN CRETE BASED ON THE LEVELIZED COST OF ELECTRICITY - GRID PARITY

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ABSTRACT

Over the coming years, the installed capacity of photovoltaic (PV) systems is expected to increase further through the net metering systems. However, questions are raised in relation to the competitiveness of PV power compared to the existing system (mainly from conventional sources).

The aim of this research project is the analysis and evaluation of PV power plants in Crete for the sustainable development of the PV sector, taking into account the impact of the existing grid of the PV operation on it.

The evaluation is done by utilizing the method of the Levelized cost of electricity (LCOE). In this research various economic parameters and parameters related to the transmission and distribution are analyzed. The purpose, with the help of the analysis, is to quantify the so called 'Grid Parity', as well as the benefit from the investments in PV sector in Crete.

By the term 'parity' the competitiveness of PV systems output compared to other sources of electricity is defined, in order to ensure the orderly development of the sector, by developing frameworks determined by the bidirectional benefits resulting (Producers- Electrical grid)

At the end of this research various scenarios are generated to assess systems in different situation on the grid as well as alternative policies that can be developed for their sustainable development.

Keywords: LCOE, Parity, Grid, PV, IRR, net-metering, PV competitiveness

SOLAR TRICYCLE FOR URBAN USE

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ABSTRACT

This project was developed on the basis of urban green transportation in order to obtain a zero-emissions vehicle that could use photovoltaic panels. Because of the space needed for the PVs, the core idea is to design a Three Wheeler (tricycle) with Front Wheel Drive, since the motor was located in the front wheel. On the contrary of what the most of the commercial electric bikes do, this vehicle would not use grid electric power, being charged only through renewables (PVs) in order to be completely environmental friendly. For the sake of comparison, two different configurations carried out: the first was supplied by a 36VDC/500W hub motor along with three 12V/18Ah batteries connected in series, while a sophisticated rear axle with mechanical differential has been implemented, as well. The second one was powered by a 24VDC/500W hub motor along with two 12V/18Ah batteries, having totally independent rear suspension with swing-arms. Both configurations were integrated with electric brakes (front) and a double - disk brake system (rear). In order to test the vehicles, tree different patterns for typical users have been selected: (a) unstoppable use, (b) regular urban use, and (c) normal employee transportation. In all cases and independently of the solar radiation intense, both configurations presented good performance, being able to cover normal urban transportation. More precisely, the 24VDC vehicle found sufficient for all the above described patterns of usage, thus underlying that grid charging is completely unnecessary.

Keywords: Electric Vehicle, Hybrid Solar Vehicle, Zero-Emission, Photovoltaic, Solar Energy

COMPUTATIONAL ANALYSIS OF PARABOLOID CONCENTRATOR WITH PASSIVE-COOLING PHOTOVOLTAIC CELL

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ABSTRACT

Photovoltaic systems have become a mature technology for the renewable production of energy. Today, the cost of photovoltaic cells remains high and -even with the significant reduction of production cost - further reduction is required. This target can be achieved with the use of concentrating photovoltaic systems, where a suitable optical system concentrates solar light into special, high efficiency, photovoltaic cells. This paper outlines the investigation of an elliptic parabolic reflector which concentrates solar radiation on a trapezoidal homogenizer and then on a concentrating photovoltaic cell, which is attached on suitable passive cooling heat sink. For the analysis of the optical system, Monte Carlo Ray Tracing method is applied and the calculation of the concentration ratio and the homogenizer losses is performed. The analysis of the cooling system is being conducted with the finite element method, through which the geometry of the heat sink is being investigated with regard to system efficiency. Finally, the suitable combination of these methods drives the results for the energy production of the system.

Keywords: Concentrating Photovoltaic Systems, Optical Analysis, Thermal Analysis, Simulation

TRANSPARENT DYE-SENSITIZED SOLAR CELLS IN LARGE SCALE FOR INTEGRATION AND ENERGY HARVESTING IN BUILDINGS

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ABSTRACT

Dye sensitized solar cells (DSSCs) for almost two decades ago were proposed as low cost alternatives to the conventional amorphous silicon solar cells, owing to the simplicity of their fabrication procedures, practically under ambient conditions with mild chemical processes. DSSCs are placed in the category of third generation photovoltaics where new trends and materials in the photovoltaic technology are applied. 3rd generation solar cells, are based on nanostructured (mesoscopic) semiconductors and they are made of purely organic or a mixture of organic and inorganic components, thus allowing for a vast and inexhaustible choice of materials. Because of their mesoscopic character, it is possible to make transparent solar cells, which can be used as photovoltaic windows. Photovoltaic windows can be functioned by front-face light incidence but also by diffuse light and even by back face light incidence. Also because of their mesoscopic nature, 3rd generation solar cells are easy to make at ambient conditions, not necessitating severe measures of purity, thus dropping production cost. Among the different possibilities of 3rd generation solar cells DSSC have the most promising prospect. The overall efficiency of ~12% (for laboratory small size) placed DSSCs as potential inexpensive alternatives to solid state devices.

At the present work, we developed strip like dye-sensitized solar cells, which are the structural units for big size solar cells and modules, keeping width constant and changing the strip's length. Cell performance parameters that were either measured or calculated, included short-circuit current (I_{SC}), open circuit voltage (V_{OC}), maximum power (P_{max}), fill factor (*ff*) and overall cell conversion efficiency from which we concluded that the size of the cells doesn't affect the cell's performance, which is a great advantage for their commercialization. Furthermore, electrochemical impedance spectroscopy (EIS) measurements were carried out in order to determine the DSSC's equivalent circuit. Using the impedance measurements it is possible to define the resistance of the sheet resistance of the FTO substrate and the contact resistance of the FTO/TiO_2, the charge transfer resistance at the counter electrode, the charge transport resistance at the TiO_2/dye/electrolyte interface and the resistance attributed to the diffusion in the electrolyte. The experimental investigation of the cells was completed with cyclic voltammetry measurements to determine the standard potentials of redox processes and to obtain information on the reversibility of the electron transfer process.

Keywords: Dye sensitized solar cells, transparency, energy saving, organic inorganic materials

EXPERIMENTAL PERFORMANCE OF A GRID CONNECTED PHOTOVOLTAIC PLANT OF 97 kWp

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ABSTRACT

In the six years 2008-2013 there was a rapid installation of interconnected photovoltaic-power plants in Greece, due to high tariffs for energy production and simplified license procedure. The installed photovoltaic plants capacity has increased from 11MW in 2008 to 2579MW by the end of 2013, while investments in these six years reached 5 billion euros. The production of electricity as a percentage of the total energy produced by 6.7% in 2013.

This paper involves the study of an experimental performance of a grid-connected photovoltaic plant of a 97kWp capacity located in Rodopi, in Northern Greece operating from November 2012 and consists of polycrystalline photovoltaic modules of nominal capacity of 245Wp, five three-phase power inverters of 17kW and one of 15kW. The design and construction has done with the implementation of best practices (e.g. minimization solar shading, electrical losses, sorting of photovoltaics panels etc.) and the energy efficiency in 2013 was 1562 kWh/kWp.

Furthermore, there is an a established weather station for the recording of the solar radiation and wind speed at the level of photovoltaic plants and the ambient temperature and the photovoltaic panel temperature. These data are collected every 15min and stored in memory card and is available via web portal. The processed experimental data used to evaluate the performance of the photovoltaic plant, for a period of one year in which there is a smooth operation of all sensors.

In addition, there is a study of the impact of global solar radiation, ambient/photovoltaic panel temperature and wind speed on the performance of the photovoltaic plant and it is presented in charts, the correlations of these parameters with the produced electrical energy. These diagrams provide important information on the performance of photovoltaic plant and can be used for monitoring and evaluation of operation of photovoltaic plants.

Keywords: experimental evaluation, photovoltaic plants, weather station, measurements.

FABRICATION AND CHARACTERIZATION OF NOVEL TYPES OF DYE-SENSITIZED SOLAR CELLS

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ABSTRACT

Photovoltaic devices with nano-porous titanium dioxide (Ti O_2) were fabricated to improve the sensitized solar cells efficiencies by increasing the TiO interface area. In the present work a viscous paste from commercially-available P-25 titania nano-powder was prepared, by a simple chemical technique, in order to fabricate electrodes for Dye-Sensitized Solar Cells (DSSCs). The nano-porous semi-transparent TiO_2 films, about 30 μm thickness, were fabricated by "doctor blade" technique on conducting glass substrates (Fluorine doped Tin Oxide, FTO Glass), or on conducting plastic substrates (Indium Tin Oxide, ITO PET). By the use of these two different conducting substrates to DSSCs a study was performed on the effect of their use to the cells efficiency. As regards the manufacturing process of the electrodes, the glass electrodes were sintered at 500^{o}C for 30 or 90 minutes and the plastic at 80^{o}C for a corresponding time, and then the electrical characteristics of the cells, that were used, were measured and compared with cells of which electrodes had not undergone a previous annealing. The results showed that the annealing process had a significant impact on the cells efficiency, as these photovoltaics cells showed incomparably better electrical characteristics than the previous ones. Regarding the sensitization of TiO_2 films, measurements were taken of the electrical characteristics of the cells, whose electrodes were subjected to different technique and time of sensitization of the films by the dye in order to study the effect of this process on the efficiency. Besides all above, different types of counter electrodes were fabricated and after that were studied, by depositing graphite or Multi-Wall Carbon Nanotubes (MWCNTs) on conductive glass or plastic surface for the intended use of them at low cost, without platinum counter electrodes of DSSCs. The results showed comparable efficiencies of these cells with the cells whose counter electrodes were factory made by platinum. Lastly, polymer electrolytes of different compositions were prepared, consisting of polyvinylpyrrolidone (PVP), potassium iodide (KI), iodine (I_2), and ethanol or methanol as solvents and then were used in the fabrication of solid-state DSSCs. The results of their application compared with corresponding type of cells that were fabricated by available factory made liquid electrolyte. The experimental characterization of the cells included measurements of short-circuit current and open-circuit voltage, as also the determination of the maximum efficiency under real test conditions for various active areas of the cells, studying additionally the influence of this factor on the photovoltaic effect. Experiments were performed also on the operation of the solar cells under different intensities of incident solar radiation.

Keywords: Dye-sensitized solar cells, P25 TiO_2 powder, Polyvinylpyrrolidone, Carbon nanotubes, Graphite

APPLICATION OF PHOTOVOLTAIC ELECTROCOAGULATION FOR REMOVAL OF NICKEL FROM ELECTROPLATING WASTEWATER

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ABSTRACT

Nickel is one of the most toxic heavy metals and widely used in galvanic plating. Nickel electroplating effluents contain up to 500 mg/L Ni^{2+} ions, which must be controlled to the admissible limits (2 mg/L) prior to discharge to the environment.

In this work the process of photovoltaic electrocoagulation is presented, which combines the autonomous and environmental friendly photovoltaic solar energy and the electrocoagulation process aiming to the effective removal of nickel from electroplating effluents.

The photovoltaic array can be connected directly to the electrocoagulation reactor without batteries increasing, in this way, the system sustainability and eliminating the environmental threat of improper battery disposal. The photovoltaic module used was ECO LINE 72/185-200W made from monocrystalline silicon.

The experiments were conducted in Kavala Institute of Technology (latitude 40˚ 55΄, longitude 24˚ 22΄ and altitude 138 m above the sea level). The photovoltaic electrocoagulation system is made versatile according to the instantaneous solar irradiation by adjusting the wastewater flow rate to the current intensity supplied by the photovoltaic array.

All operating parameters affecting the efficiency of the proposed process, such as, pH, wastewater conductivity, flow rate, current density, electroprocessing time and solar irradiance were studied and optimal conditions were investigated. The removal of nickel is very high in the pH range 4-10. The experimental results showed that by applying a current density of 30 mA cm^2 the nickel ion concentration in the treated electroplating wastewater was effectively reduced from its initial value of 96 mg L^{-1} to the permissible limit, amounting to a removal percentage of over 99%. The corresponding electrical energy consumption was 12,5 kWh per m^3 of treated wastewater. The proposed process is appropriate for remediation of industrial wastewaters laden with heavy metals, such as nickel and especially for small applications in remote and isolated locations without connection to the public electric grid.

Keywords: electrochemical coagulation, electroplating effluents, heavy metals, nickel, photovoltaic solar energy

On the Use of Photovoltaic Systems for Drip Irrigation

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SUMMARY

The use of Renewable Energy Sources (RES) is considered as the most effective solution to encounter energy problems today. The interest in the wider use of RES is constantly growing and the development of new innovative technologies is strongly encouraged. In particular, the Photovoltaic Systems (PV) can be used in a wide range of applications and for a variety of purposes.

The greenhouse gas emissions have been significantly increasing in recent years. The main cause of this change is the increase in emissions due to activities of the energy sector. The use of solar energetic collectors to replace the electricity can lead to various environmental benefits.

In the agricultural sector an important application of PV is for pumping water for irrigation especially in remote areas lacking electricity grids (mainly in developing countries such as India and African countries). Energy requirements increase mainly in the warmer months of the year when solar energy availability is high. At the same time, a PV system can be completely independent as the need for energy storage can be minimised if a provision for water storage is made, which in such facilities is rather necessary. Thus the available solar energy can be used for water pumping and storing it for use at periods with little or no sunshine. Such systems are widely used for crop watering in Spain and Italy.

Modern irrigation systems use pressure to raise and distribute water through pipes and rubber hoses directly to the roots of crops or watering plants in selected areas (spraying or dripping). The water is supplied by pumping (directly from the pump) or by making use of the gravity from a raised tank or by using both (pumping the water in the tank and with a pressure distribution on the pressure assist, particularly at levels plots). Any low pressure drip irrigation system can use photovoltaic pumps for better pumping and for optimizing the crop irrigation. If a pump directly connected to a photovoltaic system is selected, the use of a controller for more stable pressure and flow is required.

The aim of this paper is to investigate the technical and economic aspects as well as the environmental impacts of the implementation of an autonomous solar energy power supply system for the irrigation in areas where no electric power supply facilities are available nearby (central power grid) and irrigation is currently facilitated mainly by fossil fuel powered individual pumps. An algorithmic approach is proposed for the calculation of the best PV system deployment. The use of photovoltaic elements in such areas may be economically viable and offer an environmentally friendly solution. The environmental impacts mainly refer to greenhouse emissions reduction and fossil fuel depletion prevention. On the other hand, adverse impacts (not easily quantifiable now) may result from PV material waste removal or recycling at the end of their life.

WIND ENERGY

ENERGY GARDEN. A HARMONIOUS COEXISTENCE BETWEEN AGRICULTURE AND WIND ENERGY

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ABSTRACT

The development of wind energy in Greece took place primarily on hill tops and along mountain ridges where the resource is favorable in comparison to plains. With the excellent sites now occupied by 1902 MW of operating wind farms and taking into account the country's obligatory target for 7500 MW of wind development by the year 2020, there is an urgent need to investigate other areas that are used for agriculture or cattle grazing today.

The paper presents an example of a plain area measuring 5 by 5 km where there are mainly olive trees and agricultural land. The evaluation of the wind recourse is based upon experimental data and the use of the CFD algorithm Windsim. Energy calculations are performed for a wind farm design that takes into account all the environmental restrictions regarding distances from towns, monuments, roads etc. Aerial photography was used in order to calculate the number of trees needed to be cut or replanted.

With commercial wind turbines ranging from 1.8 to 3 MW, the results show that it is possible to design a 150 MW wind farm with very favorable capacity factors. The land use for such a project amounts to only 2% of the available land, thus making the coexistence of agriculture and wind energy production an ideal match.

The success of such a project will and should depend upon the cooperation and general consent of the local population. The acceptance by the locals of a wind farm among their fields will benefit both the developers and the community financially, as well as environmentally. The energy gardens are the only sustainable way for the reach of our renewable targets in a way where the local communities become the protagonists of the renewable future and the protection of the environment.

Keywords: wind energy, agriculture, wind farms, social acceptance

COMPARISON OF ESTIMATED ENERGY PRODUCTION OF A WINDFARM TO THE REAL ENERGY PRODUCTION PER YEAR FOR A PERIOD OF 14 YEARS

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ABSTRACT

The differentiation of the actual energy production of a wind farm when compared with the energy calculations that were originally assumed in order for the project to be initially developed and eventually built constitutes an major issue for the wind energy research community mainly due to the rapid development of the wind power globally.

In recent years due to the rapid growth of the wind energy sector, the requirements of the financial institutes have increased as a result; to have a focus on accuracy and reliability of the assessment of the wind resource and the energy production and the export of uncertainty. The questions concern the wind energy market worldwide is whether the energy output of the wind farm is within expectations, there is under-estimation or over-estimation and if you can adopt commonly accepted methodologies and practices that contribute to reliable estimation of energy production of a wind farm for the duration of its operation.

Also at this year's Conference and Exhibition of the European Wind Energy Association (EWEA 2014) held in Barcelona, there was unity talks and posters on the evaluation of the estimated and real energy production of windfarms which was attended by authors publishing in poster form.

This paper discusses the methodology for the preparation of a comprehensive energy study and wind potential assessment using the state-of-the-art computational tools available today (DTU Wind WAsP & EMD WindPro) and long-term mesoscale data with high spatial and temporal analysis.

The study was carried out on an windfarm with nominal capacity 1,5 MW in South Evia island consisting of two (2) wind turbines, using wind measurements onsite. Furthermore, a comparison of the estimations of the energy production to energy production in the respective years 2000-2013, setting appropriate correction factors so that the comparison to be accurate and reliable. The aim is to be extracted specific conclusions about the differentiation of the energy results and the reasons.

The comparison of the estimated energy production with the actual one from an operating windfarm in Greece located in complex terrain, operating for 14 years, offers useful conclusions that will further help to improve the accuracy of the calculations and will identify critical factors that should be taken into account in the calculation, but also during operation of the windfarm.

Keywords: energy production, comparison, wind potential.

COMPARATIVE TECHNICAL-ECONOMICAL ANALYSIS OF GRID CONNECTION OF WINDFARMS & PERFORMANCE OPTIMIZATION OF THE INVESTMENT

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ABSTRACT

This paper focuses on the techno-economic investigation of the best grid interconnection to the grid. It examines alternative interconnection solutions to the grid (eg cable conduits with different material or section) in relation to their costs and expected energy losses on interconnection lines.

For the economic evaluation of alternative scenarios, it is applied the widely used index for investments evaluation, the Net Present Value (NPV).

This study is extremely important because in some cases the initial investment cost seems higher, the techno-economic analysis of the project life cycle shows that the interconnection of the wind farm could be implemented in a cost effective manner. Thus, a tool for investors to maximize the benefits of their investment is given.

Keywords: interconnection of windfarms, technical-economical investigation, NPV

COMPARATIVE EVALUATION OF EMPIRICAL DESIGN METHODS FOR HYBRID POWER SYSTEMS

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ABSTRACT

Last years the interest about hybrid autonomous power systems has been renewed not only for use in isolated areas due to the reduced cost of renewable energy systems' units (PV, wind turbines, etc) and due to the increase of conventional energy cost (fossil fuels, electrical energy). Although the last years' research has lead to the development of design algorithms the empirical design rules that have been developed in the past and considered mainly autonomous systems are still considered useful and an important design tool for an initial sizing.

In the present work was examined the possibility of using some of those methods in the initial design stage of a hybrid power system (HPS) that exploit more that one renewable energy sources (RES), energy storage system and fossil fuel unit. Initially the analytical models were used for the sizing of each component separately and then the HOMER software was used for the optimization of the initial design using techno-economic criteria like the cost of energy produced (COE) and the ability of the designed system to cover the load.

Two types of loads were examined: a) constant load in daily, seasonal and yearly base, b) daily seasonally fluctuating and load. Both applications were examined for combinations of three different solar potentials, two wind potential and two basic HPS design with and without wind turbine (WT) in the case of very low wind potential.

From the results it comes out that the choice of best method depends on: a) the time profile of load and mainly on the fluctuation existence and type (daily, seasonal etc), b) from the composition of the HPS and c) from the available renewable energy potential. As far it concerns the PV it was proved that best results were given from the Ah or/and Wh method. The best method for the batteries sizing is the Ah or/and the Wh method considering one day autonomy. It is recommended the sizing of diesel Generator only for batteries' charging. The examined method gives satisfactory prediction for the case of timely constant load but overestimates the sizing in the case of fluctuating load. Finally the examined method for the WT sizing gives satisfactory results in the determination of power curve for the case of low wind potential but fails in the nominal power prediction.

Key Words: Hybrid Power System, Renewable Energy Sources

AERODYNAMIC ANALYSIS AND DESIGN OF SMALL WIND TURBINES WITH SHROUD

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ABSTRACT

Small wind turbines can be an important economic and convenient source of energy for buildings. In urban areas air flow encounters major obstacles such as the existence of building complexes of different height and density. For this reason, the air flow conditions are unstable, with large variations in both magnitude and direction of velocity and with high turbulence intensity. Therefore, under these conditions the range of the wind turbine efficiency is large.

However, one of the methods developed to increase the efficiency of horizontal axis wind turbines and to overcome the theoretical Betz limit is the introduction of a converging-diverging shroud around the turbine. This technique can also be applied to vertical axis wind turbines and through building integration it can take advantage of existing geometric features of a building.

The purpose of the present research work is the aerodynamic design and computational analysis of such an arrangement with the use of Computational Fluid Dynamics (CFD). To further improve the performance of the shroud a flange is placed at its diverging outlet, which smoothes the flow along the diffuser interior, allowing larger diffusion angles to be utilized. By varying the outer diametre of the flange and the wind speed, the effects of the above on the flow field and the power coefficient of the turbine were investigated.

The computational study was performed using the commercial CFD software package ANSYS CFX and by applying appropriate turbulence models. The results showed that the introduction of the shroud causes a considerable improvement in the performance of the wind turbine and the proposed modification is particularly attractive for small wind turbines. A detailed flow analysis was undertaken and the reasons for the aforementioned improvement are identified and discussed.

Keywords: wind turbines, flanged shroud, Betz limit, Computational Fluid Dynamics, power coefficient optimisation

TORNADOES, WATERSPOUTS AND WINDFARMS IN GREECE – DANGERS AND CONSEQUENCES

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ABSTRACT

Tornadoes and waterspouts occur in various parts of Greece and the research of recent years has shown that it is not as rare as previously thought. Research and systematic recording began in Greece in 2000 and carried out systematically in the last 14 years. Based on this data, tornadoes and waterspouts or tornado funnel clouds occur at about 50 days a year, on average. Analysis of the geographical distribution showed that tornadoes appear almost in all areas, but with a greater frequency over the Ionian islands, the coastal areas of Western Greece and the low elevation areas of Macedonia and Thessaly, and the sea areas of northern Crete and Rhodes islands. Regarding the strong and highly destructive tornadoes ie.at least F2 intensity of the scale Fujita, they appear on average six days a year in various areas of the country.

Wind turbines are classified into three IEC classes depending on the wind potential in the installation location (Class 1: high wind potential class 2: moderate wind potential and class 3 for low wind potential). The standard IEC 61400-1 sets out the factors to be tested for the installation of a windturbine through site compliance study. The study was carried out for the type of windturbine for a given installation area of a wind farm and the particular location based on the design limits of the windturbine. The design of windturbine guarantees that can safely withstand the environmental conditions of the installation area.

One of the most important factors of the compliance study for the windturbines is the estimation of extreme wind values (Vref- speed reference class (10min). A windturbine is designed for a class with the reference speed Vref is expected to operate safely in climatic conditions where the extreme value of the ten-minute wind speed at the height of the hub height and recurrence interval of 50 years is less than or equal to Vref. The parameter Vref is stochastic expressed in probabilistic terms and its value is likely but not exact. The cumulative incidence of extreme wind speeds is necessary for the calculation of Vref. The calculation is performed by means of statistical methods POT-N (Method of Independent Storms-MIS) and Gumbel. As is well known statistical methods based on wind measurements a few years cannot give predictions for violent natural phenomena such as tornadoes.

The aim of this paper is to examine the occurrence of tornadoes/waterspouts in Greece during the period of 14 years from 2000 to 2013 (spatial and temporal distribution) and to investigate the basic characteristics and the likelihood of their occurrence by regional unity. Also, a comparison of the above data with the boundaries of the three IEC classes and the under development windfarm area is done. Useful conclusions about the risks of a windfarm and the consequences it may have the appearance of a tornado/waterspout.

The climatology and data risk of tornadoes/waterspouts for different areas should be included in the technical-economic analysis of the windfarms in Greece.

Keywords: tornadoes, waterspouts, site compliance, windturbines, Greece

EFFICIENCY INCREASE OF A LOW POWER WIND SYSTEM WITH SQUIRREL CAGE INDUCTION GENERATOR

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ABSTRACT

Nowadays, the wind power industry is growing very fast and the modern wind turbines are efficient, reliable and produce power at reasonable cost. Utilizing a squirrel cage induction generator as a means to convert the mechanical energy captured by the wind turbine to electrical energy has a series of advantages, making it an attractive option for small and medium size wind energy conversion systems. A squirrel cage induction generator has low manufacturing cost with robust construction compared to a permanent magnet synchronous generator. Also, it requires little maintenance compared to a wound rotor synchronous generator and a doubly fed induction generator.

This paper presents an optimal efficiency control strategy for wind energy conversion systems with squirrel cage induction generators. The developed control scheme provides optimal efficiency of the induction generator and maximum power extraction from the wind turbine. Thus, maximum power harvesting from the whole wind energy system is achieved and additionally expansion of the exploitable wind speed region towards the lower-speed range is accomplished.

A Minimum Electric Loss (MEL) controller is introduced in order to minimize the generator electric loss and a Maximum Power Point Tracking (MPPT) controller is used in order to maximize the wind turbine output power. Common input to the two optimal controllers is only the generator speed, while the measurement of the wind speed is not required. The controllers determine the optimal d- and q-axis stator current components of the squirrel cage induction generator through optimal conditions and therefore, fast dynamic response of the wind energy system is accomplished. Selective experimental results are provided in order to validate the theoretical considerations and demonstrate the effectiveness and the operational improvements of the proposed control scheme.

Keywords: Wind power generation, optimal control, power generation, generators, variable speed drives.

ESTIMATION OF WIND POTENTIAL AND ENERGY PRODUCTION OF SMALL WINDTURBINES USING HIGH RESOLUTION MESOSCALE DATA

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ABSTRACT

In recent years, small windturbines have a very significant development around the world. According to data from the World Wind Energy Association (WWEA), the growth rate of the global market of small windturbines is increasing, a trend that will continue in the future. Small windturbines were in operation at the end of 2012 amounted to 806,000 with a total installed capacity of 687 MW with leading countries China, USA and UK.

In Greece, the legislative framework for the opportunity of installation small windturbines is in force since 2010 for windturbines with nominal power to 50KW. Despite the large investment interest by depositing approximately 1000 small connection requests for small windturbines (capacity ~ 500MW) to the Operator of Grid and Non-interconnected islands, almost no application has received an offer and few projects have been performed. The law 4203/2013 appointed a special program of small windturbines established by the Minister of Environment, Energy and Climate Change, until 30.6.2014 and appointed and requirements for connecting small windturbines in electrical grids. In late 2013, the cancellation of the process of connection requests for small wind power plants in the non-interconnected islands, carrying on after the approval of the Special Program, stopped any activity. Furthermore, in June 2014 was the postponement of the issue of Ministerial Decision on the specific program and the Law 4254/2014 expired the increased selling price of electricity from small windturbines. So, today the situation in the market for small wind turbines is in zero point in Greece, pending the development of the Special Development Program.

The efficiency of a small windturbine, ie electrical energy produced per installed kW annually is determined by the quality of the wind resource in the region. Main problem for small windturbines investors is the reliable knowledge and certainly the final solution is the onsite measurement. But before the installation of a windmast on the position of the small windturbine and the measurement of the wind resource, are currently available methods for the accurate, reliable and long-term assessment of wind energy potential using high resolution mesoscale data. Yet through these data and complex software packages can be extracted long-term energy production.

The study aims to describe the process of assessment of the wind resource and energy production small windturbines using mesoscale data from the base EMD ConWx lasting 20 years and at heights of 10 and 25 meters (grid 3x3 km node data - hourly speed, wind direction as and temperature, atmospheric pressure). It is presented in detail the methodology used and results are presented for two small islands in the Aegean Sea (wind atlas a height of 18 and 30 meters from the ground surface) and calculation of the energy production of two small windturbines with nominal capacity of 10 and 50kW.

Keywords: small windturbines, wind potential, energy production, EMD ConWx.

EVALUATION OF USE OF REANALYSIS DATA THROUGH COMPARISON WITH LONG-TERM WIND MEASUREMENTS IN GREECE

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ABSTRACT

The methodology for estimation of wind energy potential of a site includes the correction of the limited duration of wind measurements (usually 1 year) to long-term, so be approached with the utmost precision the production of a wind farm through its expected lifetime.

In recent years, wind data are available (and other physical quantities) from databases which have resulted from processing (Reanalysis data) satellite measurements in combination with various climate models and the digital terrain. These data are in the form of time series with sufficient spatial and temporal resolution.

The ultimate aim of the analysis of these data is to determine the long-term wind characteristics prevailing in the area of windfarm. The annual wind resource climate varies in time due to climate variability. The monthly variability of the wind resource is important, but the deviation of the mean annual wind speed usually lies in the range 95-105% of the climatic value. Given the lifetime of a windfarm and the availability of short-term measurements in the study area, it is required their connection with reference long-time wind data series.

This paper aims to evaluate the use of different Reanalysis data sources of a period of over 20 years, with long-term wind measurements from seven stations from CRES with height of 10-100m and time duration 3-22 years. The Reanalysis data sources are: a. Blended coastal winds - (10m agl.), b.CFSR-E- (10m agl.), c. ConWx - (10/25/50/75/100/150 / 200m agl.), d. EMD ERA - (10/25/50/75/100/150/200m agl.), e. MERRA (50m agl.), f. NCAR (10/42m agl.). Correlations are performed through three different MCP techniques (Measure-Correlate-Predict). The results depends on the used MCP method, the temporal resolution of the measurements and the wind direction. There are very high correlations mainly using data ConWx, MERRA, EMD ERA and especially in monthly rates.

The strengths and the weaknesses of the six studied reanalysis data sources after comparing them with the long-term high-quality wind measurements are identified. Generally the use of data ConWx, MERRA and EMD-ERA lead to improved correlation coefficients, but also restrictions on the selection of appropriate reanalysis data sources, mainly in windfarms in extremely complex and seaside terrain. This evaluation study provides useful information about the selection criteria of the most appropriate source of data reanalysis, for the successful correction of measured wind potential and the estimated energy production of a windfarm in long-term status.

Keywords: energy production, comparison, wind potential.

EXPERIMENTAL AND COMPUTATIONAL STUDY OF THE AERODYNAMIC BEHAVIOR OF THE NACA 0012 AND S809 AIRFOIL AT LOW REYNOLDS NUMBER AND DIFFERENT LIQUID WATER CONTENTS, FOR WIND TURBINE BLADES APPLICATION

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ABSTRACT

The aim of the present research is the study of the aerodynamic behavior in two-phase flow of the NACA 0012 and the S809 airfoils, which are used for the construction of wind turbine blades. First of all, experimental and computational study of one-phase flow over the airfoils and afterwards study of two-phase flow for different Liquid Water Contents over the same bodies is conducted. The comparison of the results between dry and wet conditions is necessary in order to show the effects of two-phase flow at the aerodynamic performance. Wind tunnel tests were conducted to show the aerodynamic behavior of airfoils and wings in one-phase and two-phase flows. To simulate two-phase flow, the wind tunnel of the Fluid Mechanics Laboratory has to be configured with adding commercial rain simulated nozzles. The experiments of one-phase flow and two-phase flow are conducted for the same air velocity. For the computational analysis the commercial CFD code ANSYS Fluent is used. The computational domain over the two airfoils is composed of 80000 cells emerged in a structured way. The simulation of rain was accomplished by using the two-phase flow Discrete Phase Model (DPM). This model consists of spherical particles, which represent droplets or bubbles, dispersed in the continuous phase. The realizable k – ε turbulence model is the most appropriate for such simulations. The computational results of aerodynamic coefficients are compared with the corresponding experimental results, in order to validate the CFD developed model. The computational results show the pressure distribution and the velocity vectors over the airfoils for different angles of attack. The water film height and the location of rivulet formation on the upper surface of the airfoil are presented. The results show that the aerodynamic performance degrades when encountering rain, especially lift is degreased and drag is increased.

Keywords: Two–phase flow, Aerodynamic behavior, Airfoil, Experimental study, Computational study

MINEFIELDS AND WINDFARMS IN GREECE – EXAMINATION OF WESTERN MACEDONIA AND EPIRUS REGIONS

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ABSTRACT

In regions of Epirus and Western Macedonia, it has been identified about 1,100 larger areas containing either old minefields or suspected areas. The registration and demarcation of danger areas is incomplete and inaccurate, based mainly on information or after accidents. The information on dangerous or suspicious sites are recorded and scattered in various institutions (Greek Army, Forest Services, Prefectures, Municipalities, etc.) in various forms and unclassified. These areas are mostly mountainous, forested and inaccessible, resulting in difficult mapping with conventional media and technology. In this context a website of demining old minefields and suspected areas in the regions of Western Macedonia and Epirus has been created (https://mines.pdm.gr) which provides information material for areas marked as minefields and suspected areas (coordinates, maps, size, number and type of mine etc) where available these items .

In this study we used the material of previous mentioned website printed at Google Earth satellite maps and compared with areas of the under design wind farms such as those provided by the website of Geo information Chart of the Regulatory Authority for Energy (RAE) (www.rae.gr/geo).

It has identified numerous licensed wind farms areas where include within old minefields or suspected mined areas. The research team extracts the specific areas and provides information for the development company of the project and the type of the mined area (suspected or affirmed area, mine type and other available information).

Finally, the authors outline their proposals for monitoring the presence of landmines - areas with remnants of war, in the areas of development of wind farms in the licensing phase of the project but also for the measurement of wind potential through the installation of wind masts.

Keywords: windfarms, minefields, licensing, Greece, war.

BIOMASS

CHARACTERISTICS OF EVERGREEN HARDWOOD FOREST SPECIES UTILISED AS BIOFUELS AND THE EFFECT OF BARK ON THEM

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ABSTRACT

A significant proportion of Mediterranean forest vegetation consists of evergreen small diameter hardwood trees and shrubs which are traditionally used as fuelwood for domestic heating purposes. Nevertheless, their utilization in the form of pellets or briquettes could increase their energy efficiency. Due to differences in chemical structure, bark and wood present different fuel characteristics. In this study the higher heating value, lower heating value and ash content of wood and bark of five Mediterranean evergreen hardwoods (Quercus coccifera, Quercus ilex, Arbutus unedo, Phillyrea latifolia and Erica arborea) and two deciduous species (Fagus sylvatica and Ostrya carpinifolia) growing in northern Greece were investigated. For each species the stem diameter, bark thickness and wood : bark ratios were also determined. The results showed that the bark of all tested evergreen hardwood species presented significantly higher ash content than deciduous species did and can be used in pellet production only when carefully mixed with wood in order to keep ash content lower than 3%. Quercus coccifera bark showed the highest ash content values. All of the tested evergreen hardwoods showed heating values higher for wood than for bark, except for Phyllirea latifolia which showed significantly higher bark than wood heating value. The highest heating value of all investigated wood samples was presented by Erica arborea. Correlation of ash against higher and lower heating values for all species was found to be weak.

Keywords: Evergreen hardwoods, bark, wood, biofuels, ash, heating value

EXPLOITATION OF FOREST BIOMASS FOR ENERGY PRODUCTION. CONTRIBUTION TO THE ENVIRONMENT AND TO REGIONAL DEVELOPMENT

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ABSTRACT

The predicted exhaustion of fossil fuels and in particular the increasing concern about CO_2 emissions and their impact on climate change have focused global attention on biomass and particularly in forest biomass for energy production. The forest biomass as an energy source is also gaining more and more interest for economic and regional development, particularly for Greece. This paper is an overview of the different types of forest biomass and their conversion systems into the various forms of combustible material (solid, liquid, gas), analyzes the possibilities of production and exploitation of forest biomass for energy production in Greece and emphasizes its contribution to the regional development of the country. Based on the above, recommendations are substantiated for the more complete and more rational production and use of forest biomass by the introduction of modern forest and woodland management methods and new models and standards of exlpoiting the total forest woody biomass produced in them, development of a modern information system of controlling production, utilization, handling, supply, quality testing, marketing and controling of solid biofuels.

Keywords: Types of forest biomass, energy production methods, soli, liquid, gas biofuels, regional development, environmental contribution.

HARVESTING METHODS OF LOGGING RESIDUES FOR ENERGY PRODUCTION

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ABSTRACT

In the last years, the use of residues, that remain unutilized in the forests after harvesting, has attracted the interest for production of bioenergy and biochemicals. In the past, logging residues have not been unutilized, mainly because of high harvesting and transportation costs and technical difficulties. Today, harvesting and transportation technologies have been developed that in the light of oil rising prices make their recovery viable. Also, new conversion technologies of biomass into energy have been developed that allow the conversion of residues into energy in small units or their conversion into refined solid biofuels (wood pellets) that can be installed near or within the forests and reduce the cost further. In this work, a comparative review is given of the various methods of harvesting logging residues that are been used in other countries and of new technologies that have been developed. Also, an assessment-evaluation of their potential use in the Greek forests is given.

Keywords: logging residues, energy production, wood pellets, harvesting systems and methods o logging residues.

BIOFUELS PRODUCTION FROM MICRO-ALGAE

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ABSTRACT

Nowadays, the energy problem appears to be more acute than ever, thus the use of renewable energy sources has become imperative. In recent years, the interest of the scientific community has focused on replacing fossil fuels with fuels derived from various biomass sources. The production of biofuels from microalgae appears to be a very promising research field.

Comparing to other sources of biomass and additionally to hydrocarbons, micro-algae might contain very considerable amounts of lipids and proteins. One of the techniques used for the production of biofuels from microalgae, is that off ast pyrolysis, ie the rapid thermal decomposition of organic matter (controlled heating in the absence of oxygen) which aims to produce biofuels. Nevertheless, microalgae could be used as a feed and after appropriate pre-treatment, which includes removing valuable components (proteins, lipids). The aim of this paper is to investigate the prospect of biofuels production not only from microalgae biomass but also from the residues obtained after extraction of lipids or other valuable components using pyrolysis of algae.

Keywords: Microalgae, Pyrolysis, Bio-Fuels

SUSTAINABLE PRODUCTION OF 2ND GENERATION BIODIESEL VIA WASTE COOKING OIL CATALYTIC HYDROTREATMENT

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ABSTRACT

A new technology based on catalytic hydrotreating of residual biomass for new biodiesel production has been developed in the Centre of Research and Technology Hellas (CERTH). The technology was evaluated in a hydroprocessing pilot-plant of CERTH where feedstock origin as well as optimal catalysts and operating parameters where identified. During the study, three different commercial hydrotreating catalysts were evaluated for the conversion of waste cooking oil (WCO) into biofuels. The catalyst effectiveness was assessed over a temperature range of 330°-398°C. Moreover, three operating parameters were also studied, pressure (8.27-9.65MPa), H_2/Oil ratio (543-890Nm^3/m) and LHSV (0.5-1.5hr^{-1}). All these parameters were evaluated in terms of diesel yield and product quality. It was found that the yield of this new technology is over 90% v/v, while the 2nd generation biodiesel is a high quality fuel with high cetane index 77, no oxygen content and high heating value (49MJ/kg). Furthermore, two tones of this new biofuel were produced for a demo application in a garbage truck of Municipality of Thessaloniki for two months. Considering the quantities of WCO in Greek market and the yields of the technology, this new biofuel can cover 9,5% of diesel needs in Greece. Another aim of this study was to perform a Life Cycle Assessment (LCA) of the new 2nd generation biodiesel via WCO catalytic hydrotreatment, by quantifying its environmental impacts and in particular the associated greenhouse gas (GHG) emissions. The LCA results showed that the new biodiesel's production process is more environmentally friendly than both fossil diesel and conventional Fatty Acid Methyl Esters (FAME) biodiesel. The major contributor to the GHG emissions of the examined production process was the H_2 requirements in the hydrotreatment process. In order to additionally reduce the calculated GHG emissions the incorporation of H_2 from renewable energy sources (RES) in the hydrotreatment process was investigated.

Keywords: waste cooking oil, catalytic hydrotreatment, environment, sustainability

SUSTAINABLE BIO-ENERGY PRODUCTION SYSTEM FROM THE MANAGEMENT OF SOLID WASTE OF OIL TREE CULTIVATION AND OLIVE OIL PRODUCTION

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ABSTRACT

The scope of this paper is the investigation of an alternative waste management practice of solid waste generated from olive cultivation and olive oil production process through the route of gasification. The viability of the proposed system assessed using experimental data from the operation of a pilot cogeneration system that combines a fluidized bed reactor and an internal combustion engine. In the analysis also actual data from a farmer-mill manager were used. The functional unit in the analysis is a ten hectare grove. The results showed that the management of 40.0 t of solid and semi-solid waste can produce enough syngas to produce electricity, in order to cover the energy needs of the operating mill and a surplus that could be sold to the grid, resulting in an additional income. The sustainability of the system was tested in terms of economic, social and environmental efficiency. The results shown that small-scale gasification systems based on agricultural residues valorization are likely to play an important role in future energy supplies for Mediterranean countries.

Keywords: Biomass, Bio-Energy, Gasification, Agricultural Waste Management, Sustainability

COLLECTION AND MANAGEMENT STATIONS OF OLIVE HUSK FOR ENERGY EXPLOITATION PURPOSES

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ABSTRACT

The management of olive husk for energy exploitation purposes consist one of the main challenges for the Mediterranean countries, which produce an average of more than 90% of world olive oil production. The olive husk is an agricultural solid residue that shows excellent energy properties. Due to the seproperties, olive husk is established as a promising solid biomass source. The integrated management and processing of olive husk at all stages of the supply chain is a very scientifically interesting subject which requires further research. In this work, the main parameters of viability and sustainability of olive husk supply chain as an energy source are presented. The main stages of handling and processing are analyzed in order to determine the main parameters which must be taken into account in the design of integrated supply chains. Finally, a pilot line of processing and pelletizing of olive husk is presented. The pilot line is located in the Municipality Yeri in Cyprus and it has a potential of processing 1 tn solid waste daily. This work was carried out within the project "Design and development centers for the collection, management and disposal of olive husk for energy recover purposes" – K.E.D.E.LE.A. The initiative is part of the Interreg IVC Programme (Greece-Cyprus) and co-financed by the European Regional Development Fund (ERDF)and national funds of Greece and Cyprus.

Key words: biomass, olive husk, supply chain, pilot unit.

EXPLOITATION OF STOCK RAISING FARMS WASTES FOR POWER

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ABSTRACT

Biomass, at regional level, is a very valuable renewable energy resource serving for heat and power generation. At the moment, there are various forms of biomass that can be exploited in this direction. This paper focuses on biogas that can be produced from stock raising farms, an energy source that up till now has not received the appropriate attention compared to other forms of biomass.

In this context the scope of the present work includes the identification of the stock waste energy potential for power production in Greece as well as to highlight characteristics/ points of attention for this specific investment plan. Of particular interest and focus of this work, on top of recording and geographical illustrating the waste energy potential is the technical and economic analysis of the assorted investments and the commercial availability of the respective equipment.

Finally a case study is presented, examining the development and installation of an anaerobic digestion plant in Northern Greece, for a project lifetime of 20 years, accounting also its environmental benefits. In addition to the techno-economic analysis the idea of distributed and decentralized energy generation in accordance to fossil fuels' minimisation-utilisation with the corresponding energy and environmental benefits are supported.

Keywords: Biogas, power production, techno-economic evaluation, environmental benefits

Experimental study of combustion in a spark ignition engine operating with producer gas from various biomass feedstocks

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Abstract

Spark-ignition engines running on gaseous fuels are commonly used for combined heat and power (CHP) production. In the present work, an experimental investigation has been conducted in order to study combustion in a spark-ignition engine fueled with producer gas. The engine is a single cylinder one, coupled to a fluidized bed gasifier in a mobile combined heat and power (CHP) production unit. Three biomass feedstocks were evaluated, which are olive, peach and grape kernels. Mixtures of each producer gas separately with propane at various blending ratios were fed to the engine, operating at various engine speeds. Cylinder pressure measurements were performed, followed by heat release rate analysis. Loss in power output compared to neat propane operation was experienced, owing to the lower calorific value of the producer gas, independently of the feedstock. Additionally, lower cylinder pressures and heat release rates were observed, coupled to prolonged combustion duration. Finally, combustion stability was moderately affected by the introduction of producer gas.

Keywords: Spark-ignition engine, Producer gas, Biomass, Gasification,Cogeneration

EVALUATION OF THE IMPACT OF1ST GENERATION FAME BIODIESEL AND 2ND GENERATION HYBRID BIOFUEL ON INJECTION SYSTEM OF MODERN DIESEL ENGINE

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ABSTRACT

In order to increase the share of renewable energy sources and reduce the dependency on imported fossil fuels, biodiesel fuel blends are widely used. Current Greek market diesel has up to 7% (B7) of 1st generation biodiesel (Fatty Acid Methyl Esters, FAME). The European Union has set the target of renewable sources fraction in transport sector to a minimum of 10% by year 2020. This may lead to a gradual increase of biofuels in market.

The usage of FAME over years showed a potential negative impact on the parts of a modern diesel engine and more specifically on the components of the Fuel Injection Equipment (FIE). Due to poor oxidation stability, FAME compounds are susceptible to oxidation reactions. The products of these reactions often lead to the formation of Internal Diesel Injector Deposits (IDID). The accumulation of these deposits can lead to injector failure and poor engine operation.

Scope of this study is to evaluate the impact of 4 fuelson the injectors of a high pressure common rail diesel engine. The tests were performed on a prototype FIE test rig which simulates long term vehicle operation within short test duration. The test rigaccelerates fuel degradation and reproduces the mechanism of injector deposits.B0 fossil diesel with no biodiesel or additives was used as reference. Standard Greek market B7 diesel was tested in order to assess the impact of current market fuels. Additionally, a B20 test fuel with 20% FAME and 80% petrodiesel was produced and tested to clarify the impact of possible increase of FAME. The final fuel tested was a hybrid 2nd generation S7 biofuel produced by hydrotreatment of heavy Gas Oil, Waste Cooking Oil and FAME mixture.

It was observed that reference B0 with no FAME did not lead to formation ofdeposits inside the injectors. Extended test rigoperation with B7 market fuel reduced injection flow rate due to formation of deposits. B20 with high FAME content further increased the rate of injector degradation leading to faster failure. The use of hybrid 2nd generationS7 did affect injector operation.

Keywords: 1st generation biodiesel, FAME, 2nd generation biofuel, fuel injection equipment, injector, fuel degradation, deposits

LIFE CYCLE ASSESSMENT OF SOLID BIOMASS TORREFACTION

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ABSTRACT

Pyrolysis is a thermochemical process for the treatment and energy utilization of solid biomass. A number of pilot-research pyrolysis plants as well as industrial applications of pyrolysis are found in the Greek region. Life Cycle Assessment is a useful methodology for the evaluation and comparison of the environmental impact of pyrolysis over other thermochemical processing methods.

This paper presents a comprehensive environmental assessment of solid biomass pyrolysis process through an integrated Life Cycle Analysis. Torrefaction, a mild pyrolysis process has been investigated, which is considered as an optimum process regarding energy consumption and environmental footprint. Eucalyptus wood waste was selected as the biomass source. Mass and energy balances were considered in the study and the environmental impact of each process of the whole torrefaction system were defined by using GaBi software. The analysis of the results regarding the environmental impact of the process, allows the technical evaluation of torrefaction as well as the promotion of technical alternatives for further improvement and optimization of the process.

Keywords: Torrefaction, Biomass, Life Cycle Assessment

GEOTHERMAL ENERGY – GROUND SOURCE HEAT PUMPS

EVALUATION OF GEOTHERMAL RESOURCES AND THEIR UTILIZATION IN SANTORINI ISLAND

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ABSTRACT

This paper describes the geothermal situation in Santorini (or Thera) island, based on recent and earlier exploration surveys. Furthermore, it presents the results of a geothermal project that is in progress since April 2014 and deals with the evaluation of the island's geothermal resources and the possibilities/ methods of their utilization.

The geological, tectonic and volcanic structure of Santorini has contributed to the development of favorable conditions in terms of geothermal potential. The geothermal research has shown that the geothermal anomaly is located inside, or, in the vicinity of the geologic bedrock, which contains impermeable formations that isolate and partially protect the thermal fluids from the colder meteoric water and the intrusion of the sea. The "open" active normal faults of the area operate as flow paths for the geothermal fluids, allowing them to rise to the surface.

High enthalpy fluids (T>150 °C) have been found inside the caldera of the volcano, which, however, cannot be exploited due to the specific characteristics and particularities of this location. Medium enthalpyreservoirs (T=90-150 °C) most possiblyexistin the southern part of the island in depths less than 1 km, as it is concluded by the increased geothermal gradient, the geophysical data and the chemical geothermometry. The drilling exploration in southern Santorini (Megalochori-Agia Anna area) confirmed the existence of lowenthalpyfluids at depths less than 300m, withtemperaturesup to 65 °C and high geothermal gradients. Very shallow reservoirs with saline water and relatively increased temperatures (20-25 °C)are found almost everywhere on Santorini.

In the frame of the current geothermal project, extensive fieldwork has been carried out in order to identify, determine and record the characteristics of the low enthalpy geothermal potential in Santorini. For this purpose, temperature and electrical conductivity has been measured in more than 135 wells in Thera and Therasia. As expected, the higher temperatures have been found in the southern part of Santorini and the lower in the northern part of the island (in the area of Oia). However, the results were interesting and "promising" for the central part of the island, where temperatures up to 28 °C have been measured in very shallow wells, indicating high thermal gradients also in this area.

ThegeothermalpotentialofSantorinicanbeutilizedinseveralapplications, adapted to meet the requirements of the touristic and rural character of the island. The medium enthalpyfluids could be used for power generation, whereas the lower temperature water can be used for space and district heating, for various agricultural (e.g. tomato drying) activities and in the tourism sector (e.g. hotel heating/cooling, pools, spas, etc).

Keywords: geothermal exploration, well measurements, uses

ECONOMIC OPTIMIZATION OF SYSTEMS COMBINING VERTICAL GROUND HEAT EXCHANGER WITH CONVENTIONAL HEATING AND COOLING SYSTEMS

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SUMMARY

The need for energy conservation over the last few decades has led to an increased use of closed shallow geothermal systems for both heating and cooling. Thermal energy required for heating commercial buildings is lower, while cooling energy is higher in comparison with equivalent residential buildings. Therefore in areas with mild climate and lack of free space, reversible heat pumps combined with vertical ground heat exchangers are considered a very good choice.

This paper presents an optimization model for the determination of the best combination of ground source heat pumps (GSHP) and conventional heating - cooling systems. The variables in the model include the heating and cooling capacity of both the GSHP and the supplementary system and the payback period. The model is calibrated and used to study a commercial building of Neapoli, Kozani, Greece. All the factors which are involved in the calculations such as building characteristics, outdoor design conditions, indoor design conditions, soil characteristics, efficiency of heat pump and heating and cooling load were taken into account according to the national (Greek) rules and standards. The goal of the optimization model is the minimization of the cost. The cost items taken into account are the following: a) purchase of the reversible ground source heat pump, b) purchase of the supplementary systems for heating and cooling, c) maintenance of both systems over the years and d) installation of the geothermal exchanger. Using linear programming the model calculates the optimum capacity of each system, in order to meet the heating and cooling load respectively.

The case study results show that optimum combination depends strongly on the payout period. Larger periods lead to increased share of GSHP. While results depend heavily on local conditions, the methodology presented in this paper is a useful tool for energy-conscious engineers.

Key words: shallow geothermal systems, heat pump, linear programming, optimizantion, RETScreen 4

THERMOMAP - A EUROPEAN PROJECT FOR MAPPING THE VERY SHALLOW GEOTHERMAL POTENTIAL

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ABSTRACT

”ThermoMap” (“Area mapping of superficial geothermic resources by soil and groundwater data”) was an innovative European Commission co-funded project aiming to map the very Shallow Geothermal Potential (“vSGP”) to a maximum depth of 10 m across Europe. The main objective of this project was to foster an information environment for the development of shallow geothermal systems across Europe. The ThermoMap project has collected, combined, harmonized and analysed pre-existing data sets (geological, hydrogeological, soil, climate and relief data) to calculate a value for the shallow geothermal potential, defined as the thermal conductivity and/or heat capacity of unconsolidated ground at depths of 0-10 m. The analysis and processing of these geodata were performed in a GIS-environment with standardized methods, valid for all partners. Twelve partners from nine European countries worked together in this project. The use of the existing geoscientific data sets and their GIS processing can contribute to finding favorable areas for superficial geothermal exploitation using Geothermal Heat Pump Systems in a short time, without high costs and with reliable design. The estimated geothermal potential values were integrated in an open source WebGIS as well as providing the background parameters used for mapping. Users (companies, public authorities, designers, engineers, scientists, researchers, investors, house builders, privates etc) can check the vSGP in a certain location. The ThermoMap project has developed two very useful tools: a WebGIS application (MapViewer) and a Calculator. The ThermoMap Viewer is a special WebGIS service, i.e. an interactive map, showing the vSGP across Europe and giving an overview and more detailed information about the local geothermal potential. At European level, the European Outline Map (EOM) gives a first estimation of the shallowest zone’s thermal conductivity for the whole of Europe at a scale of 1:250,000. Except for this European Outline Map, the participating project partners defined test areas for illustrating the very shallow geothermal potential (thermal conductivity and heat capacity) in detail for three depth layers to a maximum depth of 10 m at various larger scales. Soil and soft rock material from the test areas were sampled and analysed for defining the soil texture and the thermal conductivity was measured under different moisture conditions. These measurements showed a good agreement between measured data and estimated values. The Greek test area was the wider area of Kalamata. The ThermoMap Calculator allows users to check the shallow geothermal potential at a certain location by inputting specific information. This tool can enhance existing data or generate new data. If external data exists (e.g. for local soil analysis), the estimation values can be improved. The incorporated Calculator is populated with information from the European Outline Map and users can input new or modify existing data. When the Calculator is accessible outside the MapViewer, there are no pre-filled values.

Keywords: shallow geothermal energy, geothermal heat pump systems, geoexchanger, thermal conductivity, WebGIS application

USE OF SHALLOW GEOTHERMAL ENERGY BY MEANS OF HEAT PUMPS FOR EARLY GROWING OF ASPARAGUS FIELDS UNDER LOW TUNNEL

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ABSTRACT

Agricultural production in Greece is mainly based on open field cultivations with products that grow within the regular climatic season. Vegetable growers in regions with climate like the one found at Northern Greece do not have a lot of flexibility because climatic conditions restrict the growing season to a very narrow window. Because of this narrow window of production, most crops reach maturity at the same time, harvest is synchronized, and all growers hit the market at the same time. The direct consequence of the synchronized peak in production is a drop in the price paid to growers. Definitely "home runs" in agriculture can be made either in the early or in the late season. Since 2006 in the region of Chrysoupolis-Kavala have been developed strategies to extend those "profit windows". One of the most efficient tools for asparagus early growing is the use of low-cost shallow geothermal energy when exploited by geothermal heat pumps in conjunction with low tunnels.

During the last ten years Greek asparagus harvest period is very often overlapped by the German one. The latter reflects to the prices, which are getting progressively lower and lower every year. The only solution to overcome this fact lays to the early production using a low cost source of thermal energy. One of the most abundant natural-occurring green energy is geothermal energy. However, geothermal fields or waters with T>30°C, necessary for open field heating process, are not present in all areas. An alternative to the scarcity of low cost energy resources may be the exploitation of the abundant heat potential of the low depth aquifers, by using heat pumps technology.

Water to water geothermal heat pump systems have been installed and are already working in five white asparagus plantations (11 ha) in the wider area of Chrysoupolis-Kavala. The total heating power provided to the plantations reaches 1300KW_{th}. The maximum electrical power consumed by the heat pumps is close to 250 KW_e. The working fluid in the evaporator's side of the heat pump is the water of low depth wells (30-100 m) that enters the heat pumps with temperature ranging between 16 and 19.5°C. When temperature of the water exceeds 18°C, heat extraction is realized by successive evaporation in two stages in a serial configuration enhancing the rational management of the water resources. Heat extracted from the water (open loop) is transferred to the asparagus field within PE pipes (closed loop).The maximum field entering temperatures obtained does not exceed 35°C and the coefficient of performance (C.O.P.) is regularly close to 3.5-4.0. Heating process is being scheduled to start every year at the beginning of February and needs almost twenty days under the desired temperatures, in order production to start. Production rates and quality of asparagus spears remain very high when compared with not heated plantations. After seven successive production periods "home runs" have been doubled and the economic feasibility of the exploitation of shallow geothermal energy using heat pumpsseems to be very attractive.

This very extended and successful field application of heating process of an agricultural plantation by means of geothermal heat pumps enables other similar agricultural applications to be faced in the same profitable way. Such temperatures in low depth aquifers (15-25°C) are very common in the majority of recent sedimentary basins, where the most extended and intensive agricultural areas are met. The fact that a geothermal heat pump exploits the heat potential of the water and then the water re-enters the aquifer, makes this technique environmental friendly, while the fact that the energy cost is quite low compared to the conventional energy sources, makes it efficient and attractive for any other agricultural product that can be handled under low tunnels.

THE GEOTHERMAL FIELD OF ARISTINO-ALEXANDROUPOLIS. EXPLORATION AND EXPLOITATION

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ABSTRACT

The confirmed geothermal field of Aristino-Alexandroupolis that covers an area of about 20 Km^2 is located west of the Traianoupolis thermal springs area. The main part of the geothermal anomaly is located in areas with active tectonics and volcanic edifices of Oligocene-Miocene period, consisting of rhyolite domes intrusions and high alterated pyroclastic and ignimbritic restes. The main and most extended low enthalpy geothermal reservoir is developed at depths from 250 m to 400 m, within the alterated volcanic formations of high secondary permeability. Pumping tests carried on the hottest production well AA-3P has given standard flow rate of 100 m^3/h with maximum temperature measured at 89,3°C.

Geothermal fluids of the deeper and hottest reservoir result from the mixing of waters of meteoric and sea origin. They are of Na-Cl type with TDS values close to 10,5 g/l and relatively high Ca^{2+} and SO_4^{2-} concentrations. Given the chemical composition of the geothermal fluids it results that they are saturated with respect to calcium carbonate but, due to the low supersaturation index in parallel with the high temperature and pH values, they don't present a remarkable tendency for $CaCO_3$ precipitation, which should take place more particularly inside the parts of the network of higher flow velocity (e.g. plate heat exchangers). Due to the high Cl^- values, geothermal waters are prone for pit corrosion effect that should be seriously taken into consideration in the final selection process of the piping and spare parts of the network.

Based on a multipurpose exploitation pattern, it is feasible enough to apply a drop of the initial temperature close to 55-60 °C. The latter represents a recoverable thermal power of 7 MW per production well as it concerns the northern and hottest part of the hydrothermal system. The first phase of exploitation deals with the existing production well AA-3P and the new one AA-6P, which should be drilled quite close to the existing one. The pumping of a total rate of 150 m^3/h should provide an installed thermal capacity in the order of 10 MW. Initially the available thermal capacity will cover the energy requirements for: 11 establishments of public interest with a total covered area of 0,8 ha in the village of Anthia and Aristino as well, legumes hydroponics greenhouses of 5 ha and a greenhouse microalgae cultivation of 1,5 ha.

The management of geothermal waters will be ensured by means of a central thermal station, where the principal component is a three plate heat exchangers complex. After the heat exchanging process, geothermal fluids should be driven to the reinjection wells in the southern part of the field, where the temperature at the top of the geothermal reservoir doesn't exceed 32°C. The final stage of the exploitation pattern comprises independent local thermal stations for each final energy consumer, ensuring by this way the autonomous and most secure function between the main transport networks and the exploitation networks of each terminal user.

A GROUND SOURCE HEAT PUMP SYSTEM TO HEAT A COFFEE HOUSE AT THE COASTAL AREA OF THESSALONIKI

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ABSTRACT

The design data of a ground source heat pump system of water to air type for the heating of a coffee house at the Coastal Area of Thessaloniki are presented. The HP's primary loop is drill water that is temporarily stored in an underground linear water tank constructed for irrigation purposes as well as for public toilets' flushing at the coastal area of Thessaloniki. Construction and design data of the installation are presented as well as prospective energy data of the systems' operation.

Keywords: geothermal energy, geoexchanger, ground source heat pump, new coastal area of Thessaloniki

PARAMETRIC INVESTIGATION OF POWER GENERATION FROM MEDIUM ENTHALPY FLUIDS IN GREECE

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ABSTRACT

In Northern Greece and in some Aegean islands there are a large number of low-enthalpy geothermal fields with water temperatures of 30-90 °C. These fields are at very shallow depths (typically 100-500 m) in the sedimentary basins of North-eastern Greece (e.g. basins of Strymon, Nestos and Evros Rivers) and the islands of Samothrace, Chios and Lesvos. The geological and tectonic conditions in these areas are favorable for the presence of medium enthalpy geothermal fields at greater depths. This paper deals with the parametric study of two binary cycles that can be used to exploit the medium temperature geothermal resources in Northern Greece. Models have been developed for small power plants for the KALINA (KCS34) Cycle and the Organic Rankine Cycle (ORC). The modeling of the units was carried out using the software Aspen Plus. The reliability of these models was validated with experimental data from two small commercial installations. These models were used for the parametric study of the performance of the units for a typical range of climatic and geothermal conditions in a Greek geothermal field. The main parameters considered are the temperature of the geothermal fluid (ranging from 90 to 120 °C) and the reinjection temperature of the fluid, which is supposed to be in the range 70 – 80 °C.

Keywords: Power generation, exergy analysis, Kalina cycle, Organic Rankine Cycle, Aspen Plus

ENERGY, ENVIRONMENTAL AND ECONOMIC BENEFITS OF THE INSTALLATION OF GROUND SOURCE HEAT PUMPS SYSTEMS ON COMMERCIAL BUILDINGS OF CYPRUS

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ABSTRACT

Nowadays, ground source heat pump systems are considered as one of the most effective technologies for space heating and cooling in private and public buildings. Moreover these systems are environmentally friendly as they consume less primary energy and reduce emissions of greenhouse gases.

The aim of this paper is to evaluate the installation of ground source heat pump systems in commercial buildings of Cyprus in terms of primary energy consumption, carbon dioxide emission, and net present value index. More specifically, a typical reference office building was designed, taking into account the architectural characteristics of the Cypriot building stock, as well as the minimum legislated thermal requirements for the building elements. Then the energy demand of the building envelope was estimated using the energy simulation software EnergyPlus, in hourly basis. The results are turned into primary energy consumption assuming two common conventional heating systems of the Cypriot buildings, an oil - and a gas -fired boiler and an air-cooled water chiller. The same energy demand is assumed to be covered by a ground source heat pump system, which consists of a vertical ground heat exchanger and water-to-water heat pumps. The ground source heat pump system was designed using the EED software and analyzed with the aid of in-house developed and validated code. In addition and based on the primary energy consumption of each alternative systems, carbon dioxide emissions are calculated using verified emission factors of the Cypriot energy system. Finally, the economic analysis of the alternative systems is performed using the methodology of regulation 244/2012/EU.

HYDROPOWER – SEA WAVES ENERGY

WAVE ENERGY EXPLOITATION: STUDYING THE WAVE ENERGY POTENTIAL OF AEGEAN ARCHIPELAGOS CASE STUDIES

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ABSTRACT

During the last decades, a constantly growing interest is recorded in the field of Renewable Energy Sources, leading to the implementation of several energy projects, excluding however non-interconnected islands. To this end, although the idea of exploiting the sea energy potential is not new, it is still an energy option of limited real world applications. On the other hand, by acknowledging the vast sea energy potential as well as the fact that coastal and island areas can harvest significant benefits from the application of similar energy solutions, the current study pays special attention to the evaluation of wave energy potential across the Aegean Sea region. At the same time, an effort is carried out in order to assess specific areas of interest, where the local wave energy potential encourages power generation applications. Then, the study proceeds with the analysis of data for certain selected areas, using long-term measurements from the available, official sources of information. Based on the results of the current research, implementation of novel marine technologies can be supported, leading to the production of considerable benefits for several island areas of our country.

Keywords: Wave height, energy production, island areas

INTEGRATED OVERTOPPING WAVE ENERGY CONVERTER IN A HYBRID POWER GENERATION SYSTEM

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ABSTRACT

The reality of climate change brings into the foreground the need for redefining marine construction technologies. This paper aims to evaluate and optimize the performance of an overtopping type wave energy converter (OWEC), taking into account the energy potential that renewable energies can offer in the Greek context by considering them under economic and environmental terms.

This study focuses on a small, off–grid island in the Aegean archipelago, the island of Donousa. At the present time, Donousa's power requirements are exclusively covered by fossil fuel, despite the great wind and wave energy potential of the area.

The OWEC technology explored in this study can be combined with many technologies of energy production so that it may constitute part of various hybrid systems' configurations. Two scenarios of hybrid systems' configurations have been investigated (one coastal and one off-shore), both combining the OWEC technology with a micro-gas turbine of 80kW and a wind turbine of 200kW.

This kind of overtopping wave converter is expected to generate 320MWh/y and cover 50% of the islands energy demands. When the OWEC technology is combined with the wind turbine energy generation technology, energy autonomy can be achieved with the simultaneous use of wind and wave energy. The hybrid system components where investigated under financial parameters. From the techno-economic assessment point of view, the offshore integration could provide power production but also constitute a feasible technology.

Overall, marine construction technologies could be designed so that they could offer power generation apart from their protective function and coastal erosion prevention. The most important outcome of this study concerns the off-shore OWEC technology configuration (Scenario B.2), as it introduces a new direction in the design of off-shore wind energy parks, where the synergy of the combined renewable energy technologies can reduce the number of the necessary off-shore wind turbines for the generation of the needed energy amount.

Keywords: marine, seawall, overtopping, wave energy, hybrid power generation system

DESALINATION – ENERGY STORAGE

DESALINATION TECHNOLOGIES WITH RES

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ABSTRACT

Converting seawater or brackish water into freshwater is a promising approach to overcome the insufficiency in water supply caused by population increase, increase of agricultural and irrigation needs, industrial and tourism needs, etc. Production of freshwater using desalination technologies driven by renewable energy sources (RESs) is thought to be a viable solution to the water scarcity in remote areas characterized by lack of potable water and lack of an electricity grid. RES–desalination matching is mainly categorized as distillation desalination technologies driven by heat produced by RESs, and membrane and distillation desalination technologies driven by electricity or mechanical energy produced by RESs. The selection of the most appropriate combination is mainly site specific. Parameters that affect the final decision are discussed in the present work.

Applications of relatively small scale exist around the world; some of the most known are examined in this paper.

This work focuses on the state-of-the-art of the RES desalination technologies, their current applications, the lessons learned, and the economics and market of these technologies internationally.

Keywords: seawater, brackish water desalination, distillation methods, membrane methods, solar thermal collectors, photovoltaics, wind energy, RES.

MEMBRANE DISTILLATION: REVIEW OF EXPERIMENTAL INSTALLATIONS AND MODELING FOR PROCESS OPTIMIZATION

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ABSTRACT

The purpose of the present study is to elaborate an effective scenario of a theoretical and experimental investigation of potential thermohydraulic optimization of distillation process by using the Membrane Distillation (MD) technology. Therefore, a critical assessment of the up to date experience of previous installed systems has been attempt. Also, the development of a suitable mathematical model, which can be used to study the effect of the significant parameters that influence the quality and quantity of the produced desalinated water, is presented. This model can be used to study the thermal flow in cases of connection with thermal solar system and the use of the recovered heat of condensation, with final aim of maximizing the productivity and the energy optimization of the process.

The research for the MD process optimization has been focused in the study of various process configurations and in the synthesis of new membranes with desirable characteristic properties (porosity, pore size, membrane thickness). For that purpose, several experimental actions have been carried out in laboratory scale for the investigation, both the membrane performance and the effect of systems operating parameters (feed flow, hot and cold stream temperature). Moreover, a few MD pilot plants have implemented with the in order to study the economic viability and energy efficiency of the process in real scale. At the level of process simulation, some efforts of development and suitable mathematical models validation have been recorded, with the obvious need of their further validation and generalization in the simulation of integrated desalination plants by using MD process

Keywords:

Membrane distillation, operating parameters, lab scale pilot units, full scale units, mathematical model.

DIRECT DRIVEN (BATTERY-LESS) INNOVATIVE PHOTOVOLTAIC REVERSE OSMOSIS DESALINATION SYSTEM

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ABSTRACT

One of the most important goods necessary for human survival and development is potable water. At the dawn of the 21st century there are still many areas around the world that do not have access to potable water. It is estimated that more than one billion of people have no access to clean fresh water. In developed countries, potable water is available but usually at high costs because of the transportation cost added to its price. Desalination emerges as a solution to the lack of potable water. Sea water can be turned into high quality drinking water. When the desalination processes are coupled with renewable energy technologies then the systems become environmentally friendly and can aid the development of these areas – areas situated in both the developed and the developing world.

The proposed system is an innovative reverse osmosis desalination system for sea water capable of covering the needs in potable water for settlements presenting low cost and minimized environmental footprint. The system is powered by PVs and a wind turbine and will be able to produce between 2.5 - 5 m^3 per day, capable of covering the needs between 25 and 50 people with an average water consumption of 100 lt per day. This system features no lead acid batteries. The desalination unit is equipped with an energy recovery subsystem and is able to operate in part load. This system features two main innovations. The first is concerned with two short term energy storage subsystems and the second one is an advanced intelligent energy management system based on computational intelligence allowing the unit to operate in part load and achieving overall greater efficiency. This energy management system also includes advanced algorithms based on grey model theory for the prediction of the produced power from the photovoltaics and the wind turbine. The design of this system aims at lowering the cost of desalinated sea water below 5 €/m^3 for units with nominal water production of up to 5 m^3 per day.

ELECTRIC ENERGY STORAGE TO SUPPORT HIGH RES PENETRATION

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ABSTRACT

The expanding development of RES and the consequent requirement for high penetration of wind and PV intermittent production will create the need to manage a part of this production that cannot be channeled directly to the grid, either due to stability problems, or because it may exceed the total demand.

This problem is already being considered in most national systems of developed countries, while storing of excess RES production in pumped storage units is currently the most mature and available technology internationally, and especially in Greece, due to the favorable topography and the important existing know-how from the operation of several large hydropower plants.

The assessment of future energy storage needs of the Greek electricity system is essential for the effective planning and timely construction and integration of new pumped storage units, in order to support the scheduled development of RES in the next decades by economically viable investments.

This paper presents results from the investigation carried out at the NTUA in the framework of a relevant European research project involving six other countries. Various scenarios for future development of the electricity system with high RES share in Greece are examined, and the operation of the whole system is modeled using special software, in order to reproduce the time series of the excess RES production that needs storage. These results are then utilized to simulate the operation of the pumped storage units integrated in the system, and to assess the future needs for installed pumping power and storage capacity.

Keywords: High RES penetration, Electric Energy Storage, Pumped Hydro, Grid modeling

NUMERICAL SIMULATION OF THE PHASE CHANGE PROCESS OF AN ENCAPSULATED PCM INSIDE A SPHERICAL CAVITY FOR USE IN LATENT HEAT THERMAL ENERGY STORAGE SYSTEMS

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ABSTRACT

The present study explores numerically the process of melting of a phase change material (PCM) in a spherical geometry by using computational fluid dynamics (CFD) methods. Specifically, we investigate the case of the sugar alcohol 'D-mannitol', which is a PCM with melting point lying within the temperature range of 'medium temperatures' (100 - 250 ^{o}C). Transient simulations are performed using the software ANSYS Fluent for solving the 2-D natural convection flow and heat transfer inside the capsule. The computational results show the major importance of the natural convection in the melt when comparing with simpler approaches which take into account only the heat conduction. As there is a lack of experimental data for the phase change behavior of suitable PCMs in the 'medium temperature' range, this simulation can provide a good starting point for the optimal design of latent heat thermal energy storage systems (LHTES) used in conjunction with concentrated solar power systems (CSP).

Keywords: thermal energy storage, phase change materials, melting, CFD, spherical cavity

ENERGY PERFORMANCE OF A GREEK DEMO HOUSE WITH PHASE CHANGE MATERIALS: EXPERIMENTAL AND COMPUTATIONAL INVESTIGATION

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ABSTRACT

A two - storey typical family house was built in the mid – western part of Greece, comprising a load bearing steel skeleton and dry wall systems. Its walls consist of multiple layers of insulation materials and gypsum plasterboard panels containing Phase Change Materials (PCMs) for thermal energy storage purposes. A detailed matrix of sensors was installed in different locations of all external walls of the house, as well as indoors, in order to provide detailed temperature measurements and thus lead to a thorough depiction of the house's thermal behaviour. The house is being monitored since 2010. In the first part of this work monitoring data are presented for 2012 and 2011 with respect to highlighting the activation of PCMs and its consequent influence on the thermal performance of the demo house envelope. It should be noted that during the reported period of time the house remained closed - unoccupied and the installed energy systems were not operating. Monthly averaged indoor air temperatures are depicted near the living room (LVR) east wall. Furthermore, the monthly - averaged decrement factor (DC) values emerging from temperature measurements obtained at various layers (or cavity) of the LVR east wall are presented. Overall, it can be stated that the influence of PCMs on the smoothing of the wall temperature fluctuations is apparent. Their contribution can reach a maximum of 30-40% to the wall's DC during late spring, early summer and autumn. In the second part of the paper a transient composite computational model is implemented for the simulation of the demo house. The computational model is developed in the platform of the TRNSYS software and is linked to a subroutine written in MATLAB to account for the PCM effect. After being validated in a simpler test case, the developed computational tool is used for the simulation of the demo house energy performance and results show a significant reduction of the annual cooling loads of the house can be anticipated (approximately 29%) when PCMs are implemented in the building walls. A parametric study, considers PCM wallboards with different phase change temperature range and examines the possibility of higher energy savings. Results show that the choice of the appropriate PCM wallboard is highly affected by the weather conditions.

Keywords: Phase Change Materials, Energy Storage, Demo House Monitoring, Building Energy Simulation

H2 - FUEL CELLS

GREEN HYDROGEN FROM BIO-OIL STEAM REFORMING: ENVIRONMENTAL ASSESSMENT VIA LIFE CYCLE ANALYSIS

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ABSTRACT

Global warming and the associated efforts for decreasing CO_2 emissions have rendered hydrogen one of the most important energy carriers of this century. Hydrogen can potentially be "CO_2-free" when used as fuel in fuel cells or internal combustion engines, as it does not contain carbon in its structure and thus only H_2O is formed from its reaction with oxygen. However, hydrogen does not occur free in nature and has to be extracted from hydrogen-containing sources. Its environmental profile depends on both on the actual resource used (fossil vs renewable) and the process employed and therefore, it is essential to assess the different hydrogen production methods and power trains using a life cycle analysis or well-to-wheels approach.

In this Life Cycle Analysis (LCA) study, the environmental impacts of hydrogen production from lignocellulosic biomass via pyrolysis and subsequent steam reforming of bio-oil were evaluated and compared to the conventional production of hydrogen from natural gas steam reforming. Hydrogen was assumed to be used as transportation fuel in an internal combustion engine vehicle. Two scenarios for the provision of lignocellulosic biomass were considered: wood waste and dedicated willow cultivation.

The LCA analysis showed that the production of bio-hydrogen consumes less fossil energy in the total lifecycle, mainly due to the renewable nature of the fuel that results in zero energy consumption in the combustion step. The total (fossil and renewable) energy demand is however higher compared to fossil hydrogen, due to the higher process energy demands and methanol used to stabilize bio-oil. Improvements could occur if these are sourced from renewable energy sources. The overall benefit of using a CO_2 neutral renewable feedstock for the production of hydrogen is unquestionable. In terms of global warming, production of hydrogen from biomass through pyrolysis and reforming results in major GHG emissions, ranging from 40% to 50%, depending on the biomass source. The use of cultivated biomass aggravates the GHG emissions balance, mainly due to the N_2O emissions at the cultivation step.

Keywords: Hydrogen, Biomass pyrolysis, Bio-oil steam reforming, Natural gas, Life Cycle Analysis

CATALYTIC DECOMPOSITION OF H_2S TOWARD H_2 IN THE PRESENCE OF EXCESS H_2O OVER Co/CeO_2

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ABSTRACT

In the present communication, the catalytic decomposition of Hydrogen Sulfide (H_2S) toward H_2 production over Co/CeO_2 catalysts with different Co loadings (0-100 wt.%), in the presence of excess H_2O (90%) is examined. The work is aiming to identify optimum catalysts that will be applied as ode electrodes in proton conducting solid electrolyte membrane reactors. In this regard, a series of Co/CeO_2 catalysts was prepared using the wet impregnation method and their performance toward H_2S decomposition to H_2, was evaluated. The physico-chemical and morphological characteristics of the catalysts were determined by BET, XRD and SEM methods. The experimental results showed that the 30% wt. Co/CeO_2 catalysts exhibited the optimum activity performance and excellent stable behavior, which were attributed to the *in situ* formed Co- and CeO_2-sulfide phases during reaction.

Keywords: H_2S Decomposition, Black Sea, Excess H_2O, Cobalt, CeO_2, Electrochemical reactors

INTEGRATED DESIGN, OPTIMIZATION AND SUPERVISORY CONTROL OF RENEWABLE HYDROGEN PRODUCTION STATIONS

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ABSTRACT

This work presents a framework that was developed for the optimum design and efficient operation of autonomous or grid connected renewable hydrogen production stations. More specifically, the developed methodology determines the optimum values of the operational parameters of each subsystem in order to minimize the requested power for the production of hydrogen. Each subsystem serves a specific role while it interacts me the other subsystems. As a result a multivariable complex system is created that should be systematically managed. Therefore, for the optimum operation of the station a supervisory control system is necessary that will consider the requirements for the operation of each subsystem while maximizing their performance. The operation limits are determined by the solution of an optimization problem that targets at the maximum production of hydrogen, the lifetime of each subsystem and the production of hydrogen.

The developed framework is implemented at the autonomous renewable hydrogen production station which is designed and constructed by the Process Systems Design and Implementation (PSDI) laboratory of Center for Research and Technology Hellas (CERTH), located at Thessaloniki, Greece. The hydrogen is produced via water electrolysis and it is stored in high pressure cylinders. The required power is provided by a lead-acid accumulator which is charged by a photovoltaic (PV) array. The station operates unattended and it is monitored remotely using an industrial supervisory control and data acquisition system (SCADA). A decision making process is realized by a flexible energy management strategy (EMS) using a finite state machine approach. The proposed study assesses the performance of the station in the context of an efficient hydrogen production and investigates the way that a number of energy saving actions affect the long-term hydrogen inventory and station autonomy. Overall the experimental results are used to reveal the potential of the station and present the excellent synergy among the various heterogeneous subsystems.

Keywords: Renewable hydrogen, optimum hydrogen production, autonomous and automatic operation

EXPERIMENTAL CHARACTERIZATION AND NUMERICAL SIMULATION OF NANO-STRUCTURED TRANSPARENT CONDUCTING OXIDE MEMBRANES FOR HYDROGEN PRODUCTION FROM WATER SPLITTING AT LOW-TEMPERATURES

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ABSTRACT

Solar energy can contribute effectively to the conservation of energy resources, security of energy supply and the reduction of greenhouse gas emissions. Solar energy can in principle be exploited to produce renewable hydrogen from water splitting. A novel method for the production of renewable hydrogen at ambient temperatures is based on mimicking the process of photosynthesis by which leaves can separate water into H_2 and O_2 by means of solar energy. The device consists of two electrodes separated by water The anode is made of suitable transparent electroconductive (TCO, Transparent Conductive Oxide) porous material and is exposed to sunlight. The dissociation of water takes place in the porous anode and the generated oxygen is removed through the hydrophobic pore assisted induced vibration of the water within the nano-structured anode. The generated electrons and protons are combined to form pure hydrogen. The efficiency of water splitting depends largely on the choice of appropriate TCO and the optimization of the nano-structured membrane. The scope of the present work is to optimize the design of nano-structured porous anode using a combination of experimental characterization and numerical simulation tools. The first stage of the work involves TCO morphological characterization of powders and membranes using electron microscopy (SEM, TEM). Numerical simulation tools are developed for the design of micro-porous membranes by virtual material models based on the creation of 3-D digital membrane samples using stochastic particle deposition algorithms. In this way it is possible to digitally reconstruct membranes and evaluate different design variables dependent on micro-structural characteristics. The parameters that can be controlled include the thickness and the total porosity of the electrode, the average size and particle size distribution, the degree of aggregation etc. Typical results are presented and a relative assessment of TCO powders/membranes is performed. Simulation results can also be used to extract weighted values of macroscopic membrane properties (permeability, thermal and electrical conductivity, etc) for use in three-dimensional CFD calculations.

Keywords: Renewable Hydrogen, Electro-conducting Membranes, Digital Reconstruction, Stochastic Particle Deposition Algorithms

A NOVEL ELECTROCHEMICAL PROCESS TO DIRECTLY CONVERT OLIVE KERNEL TO ELECTRICITY IN SOLID OXIDE FUEL CELLS

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ABSTRACT

The direct utilization of olive kernel (Mills of Crete) as fuel feed stock in Solid Oxide Fuel Cells of the type: Fuel| Co-CeO_2|YSZ|Ag|Air is explored. The influence of various operation parameters, related to i) cell temperature (700-800^oC), ii) carrier gas (inert He or reactive CO_2) and iii) molten carbonates (62 mol% Li_2CO_3 + 38 mol% K_2CO_3) and/or catalyst (20 wt% Co/CeO_2) infusion into olive kernel feedstock, on the achieved electrochemical performance was studied. The pronounced effect of catalyst as well as of molten carbonates on the achieved cell performance was revealed. At 800^oC, maximum power values equal to 10, 21.7, 23.5 and 25.7 Mw were obtained using as feedstock bare olive kernel and olive kernel admixed with catalyst, carbonates and catalyst/carbonates, respectively. The obtained results are discussed based on AC impedance spectroscopy measurements, which revealed the impact of operating parameters on overall cell and electrode resistances.

Keywords: Direct fed biomass fuel cell, olive kernel energy conversion, catalytic gasification, molten carbonates

ENERGY POLICY

RENEWABLE ENERGY SOURCES IN CRETE

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ABSTRACT

Renewable energy supplied last year 16% of the global energy consumption (includes biofuels and hydroelectricity). Fossil fuels share 81% of the Global Final Energy Consumption, and nuclear 2.8 %. Wind, solar, biofuels and geothermal energy account only for 5.4%. The share of renewable energy in global electricity production reaches 20%; the no-hydro renewable is 3.3% when 67.6% comes from fossil fuels, and 16.3 % from Hydro.

In the island of Crete the Wind and Solar Energy share of Electricity production climbed to 24 % in 2013!

In Crete since 1993 when the first Wind Farm was installed in Lassithi area, more than 10% of the annually production comes from RES. The Wind and Solar potential in Crete is among the largest in Europe. Five years ago a law came into force which allowed 100 MW of solar farms to be installed in Crete with max capacity of 80 kW each, dispersed in the fields of the island. They are paid by feed-in tariffs. This was a big success contributing in the decrease of the morning peak, stabilizing the voltage across the island and preventing the start-ups and the operation of the expensive gas turbines during the day. During the summer period (almost 5-6 months in Crete) a constant production of solar energy is expected to be added in the system everyday during daylight.

The RES power penetration reaches 45%-60% during windy and sunny days providing a good experience for the exploitation of the sun and wind potential and showing a way for the future oil independence of the island.

During summer months the performance of the Wind Farms reaches more than 40-45% and the PV Farms 29%. During the summer period, wind and solar share 23% of the total production.

A lot of effort has been made in order to minimize the curtailments of the wind farms only during the night, during bad weather conditions and thunderstorms.

All wind farms are connected on line with the dispatching Center of Crete through satellite, mobile and ADSL lines. The communication with the distant mountainous areas has been improved significantly during the last 15 years.

A telematic system is developed which monitors online 20 PV parks, up scales the power and calculates the PV power contribution in the system.

Some tools are developed in order to exploit the new capabilities of the up-to date technology of the wind turbines in order to help recovering the Power System after system faults.

EXPLORING SOCIAL DIMENTIONS OF PRICING POLICIES IN ENERGY SYSTEMS: A SYSTEM DYNAMICS APPROACH

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ABSTRACT

In recent years, energy issues have attracted the increasing attention of the public interest worldwide. The need to secure energy supply is a necessary component of everyday living as it greatly depends upon the existing energy production structure processes and it is clearly attached to the necessities dictated by the human needs and modern lifestyle. To that effect, the most critical factor for the improvement of living and the ameliorating of the societal and cultural status is closely related to the uninterrupted power supply within a rational pricing framework. Therefore, the continuous advancements in the energy production mix due to the penetration of renewable energy sources and the directives of the European Union (EU) foster sustainable energy policy-making in global economic and energy systems.

Specifically, the EU energy policy roadmap outlined by the initiatives and directives for the period 2020-2050 clearly documents the objective to secure energy supply, combating in parallel climate change and fuelling regional economic development. On the one hand, ensuring energy efficiency and independence of the EU member states, and on the other hand the continuous supply of energy at reasonable price levels through applying socially acceptable pricing and environmental friendly frameworks, is the focal point of the EU energy strategy.

Exploring alternative sustainable policies while focusing upon social acceptability of the pricing policies has been, thus far, approached only myopically in literature. Therefore, in this work we employ the System Dynamics Theory to explore alternative sustainable pricing policies for the electricity sector. Therefore, we first propose a first-effort methodological approach for the development of dynamic models for the strategic decision-making upon pricing policies emanating from the subsystems of the economy, the environment and the society and we further explore the manner in which the components of each subsystem affect (positively or negatively) the broader sustainable operations in electricity systems.

Keywords: System Dynamics, Energy Systems, Pricing Policies, Sustainability.

SOCIAL AND ECONOMIC DEVELOPMENT OF LOCAL COMMUNITIES BASED ON ELECTRICITY PRODUCTION FROM RENEWABLE ENERGY SOURCES. THE EXISTING SITUATION IN GREECE

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ABSTRACT

During the last five years, an anarchic policy has been adopted by the investors regarding the submission of a large number of applications in Greece for the implementation of electricity production projects from Renewable Energy Sources (R.E.S.). The geographical depiction of these applications, as well as the issued licenses, in the official site of the Regulatory Authority of Energy (R.A.E.), presents vividly the results of this policy. Applications and licenses without any strategic design, usually of extremely large size in relatively limited insular territories, often violating several environmental or cultural constraints introduced in the relevant legislation. Applications and licenses that have been submitted without informing the local communities, neglecting the existing industrial, agricultural or domestic activities, the land properties and, consequently, provoking the common sense and reverting the generally positive common attribute about R.E.S., recorded in Greece before 2008. During the last five years, for the first time in Greece we saw demonstrations against R.E.S. and whole communities expressing officially their objection against specific R.E.S. projects (e.g. via Municipal Councils' decisions).

This article aims at the investigation of the reasons that resulted in the above presented negative situation. Possible deficiencies of the existing legislative framework are also examined. Finally, some characteristic examples of the submitted applications or issued licenses are presented and their technical and economic feasibility is evaluated.

Beyond the reversion of the initially positive common opinion, further consequences of the improper applications are also examined. In their majority, the submitted applications and the issued licenses are characterized by low maturity. Violation of several environmental constraints, disapproval from the local communities, inadequacy to procure the required land properties, lack of R.E.S. potential measurements are some common feature of the cursory and premature applications. Ultimately, all these applications and licenses exhibit law probability to be implemented. At the same time, all these premature projects cover large geographical territories, preventing thus other mature and more realistic R.E.S. projects from applying for licensing. Consequently, the existing applications and licenses, instead of promoting the R.E.S. development in Greece, they continue to keep it steady for as long as they exist.

In the last section the article proposes measures for the rational development of R.E.S. electricity production projects in Greece. These measures aim to combine the maximization of the R.E.S. development in Greece with the protection of the local communities (natural environment and human activities). Furthermore, they aim to support the contribution and the participation of both local investors and the Municipalities in the R.E.S. projects. These measures will maximize the social and economic benefits for the local communities and should be introduced officially in the relevant legislation.

Keywords: Renewable Energy Sources Rational Development, Renewable Energy Policy, Local Communities, Municipalities, Local Communities Social Economic Development, Environmental Impacts, Human Activities

THE INTRODUCTION OF HYBRID POWER PLANTS IN NON-INTERCONNECTED INSULAR POWER SYSTEMS FOR THE MAXIMIZATION OF RENEWABLE ENERGY SOURCES PENETRATION

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ABSTRACT

This article presents the results from the study, the design and the dimensioning of hybrid power plants (hybrid stations) for the electricity production in insular non-interconnected power systems in Greece. The synthesis of the examined hybrid stations is mainly determined by the size of the insular system, given the high availability of the wind and the solar potential in Greek territory. Consequently, either wind parks or photovoltaic stations can be exploited as the base production units of the hybrid station. As storage devices, pumped storage systems (PSS), electrochemical batteries or electrolysis devices for hydrogen production can be alternatively used.

The hybrid stations are introduced in the insular systems aiming either at the maximization of the Renewable Energy Sources (RES) penetration, for small and medium size systems, or at the power demand peak saving, for large size systems. In any occasion, the dimensioning of the hybrid systems is accompanied with thorough sitting of the required works, frequently accomplished after an on-site investigation. The hybrid stations' design is always integrated with the economic evaluation of the required investments.

The hybrid stations examined in this article are introduced in insular systems of very small size (Agios Efstratios, Kastelorizo), small size (Karpathos - Kasos, Astypalaia), medium size (Rhodes, Samos) and large size (Crete). The most technically mature and economically competitive technologies are employed for each introduced hybrid station, as far as the RES and the storage devices are concerned. The economic feasibility of the required investment remains a fundamental target of the examined projects, beyond the maximization of the RES penetration or the successful power demand peak saving.

Regardless the size of the examined insular system, the results of the hybrid stations studies proved the technical and economic feasibility of these projects. The annual electricity production exceeds 90% of the annual consumption in insular systems of small and very small size. The economic feasibility of the required investments is guaranteed without the need of any kind of contribution and with vending prices of the produced electricity lower than the existing electricity production specific cost of the insular systems.

Keywords: Hybrid power plants, Pumped storage systems, Electrochemical batteries, Insular systems, Maximization of the RES penetration

THE PROJECT "GREEN ISLAND - AGIOS EFSTRATIOS" - THE COMBINED SYSTEM OF SOLAR THERMAL AND GROUND SOURCE HEAT PUMPS FOR HEATING AND COOLING IN BUILDINGS

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ABSTRACT

The energy system in Greece, compared with other European systems, is based primarily on coal, since hydrocarbons and solid fuels (lignite) cover more than 80% of the country's energy needs. In order to change the existing situation, efforts are made to promote the integration of Renewable Energy Sources (RES) in Greece. In this framework, Green Islands are created with the installation of hybrid renewable energy systems and storage devices, which provide energy, environmental and economic benefits, as demonstrated in the existing Green Islands that have been implemented worldwide.

The island of Agios Efstratios is expected to be the first Green Island in Greece with significant RES penetration in its autonomous grid system. The project "Green Island - Agios Efstratios" is a research-demonstration project, where technologically mature and innovative renewable energy technologies, as well as energy-saving technologies in the building sector, will be implemented. In this way, a high percentage of the energy needs of the island will be covered by using environmental friendly technologies. The interventions planned in the island refer to electricity production, transport means, demonstrative stationary applications, energy saving and coverage of thermal and cooling loads in buildings using renewable energy.

This paper aims to analyze the combined system of Solar Thermal and Ground Source Heat Pumps for heating and cooling in the school of the island and to present the system of solar energy storage in zeolite tank. Emphasis will be given to the design and operation of the combined system, the expected benefits of the application as well as its innovative features. Finally, there will be reference to the control system of the abovementioned installations, in order to optimize the operation, which is expected to lead to significant research findings.

Keywords: Solar Thermal Systems, Ground Source Heat Pumps, zeolite tank, Green Islands, Renewable Energy Sources (RES)

BARRIERS AND ACTIONS FOR THE PENETRATION OF GROUND SOURCE HEAT PUMP TECHNOLOGY IN THE RESIDENTIAL SECTOR

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ABSTRACT

Aim of this study is to examine the views of the individuals activated in the ground source heat pump (GSHP) sector, regarding their level of dissemination in Greek households. Specifically, the study examines their perceptions on the current and future situation of the dissemination of GSHP, penetration barriers of this technology and the actions through which adoption of the technology can be encouraged. Data collection was performed through a questionnaire during two scientific meetings (January and May 2012), as well as through the use of an electronic mailing list (July-August 2012).

The main penetration barriers are: a) the lack of public information on the technology and the benefits of GSHP, b) the economic recession, c) the lack of adequate subsidy / tax reductions for the installation and d) the installation cost. On the other hand, the main actions proposed for the removal of the barriers are: tax reductions for GSHP systems, public information activities and education activities for installers. Through factor analysis, the penetration barriers can be classified as "Market Barriers", "Information Barriers", "Regulatory Barriers", "Installation and Siting Barriers" and "Economic Barriers". The actions that can contribute to the penetration of the technology can be categorized as "Information Activities", "Economic Incentives", "Regulatory Framework" and "Technological Improvement".

Keywords: ground source heat pump, barriers, Greek households, factor analysis

THE IMPACT OF ECONOMIC CRISIS ON RESIDENTIAL HEATING AND THERMAL COMFORT IN ATHENS

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ABSTRACT

The winter of 2012 - 2013 was quite difficult for the Greek households due to the increased prices and taxes of oil used for heating purposes. In fact, the price of oil was equalled with the diesel which led to the reduction of the use of oil by 71%. Consumers turned into alternative forms of heating like firewood with a huge environmental impact. The increase ppm's in dangerous levels health and the emergence of smog was obvious not only in Athens and Thessaloniki, but even in small towns.

In the present paper an effort record the effect of economic crisis on the environment and the alteration of the decision making process for heating of Athenians is presented. The survey was conducted with the help of a questionnaire with 64 closed-type questions. A special interest was given to questions concerning the state of health and socioeconomic status of respondents.

About 500 questionnaires was collected after personal interviews in 10 different places in Athens during the spring of 2013 (April and May). The sample is representative of the Greek population since its characteristics correspond to the averages published by Greek Statistical Authority in Athens. The survey showed that only 32% of the sample used the existing heating system with oil boiler as their main source for heating and about 4% didn't heat their place at all. Also, 44% of the sample is feeling really annoyed by the high air pollution a fact that led to major changes in their lifestyle.

The results can be used as a useful tool to demonstrate to a strategic policy decision study with a view to promote cheaper and cleaner energy in order to prevent similar phenomena of fuel poverty.

Keywords: Energy poverty, Heating, Environmental pollution, Economic crisis

SOLAR ENERGY, A ROADMAP FOR NATIONAL DEVELOPMENT

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Year 2020 is a noticeable year for Europe regarding energy, because of the set energy target 20-20-20. This target, even if it will not be completely achieved, it seems to be a mark point for a significant turn to energy saving and wide use of RES (Renewable Energy Sources), considering the new energy strategy for 2030 and the advanced target of 30%. In our country, the energy profile is based on the conventional energy sources: coal, oil, natural gas and hydro, with RES to cover a small part of energy demand (mainly wind turbines and photovoltaics). For the next years, a new energy program towards 2050 should be planned, to minimize the use of coal and imported fuels (oil and natural gas) and based on national energy sources, as of solar energy (thermal collectors and photovoltaics), wind energy and other RES. It is estimated that a wide use of solar thermal collector systems will result to become Greece first country in the world, regarding installed solar energy systems per capita. Our country was at this rank up to 1990 with the fabrication, installation and exportation of solar collectors for water heating. In this paper, a study for the wide application of solar thermal collectors and photovoltaics in the built sector is presented and analyzed considering energy, economical and environmental aspects. The wide application of solar energy systems is suggested with respect to energy saving requirement, as a cost effective and environmentally adapted process. The application of energy saving methods and use of solar energy systems to achieve reduction of 20% in national energy consumption is compared with the amount of energy from oil and gas that is estimated under Ionian Sea. Finally, the developed systems in Solar Energy laboratory are briefly referred, to give an idea about their contribution to energy targets and economical development of the country.

Keywords: RES, Energy saving, Solar thermal collectors, Photovoltaics

ENERGY UPGRADE OF BUILDINGS

BENCHMARKING MICROCLIMATIC CONDITIONS (THERMAL ENVIRONMENT) IN THREE RESIDENTIAL BUILDINGS

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ABSTRACT

This paper presents the results of ongoing research that aims at energy evaluation of three different types of building shells during the summer, in existing housing in the region of Xanthi. The research includes measurements of temperature, humidity and air speed inside and outside the homes, with the aim of determining the microclimatic conditions. At the same time examining the interaction of users with the building envelope and recorded their observations about the weaknesses of each shell. The objective is to benchmark the different types of shells as to the conditions of the interior thermal environment in order to draw useful conclusions about the viability of existing structures.

Keywords: benchmarking, building envelope, interior microclimate

OVERVIEW OF ENERGY EFFICIENT UPGRADES OF RESIDENTIAL BUILDINGS

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ABSTRACT

As part of the efforts to address the environmental problem, the European Union (EU) has set a series of climate and energy targets to be achieved by 2020. These targets include a 20% reduction of greenhouse gas emissions in the EU than 1990 levels, improving energy efficiency in the EU by 20% and increasing the contribution of renewables in final energy consumption to 20%. To achieve the objectives, Member States have prepared national action plans and proposed national binding targets.

Buildings consume about 40% of the final energy in Europe and account for about 45% of carbon dioxide emissions in the atmosphere. In Greece, the residential sector accounts for 90% of the thermal and 50% of the electrical energy consumption in buildings. Residential buildings represent 77% of the total building stock and the majority of them have a poor energy performance, since as a result of their age, they have poor thermal insulation and systems with low efficiency. Accordingly, the residential sector has a great potential for significant energy savings and it is clear that the adoption of effective energy conservation measures can play a significant role in meeting the national targets for energy and climate change.

This paper presents the results for the prioritization of various measures for energy efficient upgrades of Hellenic residential buildings. The evaluation is performed using the national TABULA typology of residential buildings, taking into account the calculated energy savings, combined with the estimated payback period for each measure and 24 building types. The investigated measures include the buildings' thermal envelope and the electromechanical installations. The calculations were performed using the national software TEE-KENAK. The analysis refers to upgrades that aim to reduce energy consumption for space heating and domestic hot water, which are the main end-uses of energy in the residential sector.

Key words: dwellings, statistical data, energy consumption, conservation, ranking measures

TECHNICAL ANALYSIS OF WINDOWS' AND CONSTRUCTION ASSEMBLY FOR ENERGY SAVING

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ABSTRACT

This study examined the performance of the assembly frame construction on the masonry's surface. Particular approach given to the structural elements between the masonry and the frame. Technically, frame quality categorized through three main characteristics: 1) the characteristics of glass, 2) the structure and characteristics of the frame, and 3) the frame fitting technique on the masonry. Aim of this work is to investigate the structural failures of the frames assembly to improve their energy upgrade within the bioclimatic design in accordance with the principles of green building.

Keywords: Energy assessment, Energy conservation, Glazing, Window frames.

BUILDING ENERGY PERFORMANCE

KEY ENERGY PERFORMANCE INDICATORS OF HELLENIC RESIDENTIAL BUILDINGS

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ABSTRACT

Various performance indicators are commonly used to provide valuable insight for comparing buildings' energy performance, such as energy consumption per unit floor area or the energy class according to KENAK that is displayed on an energy certificate. This work starts with a brief comparative overview of KENAK with other internationally recognized building rating systems based on environmental criteria and energy efficiency. Next, the work captures the main results of a recent field survey of about 200 households to collect data about occupant behavior in relation to energy consumption for heating (e.g. heating systems, operating hours, prevailing thermal comfort conditions) in recent years. The results confirm the serious problems faced by Hellenic households to meet their basic heating needs. The available data also reveal significant differences from the assumptions and typical values used in the calculations under KENAK and the technical guidelines. Furthermore, the work evaluates the effectiveness of various energy conservation measures by analyzing actual energy consumption before and after refurbishment. The data are derived from actual energy consumption in dwellings that have been refurbished, including common works for improving the building envelope, the space heating or domestic hot water system. The effectiveness of the measures is assessed taking into account the prevailing weather conditions or other significant changes in the operation of the building. The data presented can be used to adapt the estimated energy consumption indicators when comparing calculations according KENAK with actual energy use or forecasting the effectiveness of energy conservation measures in the residential building stock.

Key words: residential buildings, real energy consumption, real operating conditions, effectiveness of energy conservation measures

NRG4CAST: INNOVATIVE ENERGY MONITORING - FORECASTING TOOLKIT FOR BUILDING BLOCKS

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ABSTRACT

Energy efficiency in buildings has been a priority for years, both at European and national level. Accurate and immediate monitoring of the energy consumption and the ability to predict energy needs can decisively contribute to achieve significant energy savings rates and optimize the operation of energy systems. These elements constitute a part of the targets of research project NRG4Cast funded by the 7th Framework Programme of the European Union. The purpose of the developed tool is to collect and analyze information about the topology of the network, installed devices, demand, supply and consumption of energy, environmental data management and energy costs.

The tool will provide energy management features, real-time monitoring, energy analysis and forecasting services for power distribution networks in urban / rural communities taking into account the local needs and particularities of each area. The tool includes a decision support system based on network monitoring, anomaly detection, route cause analysis, trend detection, planning and optimisation of energy scenarios. These services are using advanced knowledge technologies in particular machine learning, data and text mining, stream mining, information extraction, knowledge formalisation and reasoning.

In the current study the philosophy, features, and functionality of the NRG4CAST tool are presented, the pilot study of its implementation in buildings of the National Technical University of Athens is reported, along with the benefits which will derive from its use.

Keywords: Smart grids, real-time monitoring, analytics and forecasting software tool, data management, energy conservation, ICT

ASSESSMENT OF THE ENERGY BEHAVIOR OF HELLENIC BUILDINGS USING THE ENERGY PERFORMANCE CERTIFICATES

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ABSTRACT

The building sector has a large energy and environmental footprint, since it is responsible for about 40% of global energy used, and as much as one third of global greenhouse gas emissions. The present work is an effort to get a first overview of the energy behavior of the Hellenic buildings in their existing condition, by exploitingthedataincludedintheissuedBuildingEnergyPerformanceCertificates (EPC). In addition, energy conservation measures proposed or implemented are investigated in order to define the most common for each building type.

From the issued Energy Performance Certificates (EPC) up to June 2014, the breakdown for the domestic sector is 15% for single family houses and 85% for multifamily houses (buildings or apartments). For the tertiary sector the corresponding breakdown is 56% for commercial buildings and 16% for. The first analysis confirms that buildings at the present situation show low energy performance. Residential buildings are ranked in the last energy class (G) by 34%, while only 3% is ranked in energy classes B or higher. The average calculated primary energy is 261.3kWh/$m^2$and the average CO_2 emissions 70.3kg/m^2. In general, non-residential buildings have better energy behavior, ranked in energy class D by 37% while only 12% are ranked in the last two classes (F and G). The average calculated primary energy is 461.2kWh/m^2 and the average CO_2 emissions 145,9kg/m^2. Replacing the windows is the most common measure for both building sectors.

Keywords: energy performance certificates, energy consumption, energy class, energy conservation measures, energy savings

EVALUATION OF THE ENERGY PERFORMANCE AND INTERNAL THERMAL CONDITIONS IN SECONDARY SCHOOLS

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ABSTRACT

The energy consumption of the building sector has become a major issue of energy policy, as the building sector consumes about 40% of the total energy consumed in Europe and is responsible for about 45% of carbon dioxide emissions (CO2) in the atmosphere. The object of this work is the energy assessment and evaluation of internal thermal conditions of secondary school buildings (Lykeia) in the 3rd Climatic Zone of Greece and specifically the city of Xanthi, through energy audits and monitoring of parameters affecting indoor comfort conditions.

Analyzing the data collected it can be concluded that:

- secondary school buildings (Lykeia) in the city of Xanthi consume less energy to meet their thermal requirements, compared with the average energy consumption of school buildings throughout Greece,
- energy consumption for heating in the areas in the D Cimatic Zone are almost twice those of Xanthi.

Regarding the internal conditions in classrooms, the air temperature before the start of the operation of schools is stable at low levels and gradually increases with the turnout of the students and the operation of the heating system, reaching the highest levels at 10:00 - 11:00 and gradually decreases until 14:30. The thermal comfort is not guaranteed in all school buildings, as the air temperature during lesson hours can range from 17 to 18 °C and in another school from 20 to 24 °C.

Keywords: energy consumption, secondary schools, internal thermal conditions

POST OCCUPANCY EVALUATION OF BUILDINGS

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ABSTRACT

This paper presents a post occupancy evaluation (POE) study performed at the Castle Hill primary school in Kingston. The aim is to highlight the importance and necessity of POE of buildings in order to identify mistakes and deviations among design, construction and use.

POEs focus on the users' satisfaction and the efficient operation of the building. They are considered as the last step after the design and the construction of a building, in order to improve the indoor conditions according to the occupants' needs, and to be used as guidance for the design of future buildings. Finally, they assist to the improvement of the operation of both the building services and the equipment in order to achieve a better energy performance of the building.

For the execution of the POE environmental conditions were monitored and the occupants were surveyed using the BUS methodology. The energy performance of the building was evaluated as well. In addition, the aspects of the school design affecting the indoor environmental quality were discussed and design recommendations were proposed.

According to the monitoring, the school met the requirements of thermal comfort and indoor air quality. Occupants reported to be thermally comfortable. Some of them claimed a slight discomfort, which was attributed to the malposition of radiators on the upper part of the walls.

In terms of building design, the windows were evaluated ineffective due to the limited openable area, which led to adaptive actions by the occupants. The increase of the openable area was recommended.

Finally, the energy performance was satisfactory, and the school was ranked among the best performing ones of the whole national stock. However, future improvements, such as the reinstallation of the radiators close to the floor of the building, were deemed necessary to achieve a higher rating.

Key Words: post occupancy evaluation, environmental conditions, thermal comfort, energy performance

THE INFLUENCE OF THE NEW REGULATION ON BUILDING ENERGY PERFORMANCE ON GREEK RESIDENTIAL BUILDINGS

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ABSTRACT

This paper attempts to analyse the changes that the new regulation on the energy performance of buildings (KENAK) has brought to the Greek residential buildings, which, according to the building census of 2000, hold approximately 77% of the building stock in the country. It is worth noticing that 74% of the residential buildings in Greece are single-family houses, 14% semi-detached houses and only 12% of the residential buildings are multi-family buildings (with three or more dwellings).

Within this context, the study comprises a comparative analysis of the energy performance for two typical residential buildings, a single-family and a multi-family one, which were studied according to the requirements set before and after the application of KENAK for the four climatic zones of Greece. The cost of the measures applied for the implementation of the two regulations was evaluated, as well as the operating costs for heating, cooling and domestic hot water of the examined buildings.

According to the study, the implementation of KENAK significantly reduced the required heating loads for the buildings space heating in all climate zones by 33% to 40% for both building types; this is mainly attributed to the improvement of the thermal protection of the building shell and the high requirements imposed for the electromechanical systems. On the other hand, the required cooling load is very low and has not changed significantly. However, a significant reduction on energy consumption is achieved by the installation of solar panels for domestic hot water (DHW), which ranges from ca. 41% to 50%, depending on the climate zone and the building type.

It must be noted that the area weighted final and primary energy consumption is higher for the single-family building than the multi-family one; this was actually expected, considering the larger area of the building envelope which is exposed to the ambient environment with regard to the enclosed heating volume.

The total reduction on energy consumption achieved by the application of the requirements of KENAK is significant; in almost all cases it is reduced by almost 50%, when compared to the one obtained by the application of the former regulation, while the reduction on primary energy is even greater.

For this reason, the payback period for the additional construction costs is satisfactory, ranging from 4 to about 2.5 years for the single-family building and from 5 to17 years for the multi-family one. The optimum payback period appears for the colder climatic zones C and D.

As a result, it seems that the forthcoming introduction of stricter requirements for the building envelope can improve the energy performance of buildings; however it is expected that such a measure would not constitute a cost optimal solution for climate zones A and B, especially for multi-houses.

DISCHARGE COEFFICIENT DETERMINATION FOR NATURAL VENTILATION OPENINGS IN HIGHRISE BUILDING

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ABSTRACT

Natural ventilation is a technology that allows the reduction of energy consumption. Nevertheless, for the preparation of a program for openings usage (duration, opening size or inclination angle) is necessary the knowledge of openings' discharge coefficient, $C_{d,}$ which typically takes a value of 0.6.

In the present work the discharge coefficient of an office building openings was calculated. The office building is consisted of 7 floors with office modules aligned on two facades separated by a central corridor and it was used as reference building in the SWIFT project. The discharge coefficient was calculated for the case of wind induced cross ventilation. Since the building had a length of 67 m, it was considered a cross section which could be modeled in 2D.The openings can be inclined in different angles.

For the calculation a 2D, steady state, incompressible CFD model was developed using the finite volume method. The developed CFD model was validated against experimental data from wind tunnel measurements in a model. The turbulence was modeled with the RSM model but the standard k-ε model was used in order to create an initial flow field for the beginning of simulation.

The discharge coefficient is calculated for three different elevations (ground floor, 4th floor and 7th floor) considering four combination of inclination angles: a) windward and leeward opening inclination angle 15 ^{o}, b) windward and leeward opening inclination angle 30^{o}, c) windward opening inclination angle 15 ^{o} and leeward 30 ^{o}, and d) windward opening inclination angle 30 ^{o} and leeward 15 ^{o}. It was examined the dependence of discharge coefficient from: a) the wind velocity, the characteristics of the field where the building is situated (field roughness length and atmospheric boundary layer thickness) considering four field types (according to the European Wind Atlas classification): a) Urban area (centre and suburbs), b) Open field (classes 2 and 3).

From the results it comes out that the discharge coefficient, $C_{d,}$ ranges from 0.54 to 0.7 and is strongly depended from the inclination angle of windward and leeward openings, from the position of the opening in the building (floor), from the field roughness length of the field around the building and from the turbulence intensity of the wind. It was also calculated a discharge coefficient, C_{dw}, that relates the openings flow with the wind velocity at the infinity, which ranges between 0.13 and 0.89 and is also depended from all the above referred factors. It is considered that this coefficient could be more usable for the building designer since does not requires the knowledge of the wind velocity at the opening.

Key words: Discharge coefficient, cross ventilation, CFD, field roughness length, wind pressure

EVALUATION OF THE ENERGY BEHAVIOR OF BUILDINGS IN GREECE WITH COMPARISON WITH THE BEHAVIOR OF BUILDINGS IN OTHER COUNTRIES WITH SIMILAR CLIMATE

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ABSTRACT

According to official statistics, the performance in terms of energy behavior of buildings in Greece reveal an unclear picture compared to the respective performance of buildings in the European Union as a whole. For some indices the picture is positive and for others negative. But, apart from the sign of these indices, their validity is reduced by the fact that they result from comparisons between countries with significant differences in prevailing climatic conditions.

The paper attempts to compare data that describe the energy performance of buildings in Greece with corresponding data from the countries of southern Europe, where there is a Mediterranean climate (Portugal, Spain, Italy, Croatia, Malta, Cyprus). The comparison results in more valid conclusions. The same conclusions are also more useful to explore the margins of exploitation of renewable resources and climatic conditions in the country for the benefit of the energy performance of buildings in it.

Keywords: Greece, Buildings, Energy behavior, Mediterranean climate

THERMAL INSULATION OF BUILDING ENVELOPE

APPLICATION OF INNOVATIVE COMPOSITE COOL THERMAL INSULATING MATERIALS FOR THE ENERGY UPGRADE OF BUILDINGS

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ABSTRACT

The need to improve energy efficiency of existing buildings is more than understandable and compelling. It is expressed through the EU Directive 2002/91/EU concerning the energy performance of buildings, the Greek Law 3661/08 concerning the improvement of the energy performance of buildings; which constitutes the harmonization of the Directive in the Greek legislation as well as the Regulation on Energy Efficiency Buildings (KENAK) which together with the Technical Instructions of the Technical Chamber of Greece, are the main application of the Legislation. Common goal is the reduction of the energy consumption in buildings at least 20% according to the "20-20-20" targets and the achievement of the required substantial contributions to the building stock. The composite cool materials are a new and interesting solution for the constructions. Having identified -with extensive bibliographic research- the existing state of the market for thermal insulation materials and trends, these composite materials were characterized as a successful option. Finally external thermal insulation composite systems were produced (with photocatalytic coating) and composite materials for the roof (extruded polystyrene with low reflectivity ceramic tile) which were analyzed -initially theoretically- in order to determine the energy performance of the building before and after their application, and then applied to an existing building. Additionally there were determined the conditions before and after the installation of materials for thermal insulation capacity, by measuring the rate of heat transfer, by conducting measurements for the evaluation of the implementation of the new products of thermal comfort and air quality as well as by representative measurements of the microclimate of the area both during summer and winter. In the context of the 10th National Conference on Renewable Energy Institute for Solar Technology the results of the energy performance of new materials after their first application will be presented.

Keywords: innovative thermal insulation materials, cold materials, extruded polystyrene insulation retrospective, perform measurements

ENERGY REFURBISHMENT OF STUDENTS' RESIDENCE BUILDINGS IN KOMOTINI - IMPLEMENTATION AND OUTCOMES OF THE ELIH - MED PILOT PROJECT

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ABSTRACT

This paper describes the activities that were implemented in the pilot energy refurbishment of the 5 Students' Residence buildings of the Democritus University of Thrace in the campus of Komotini. The buildings have a total floor area of 12,863m^2 and the capacity to accommodate up to 700 students. The project was implemented through collaboration of the Democritus University of Thrace, the Centre of Renewable Energy Sources and Saving and the Region of East Macedonia and Thrace, in the framework of the strategic European project ELIH - MED («Energy - Efficiency in Low - Income Housing in the Mediterranean»).

In the ELIH - MED project there are 18 participating partner organisations from 7 Mediterranean countries (Spain, France, Italy, Slovenia, Greece, Malta and Cyprus). The project started in April 2011 and will be completed in December 2014.

The objective of the project is the identification of the most appropriate technologies and financial mechanisms for improving the energy - efficiency of social and low - income housing in the Mediterranean, and their pilot large - scale application through the implementation of 10 energy refurbishment projects in 6 of the participating countries.

Keywords: energy refurbishment, student residences, social housing, low - income housing, external insulation, energy saving, energy - efficiency, financial mechanisms, communication activities

EXPERIMENTAL INVESTIGATION OF PAVMENT MATERIALS THERMAL BEHAVIOUR AND COMFORD

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ABSTRACT

This paper aims at the experimental investigation and description of outdoor pavement materials thermal behavior, based on field measurements. Furthermore, the thermal comfort was estimated. The variables that were measured for every material were the intensity of solar radiation, the surface temperature, the wind speed and the relative humidity. Then, the ambient temperature and the rest of the above mentioned variations were measured at a 10 cm, 30 cm, 110 cm, and 150 cm high. Based on these data the PMV, SET, and PET indexes were calculated. The results of this research agree with the assumptions of the Laboratory of Environmental and Energy Design of Buildings and Settlements. The aim of the whole effort is the energy and thermal comfort upgrade of the urban areas and open spaces.

Keywords: Thermal comfort, pavement materials, PMV, SET, PET, urban design

DETERMINATION OF THE LIMITS FOR THE PREVENTION OF SURFACE VAPOR CONDENSATION, BASED ON MAXIMUM ALLOWED THERMAL TRANSMITTANCE VALUES IMPOSED BY REGULATION OF THE ENERGY EFFICIENCY OF BUILDINGS

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ABSTRACT

Surface vapor condensation on the internal building element surfaces is a moisture phenomenon of interior spaces depending on the air temperature and relative humidity, and the thermal insulation protection of the building. Insufficient thermal protection or increased internal relative humidity, increase the risk of surface condensation. Requirements imposed by the new Regulation of the energy efficiency of buildings (K.EN.A.K) limits outward heat flows and contributes in preserving increased surface temperature values of building elements, but restricts infiltration, since modern windows are airtight and prevent vapor removal.

This study examines the surface vapor condensation in internal spaces, based on the maximum allowed thermal transmittance values imposed by K.EN.A.K., for every construction element in buildings in order to determine the temperature and relative humidity limits within were condensation is prevented.

Results are organized in a table form that assist the user to determine the interior space temperature and relative humidity based on the prevailing ambient air temperature

Keywords: K.Ev.A.K., vapor condensation, dew, surface temperature.

LABORATORY MEASUREMENTS OF HEAT TRANSFER COEFFICIENT OF THE BUILDING PRODFUCTS IN GREECE

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ABSTRACT

It is known that the 30% - 40% of energy consumption in developed countries is related to the buildings and that the measures in order to reduce energy consumption aim mostly at reducing heat loss from the building envelope.
An important tool for energy savings in buildings in our country, is the application of the energy code “K.En.A.K”. According to which the entire thermal protection of the buildings is legislated and the bases for the complete environmental design take effect. For the proper implementation of the energy code K.En.A.K. and generally for reliable energy calculations, it is required the use of building products with certified thermal conductivity or heat transfer coefficients (U-value).
Also, the insulating ability (U-value) is one of the seven basic legal requirements for CE product’s Compliance.
The problems today, particularly in our country are
- Deficiencies in CE Compliance
- Deficiencies in building products certified for their insulating properties:
The thermal conductivity coefficients «U» (W/m^2K) of the combined building products, such as window frames and doors, lightweight building products and systems, rolls, safety systems, etc., which are necessary for the compliance of the product with the CE marking, are individual and unique for each building product and must be determined by procedures, either analytical with calculation methods or experimental.
Laboratory measurements for determining the heat transfer coefficient, unlike computational methods which are approximate, have the advantage of accurate determination of the coefficient, as they can take into account factors such as material defects or manufacturing defects.
The paper will present the current state of the structural elements used in the Greek construction industry relatively to their U-value, especially for the windows and the doors. The insulating capacity of these elements will be commented based on laboratory tests carried out in the Architectural Technology Laboratory of the Department of Architecture of Aristotle University of Thessaloniki.
The Architectural Technology Laboratory, certified and notified Body, has the required infrastructure (Hot-Box system) for the laboratory measurement of the thermal conductivity coefficient, and during its four years of operation has implemented more than 80 measurements.

Keywords: heat transfer coefficient, Notified Bodies, Hot Box, laboratory measurements, CE marking

APPROACHING THE THERMAL BRIDGING EFFECT IN RESIDENTIAL BUILDINGS

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ABSTRACT

The new Regulation for the Energy Performance of Buildings imposes minimum requirements for the design and the energy behavior of the building elements and envelopes. The assessment of the thermal transmittance is still determinant for the selection of the geometrical and thermophysical characteristics of the thermal insulation. Although there are no significant differentiations on the estimation of the thermal transmittance of the building elements when compared with the former regulation, the assessment of the thermal transmittance of the building envelope has been expanded, including now the heat transfer via the thermal bridges that are located across the building envelope. The thermal bridging effect is estimated by finding the linear thermal transmittance of each thermal bridge, which depends on the location and the constructional characteristics of the building elements that form their joints at, as well as the length, across which the thermal bridge is extending. Although the methodology described is not particularly complicated, it can be fatiguing due to the plethora of thermal bridges on the building envelope. In order to examine the possibility of simplifying the calculation procedure, it was considered interesting to evaluate the influence of the thermal bridging effecton the thermal transmittance of the building envelope. Within this context, the thermal bridges and the heat transfer coefficients were calculated for a set of residential buildings, assuming different positions of the thermal insulation (externally/in the core of the masonry), as well as four different locations for each building (one for each climatic zone of Greece). The statistical analysis of the results revealed the contribution of the thermal bridges on the formation of the overall thermal transmittance of the building envelope, which actually differentiates with regard to the thermal insulation position and the climatic zone. Based on these findings a new approach is being suggested for the rough estimation of the thermal bridging effect, which can be applied in cases that a detailed calculation is not necessary, such as during the energy inspections of existing buildings. The reliability and the accuracy of the suggested approach has been tested and evaluated against the existing method for assessing the thermal bridging effect on existing buildings.

Keywords: thermal bridges, thermal transmittance of building envelope, thermal insulation

THE IMPACT OF THERMAL BRIDGES ON THE THERMAL LOSSES THROUGH THE BUILDING ENVELOPE

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ABSTRACT

The new Greek Regulation for the Energy Performance of Buildings has imposed that the thermal bridging effect should be taken now into consideration in order to assess the sufficiency of the thermal protection offered by the building envelope. Within this context, a fixed procedure has been established, which is based on the identification of the linear thermal transmittance (Ψ) and the length of all linear thermal bridges found on the building envelope. The position of the thermal insulation across the layers constituting the building elements, as well as the building's geometry have been regarded as critical factors for defining the thermal losses due to the thermal bridging effect.

This paper studies the impact of three different positions of the thermal insulation layer on the determination of the thermal bridging effect with respect to the thermal losses through the building envelope. More specifically, it is assumed that the thermal insulation is positioned on the external and on the internal side, as well as in the core of the building elements. The study takes also into account different building forms, originating from a building unit, which is multiplied along the three dimensions in order to create one- or multi-storey buildings, with limited or expanded floor plan, the thermal bridges of which are accordingly restricted or increased.

The paper proves that the presence of balconies on the building's facade, the existence of an open parking space (pilotis) on the ground floor or of an unheated underground space are key parameters for the assessment of the final results.

Keywords: thermal bridges, thermal transmittance of building envelope, position of thermal insulation, Regulation for Building Energy Performance

INVESTIGATION OF THE ENERGY PERFORMANCE OF A HISTORIC BUILDING USING TEE-KENAK AND RETSCREEN 4. COMPARISON OF THE METHODS AND THE RESULTS

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SUMMARY

Historical buildings were built to last as long as possible; on the contrary modern structures are characterized by scheduled obsolescence. During the last years the scientific community has come to the conclusion that the greenest building is the one that already exists. For these reasons, energy upgrading of historical buildings is quite important.

This paper deals with calculation of heating and cooling requirements of a historical building of Neapoli, Kozani, Greece. The building is currently housing offices. It is heated by a central oil-burning system with hot water boiler and it is cooled by an air to air electrically driven heat pump. The calculations of the energy requirements and energy consumption of the building were performed using the simulation models of TEE-KENAK and RETScreen 4. To calculate the total energy requirements, both models take into account conductive and convective transmission losses, solar gains, fresh air loads, internal gains and occupant loads. The results are expressed in kWh per square meter of floor area and year (heating/cooling season) and are given in tabulated form.

Results of the two models are not identical. The TEE-KENAK model ends up with up to 33% higher energy demand for heating and up to 11% lower energy demand for cooling, compared to RETScreen. The reason of this discrepancy is that RETScreen model estimates higher values for solar and internal gains than TEE-KENAK.

Our study confirms that RETScreen is a versatile tool that helps decision makers to quickly determine the technical and financial viability of energy efficiency projects. On the other hand, TEE-KENAK is an energy certification program that can be used for estimation of the energy performance of buildings. Accuracy of its results, though, depends on the fulfillment of the underlying assumptions, which could be considered as restrictive for some cases.

Key words: historic buildings, energy simulation, TEE-KENAK, RETScreen

ENERGY CONSERVATION, BIOCLIMATIC DESIGN AND RES APPLICATIONS IN BUILDINGS

OPTIMAL APPLICATION OF PASSIVE AND ACTIVE SOLAR ENERGY SYSTEMS TO BUILDING RENOVATION

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ABSTRACT

Building sector is the most important one for the energy consumption and every step to energy saving and energy source replacement by renewable energy sources contributes to overcome the energy, environmental and economical problems. Present work includes aspects and results for the optimal application of passive and active solar energy systems to building renovation. Photovoltaics that are combined with other RES and environmental technologies, can achieve energy saving, minimizing building pollutants, especially in the existing buildings and resulting to cost effective building eco-retrofitting. Towards zero energy buildings, a wider installation of PV modules to buildings will be performed, if smart building energy technologies are applied, reducing building energy load. In this paper, the parameters to optimize the contribution of photovoltaics to building energy demand and the technologies for building eco-retrofitting are presented. Considerations for energy and building eco-improvement suggestions for a 30 years old typical one family Greek house, are presented and analyzed. Regarding photovoltaics, their mounting on building facades and inclined roofs causes electrical output reduction due to installation from their slope and azimuth angles and also heat problems. We studied experimentally the effect of these angles and of solar rays incidence angle to PVs, regarding electricity output. In addition, aspects for improved performance photovoltaic systems with low cost heat extraction mode and diffuse reflectors, developed in our solar energy laboratory, are included.

Keywords: renovation, environment, photovoltaics, performance improvement, BIPV

USE OF A GEO-THERMAL SYSTEM IN A RESIDENTIAL BUILDING, FOR ENERGY EFFICIENT HEATING, COOLING AND HOT WATER SUPPLY

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ABSTRACT

Rising fuel costs, combined with concern for the environment, leads more and more people towards alternative sources of energy to heat, cool and light their homes. In Greece, “green energy” is still far from mainstream, as only a few financial incentives to encourage investment in this field have been offered. Although lack of familiarity and high initial costs prevent householders from “greening” their new or existing homes, there are some interesting case-studies that can lead by example.

The current paper describes a 100m^2 house in Litochoro, northern Greece, which uses a ground source heat pump, combined with solar collectors, for heating, cooling and hot water supply. This geosolar system is used in tandem with underfloor heating, with flooring materials that have high thermal mass, to increase efficiency even more. Orientation of the spaces as well as thermal insulation and shading also play an important role in the energy performance of the building.

After three years of monitoring, the energy consumption for heating, cooling and hot water supply is compared to the estimated heating and cooling loads (simulated in software), but also to reported petrol consumption in other apartments in Litochoro of the same size. The savings emerged to be great and the payback period for the “unconventional” part of the installation (boreholes, mechanical equipment, solar collectors, underfloor system) is calculated to be about 8,5 years

Keywords: Ground source heat pump, solar collectors, underfloor heating system

COMBINATION OF AN OPAQUE HYBRID VELTILATED PHOTOVOLTAIC FACEDE WITH A HEAT PUMP

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ABSTRACT

One of the future goals of the buildings construction sector is the energy reduction due to new technologies. Technologies that incorporate renewable sources of energy into the building's main elements such a facade in order to produce or recover energy. This study sets a goal to evaluate the total energy assessment of a system with a heat pump and a hybrid ventilated opaque photovoltaic facade that works as an air pre-heater to the pump. The presented calculations, have been made by using the TRNSYS simulation program with an add one of a prototype model for ventilated photovoltaic facades. Themodel have been compared and evaluated with experimental data of physical scale double facades exposed in real operating situations. Results of this present study, shows that the proposed system can be an effective one in some specific situations,

Keywords: Double facade, Hybrid, Photovoltaic, Heat Pump, Simulation, TRNSYS, Efficiently

HEAT PUMP HOT WATER SYSTEMS MODELING

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ABSTRACT

Heat pumps achieve the transfer of heat from a low temperature source towards a sink of higher temperature. Technological evolution has led to the increase of the efficiency of the systems; this ability has turned the interest for their application not only for air-conditioning purposes, but for other uses as well, like hot water or space heating. Within this framework, and given the entrance of the systems in the commercial sector, the modeling of the systems operation can be highly important. The main reasons for that can refer to the evaluation of the performance of existing systems, as well as to the optimization of systems design, especially for temperatures of the heat medium of the source or sink differing from the temperature level of classical air-conditioning applications.

Focusing on the case of heat pumps used for the production of hot water, the depth of the involved processes analysis influences the degree of complexity of the assumed approach. The simplest approach refers to the development of linear regressions for describing quantities as the COP or the thermal power provided to the sink (i.e. storage tank) by the heat pump. These approaches are characterized as "black-box" approaches, as they overlook the individual internal processes in a system, thus concentrating on its overall behavior. Within this context, the limitation of their validity only for the respective system is referred to.

The exploitation of regressions on the basis of neural networks can also be useful, allowing the production of functions which can describe not only quantities concerning the performance of the complete system, but also internal quantities of the cooling cycle.

The analysis of the cooling cycle and the modeling of the respective processes, allows the prediction of system performance in the case that the characteristics of an element if the set-up change; on the other hand, such an approach can be rather complex, while also requiring the input of detailed, hard-to-detect technical system information.

In the proposed work, the three aforementioned basic modeling approaches (linear regressions, neural networks, cooling cycle analysis) are considered. The effectiveness of each approach, with regard to its complexity as well as the featured opportunities on a level of system performance evaluation and design optimization are investigated. Analysis is performed on the basis of experimental data obtained through the operation of a heat pump domestic hot water system.

Keywords: heat pumps, domestic hot water, modeling, neural networks

Energy balanced buildings with the use of RES, active Energy Saving technologies and electric consumption predictive models

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ABSTRACT

This paper presents the capability of adjusting the energy profile of conventional office buildings into energy balanced buildings. The model of an energy balanced building aims not only to produce electricity consumed during an entire year utilizing renewable energy technologies, but also seeks to optimally balance production and consumption in smaller time intervals (month, day, or even real-time), utilizing active energy saving technologies (ES) energy storage systems and forecasting models both for energy production and consumption. The results presented stem from the participation of PV Systems and Distributed Generation Dept. of CRES in the European program Smart Build "Implementing Smart Information and Communication Technology (ICT) concepts for energy efficiency in public buildings ".

Since the facility which houses the PV Systems and Distributed Generation Dept. is designed in accordance to basic principles of bioclimatic architecture, passive energy saving solutions were not sought. In contrast, using systems for the collection, logging, analysis and transmission of data, the time series of electricity production and consumption were studied and hence researched the following topics: i) the correlation of the loads with the energy profile of the PV system installed in the building, ii) the repeatability and the stochastic nature of some critical energy imbalances, iii) active energy saving techniques, iv) deferred mitigation techniques between consumption and production, v) technical limitation of power peaks using energy storage systems, or redesigning the mode of consumption.

Finally, loads and energy production were modeled in order to be integrated into functions of intelligent control forecasting systems and control of energy resources and loads in real time. In this work we present results from the phase of recording and analysis of electricity production and consumption, the mathematical models developed to predict the electricity demand and generation, as well as the operation principles of intelligent energy saving controls. Finally, we present the techniques tested to smooth the power level peaks in real time. This last action, although difficult for the energy design of a building, leads into a smooth and efficient operation of the low voltage (LV) electricity network The proposed techniques are examined both in the light of the Feed in Tariff (scheme which is available today for the electricity produced by PVs in LV network), and in the status of Net Metering, which is gaining more and more ground globally.

Keywords: Energy balanced buildings, active energy saving technologies, consumption forecasting models, RES, energy storage systems

ZED - KIM: RECENT DATA OF THE EXPERIMENTAL MODEL HOUSE FOR ZERO ENERGY DEMAND AND ZERO EMISSIONS

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ABSTRACT

This paper concerns the description and the recent data achieved regarding ZED - KIM (Zero Energy Demand - Kimmeria) which is a small prefabricated model house situated at the D.U.Th. Campus (Xanthi) aiming at the research regarding the energy production of photovoltaic panels and wind generators in the difficult climatic conditions in Northern Greece.

There are multiple tasks in this project:

a) to investigate whether Renewable Energy Sources (R.E.S.) and particularly Photovoltaics (P/V) and Wind Generators (W/G) may contribute to the energy demands of a middle family house in northern Greece

b) to help students, postgraduates and professionals of the area see what R.E.S. may produce in the specific area and under several weather conditions, all year round.

c) to present an example for an experimental proposal when a need for urgent or emergency housing arises in places where no energy supply exists.

The results from the monitoring of the R.E.S applications in ZED - KIM which are presented in this paper are very fruitful and promising. It seems that a large part of the energy demand of a house even in northern Greece, may be covered from P/V and W/G, and at the same time, reducing the CO2 emissions.

According to the data presented in this research it can be stated that if the results of the pilot house (scale 1:5) are transferred into reality and P/V arrays and W/G 5 times more than the power which is installed, with a yearly total production of 3.646 kWh, the following will occur: In an average household of 4-5 people with a house of 100 m^2 and the proper insulation, in difficult climatic conditions such as in Northern Greece, 15.386 kWh of energy are expected to be produced yearly. This will exceed the needs of an average household (4.000 kWh) and the surplus energy may be sold to PPC.

Furthermore it has been shown that the city of Xanthi which is located in Northern Greece, has high solar and wind potential which makes it suitable for the installation of hybrid systems. These systems can exploit the north-eastern Greece wind and solar potential towards satisfactory electrical production throughout the unstable weather patterns yearly.

Finally, it has been proved that photovoltaic arrays in two axis tracker, has a 17% more yearly electricity compared to those that are placed at a steady angle, equal to the latitude of the place. This percentage is about 22% during the summer months.

Keywords: Zero Energy demand, zero emissions, Photovoltaics, Wind Generator, hybrid systems, residential use

ARCHITECTURAL INTEGRATION OF ACTIVE SOLAR SYSTEMS IN BUILDING FACADES AND FLAT ROOFS OF EXISTING BUILDINGS AND OPEN SPACES OF URBAN CENTRES IN COUNTRIES IN THE EASTERN MEDITERRANEAN

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ABSTRACT

The duration of the day and the low cloud cover, in combination with the increased solar radiation (direct, diffuse and global) that are observed in countries around the Mediterranean in general, and in Greece and Cyprus in particular, make the exploitation of solar radiation through active solar systems especially important, offering energy, environmental and economic advantages. Existing buildings in contemporary urban centres include extensive surfaces, mainly flat roofs, which are of no significant use and could easily be exploited for energy conservation applications. Building façades, as well as urban open spaces, could also under certain conditions accommodate active solar systems.

The main aim of this paper is to investigate the ways in which active solar systems (photovoltaics and solar collectors, for the production of electricity and domestic hot water, respectively) could be architecturally integrated in building flat roofs and façades, as well as in urban open spaces, in the form of urban furniture. The paper includes a bibliographical review, a design investigation of the possibilities of architectural integration of active solar systems, as well as a qualitative assessment of the advantages and problems which derive from the particularities of existing buildings and urban fabric.

It is generally acknowledged that incident solar radiation values in contemporary urban centres may be reduced by the scattering caused by increased concentrations of air pollutants and particulate matter. At the same time, insolation conditions are further and significantly reduced because of the dense urban fabric. These parameters negatively affect the efficiency of the systems and their consequent energy production. Nevertheless, the architectural integration of active solar systems on existing buildings and in existing open spaces presents quantitative and qualitative advantages as far as the size of the surfaces that could be used for these installations, as well as in informing and educating the general public on issues of energy conservation, renewable energy sources and sustainable development.

Keywords: photovoltaics, solar collectors, architectural integration, existing buildings, urban open spaces

SUSTAINABLE TOURISM: ENERGY-CONSCIOUS HOTEL DESIGN IN THE REGION OF MANI IN SOUTHERN PELOPONNESE

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ABSTRACT

Tourism is one of the most important economic and social activities in Greece. More and more hotels are being built in coastal and mountainous regions, with a wide range of architectural characteristics and climatic conditions. Furthermore, due to the richness of existing traditional buildings which have been abandoned or neglected, the architecture of the Greek hospitality industry is based not only on the design of new complexes, but also on the restoration and re-use of old buildings.

When designing new tourist complexes, designers show increasing interest in implementing from sketch stage, the principles of passive energy design, as well as implementing energy saving systems, since the primary aim of every investment is achieving financial viability.

The restoration of existing traditional buildings has a special significance: when one restores a building constructed long ago, by local building masters with local material, the final product includes all the principles of passive design, and the final result can be aesthetically pleasing for its users and for the built environment surrounding it.

At the beginning of this work, worldwide tendencies are presented, regarding the design of sustainable hotels. It is well known that eco-tourism and energy saving in the tourism industry is the only way towards a sustainable future. This discussion is supported though the presentation of hotel projects abroad.

In the following chapter, the characteristics of the tourist industry in Greece are presented, as well as case studies that include renewable energy systems. The discussion focuses on the characteristics of the Mani region in southern Peloponnese, with its small and medium sized hotels. The paper concludes with the presentation of passive design principles and energy saving systems/strategies that could be implemented in small scale hotels.

A series of published articles, papers and books on energy conservation and sustainability in the hospitality industry, formed the basis of this research. The methodological framework of this work is not only the product of theoretical research, but is also based on real life projects which are being constructed in the region. Furthermore, the suggested energy saving strategies were also based on data kindly offered by companies which supply such systems to the hotel market.

The aim of this paper is to emphasize the unique characteristics of tourist development in Mani and to suggest energy conservation strategies which are economically viable in small and medium sized hotels.

Keywords: sustainable tourist development, bioclimatic hotel design, passive energy design, renewable energy systems

ENVIRONMENTAL ASSESSMENT OF TYPICAL CONSTRUCTION SOLUTIONS IN RESIDENTIAL BUILDINGS

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ABSTRACT

Climatic change has been one of the most important issues that occupies the scientific community around the world for many years now and affects economic, environmental and social policies. A continuous effort is being made in order to manage and reduce the demand and consumption of both energy and materials, with the further goal of reducing environmental impacts in all sectors of the constantly developing society. One of the most important sectors that are being developed, following the ongoing global urbanization and population growth, striving to meet the increasing demand is the construction sector. For the proper management of the demand and consumption, legalization has been adopted and methodologies and tools have been created. In the European Union such an effort is the European Community Law 2002/91/EC which appears in the Greek legislation by the law 3661/2008 and the Regulation of the Energy Performance of Buildings, aiming to upgrade the existing building stock and compliance the future construction to the new requirements. However this effort only attempts to reduce the environmental impact of the energy consumption during the operation stage of the building. The environmental impacts from the other stages of the life cycle of the building are not taken into significant account as they contribute with a small percentage at the total environmental impact of its life cycle. Nevertheless, the environmental impact from the materials and the stages of the construction of the building is also a very important issue. In this scientific area efforts have been made in Europe such as the Environmental Product Declaration. A helpful tool for this analysis is the Life Cycle Assessment (LCA), which is used to calculate the environmental impact throughout the life cycle of a material, a product or a process.

The aim of this paper is to calculate the environmental impact of typical construction solutions of the building envelope in residential buildings and for a square meter cross section. Furthermore, is to provide the ideal solution, by using the multi-criteria analysis TOPSIS, for each building element and for each climatic zone according to KENAK.

The further goal of this paper is to create a database from which an engineer or a contractor, at the design stage of the building, can use to choose the solution with the least environmental impact, depending on the climatic zone that is going to be constructed, according to the Regulation of Energy Performance in Buildings, and also taking into account the energy performance of the building and the U value.

Keywords: Life Cycle Assessment, residential buildings, energy consumption, U value

ESTABLISHMENT AND OPERATION OF INDUSTRIAL PARKS ACCORDING TO ENVIRONMENTAL CRITERIA. IMPLEMENTATION OF THE STANDARD OF "INDUSTRIAL SYMBIOSIS"

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ABSTRACT

The siting of a Manufacturing / Industrial park with environmental criteria is an attempt to organize and develop the productive capacity of a region while seeking to reduce the burden of environmental conditions. The companies involved have the opportunity to reduce production costs by increasing the efficiency of materials and energy and recycling byproducts / waste. The establishment of an Environmental Industrial Park promotes the use of new environmentally friendly technologies, structures and infrastructure and reduces the sources of pollution and waste. Through the benefit shown for Industry, society benefits too as an opportunity is given to create new jobs in cleaner Industrial Facilities.

Until today the standard of "industrial symbiosis" has not been implemented in Greece and the application of industrial ecology and eco-industry networks remains in an early stage. The paper examines the possibility to develop and organize Business Parks (B.P.) within the scope of national spatial planning, environmental protection, green growth promotion and entrepreneurship and improving the quality of life of citizens. The principles, conditions and design criteria in locating a manufacturing / industrial park in accordance with environmental standards and legislation are also examined.

A case study involving the siting and design of a Manufacturing / Industrial Park in the municipality of Pili is presented, in accordance with the principles of bioclimatic design. The principles of "industrial symbiosis" are also applied, for saving and reuse of energy, water, materials / by-products / waste and reducing the environmental burden. The process of establishing a B.P. in an area is based on a methodology discussed in steps, which examine the elements of the natural and human environment, selecting appropriate positions to specific criteria. Then these positions are evaluated and result in the final evaluation of the selected position with one of the methods of environmental assessment. Finally, the compatibility of the position considers on the elements of the natural and human environment. The environmental impact of the establishment and operation of the B.P and the sensitivity of the landscape are being assessed.

Keywords: Manufacturing / Industrial Park, Industry, Industrial Symbiosis, Business Park

ENERGY SAVING POTENTIAL BY THE APPLICATION OF GREEN ROOFS IN GREEK SCHOOL BUILDINGS

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ABSTRACT

Green roof utilization is increasing in contemporary urban centers mainly due their numerous beneficial impacts that include microclimate improvement. However, their cooling and thermal insulating features have been studied mainly in either office buildings or hotels. The aim of the present study is to evaluate the contribution of green roof systems in the energy needs of school buildings, which constitute a special type of public buildings in Greece. Different types (extensive, semi-intensive) and construction options of green roof systems were studied on eight school buildings. The energy needs of the buildings were simulated with TRNSYS simulation software, before and after the installation of the green roofs, in order to quantify their potential energy savings. The results from the simulation confirmed previous research results that reported that all tested green roof types improved the energy savings for cooling. By contrast, the energy savings for heating were much less or even insignificant. It was also shown that the use of specialized materials, such as substrates with increased porosity or a drain layer with good thermal insulation characteristics are necessary to avoid heating penalties.

Keywords: green roofs, school buildings, energy saving

Bioclimatic interventions' evaluation of urban neighborhoods

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ABSTRACT

The ultimate goal of the study is to develop a guide with the most representative interventions for neighborhoods' upgrade based on the urban environment and the climate conditions particularities. The suggested interventions will be evaluated and classified according to environmental (such as energy consumption, carbon footprint), social (thermal comfort, living standards) and economic criteria (cost-benefit efficiency).

Within the framework of the study relevant best practices in Europe will be examined, to specify the possible interventions which can be implemented and evaluate them having in mind the economic recession, in order to constitute demonstration projects ready to be implemented from municipalities. The environmental evaluation and the social profil of the interventions will be based on the international rating system BREEAM and for the economic evaluation Life Cycle Cost Analysis methodology will be used. The interventions will be classified according to the evaluation results. The main reason of the study is to develop a useful tool ready to be implemented for Municipalities, for the environmental and energy management of urban neighborhoods.

Finally, policies and integrated strategic plans will be examined in the field of cities' energy upgrade such as the Covenant of Mayors which contributes to the achievement of the EU climate and energy goals and supports the implementation of Sustainable Energy Action Plans and the promotion of renewable energy sources to Municipalities actions.

Keywords: bioclimatic upgrading, urban neighborhoods, evaluation systems

LOCAL PARTNERSHIPS FOR GREENER CITIES AND REGIONS. THE EUROPEAN INITIATIVE GREEN PARTNERSHIPS

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ABSTRACT

Local communities have a significant role in the fight against the climate change effects, as 80% of energy consumption and CO_2 emissions are directly related to urban activity. Thus, Mediterranean cities and regions adopt sustainable energy action plans in local level to achieve the targets set from the European Union.

The Green Partnerships initiative involves sustainable energy projects in 11 Mediterranean regions and municipalities. It proposes measures to address barriers that local authorities face during the implementation of sustainable energy strategies. At the same time, it contributes to the development of local partnerships and enhances the capacity of public authorities supporting the sustainable energy development in local communities. Furthermore, it addresses the local and regional authorities, economic and social partners, development organizations, chambers and all stakeholders involved in energy efficiency and renewable energy applications.

The initiative promotes the transfer of technical knowledge and capacity building of stakeholders involved, in order to provide not only technical training, but also to increase understanding in energy efficiency and sustainable development, to present best practices from the European sector and to address common barriers in the implementation of sustainable energy action plans.

Green Partnerships support the improvement of sustainable energy action plans of cities and regions involved and the creation of local partnerships between local authorities, stakeholders and companies in order to effectively implement sustainable energy projects. It is estimated that up to 40% energy savings can be achieved by implementing specific pilot projects and facilitating new investments in public sector. Finally, the implementation of pilot cases will contribute in the development of an appropriate methodology and a model that could be replicated in the future from other cities and regions.

On behalf of the initiative, the Renewable and Sustainable Energy Systems Laboratory of the Technical University of Crete in collaboration with the municipality of Rethymno are working on the development of three pilot projects that will promote sustainable energy use and improve the living quality for citizens and visitors. The three pilot projects are related to energy efficiency in public lighting, energy efficient water pumping and bioclimatic design of open space in an urban area for the creation of green neighbourhood.

Keywords: Sustainable energy planning, Energy efficiency, Sustainable development, Green city

A STUDY OF THE THERMAL BEHAVIOR OF PAVING MATERIALS IN URBAN PUBLIC SPACES IN THESSALONIKI

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ABSTRACT

This thesis studies the thermal behavior, during summer, of the most common paving materials that are used in open public spaces of Greece, and more specifically in two urban open spaces in the city of Thessaloniki, the harbor pier A' and Metamorfoseos street. Moreover, the thermal comfort conditions of the two regions are studied, while some sustainable interventions are proposed for the improvement of the microclimate of these areas.

Field research consisted of in situ measurements during July and August 2013 for the documentation of the thermal problem in the two areas. The measurements were made on various paving materials, many of which are common in both areas. These materials are: concrete paving, aggregate concrete paving, wooden deck, marble paving, cube stone paving, perforated cube stone paving, wooden bench and grass. The instruments that were used for the measurements are: Kestrel meter for measuring temperature (°C), humidity (%) and air velocity (m/s) at a height of 1.30 meters above the surface of each material, UNI-T surface temperature probe for measuring temperature (°C) on the surface of each material and Kimo meter for measuring the incident and reflected solar radiation (W/m^2) on each material. In Metamorfoseos street every measurement took place twice in every material, one at a point where the material is shaded, and one at a point where the material is sunned, in order to study the thermal behavior of each material both in the shadow and in the sun. Alongside with the measurements, the research was based on the collection of questionnaires from the visitors of the two areas, in order to investigate the level of thermal comfort feeling during their stay at summer. Furthermore, Cooling Power Index (CP, Siple and Passel) was calculated for every material, so as to study the thermal comfort conditions of each area.

The conclusions that emerged from field measurements and the Cooling Power Index calculations showed some differences between the thermal behaviors of the materials in the two urban spaces. Moreover, the crucial role of paving materials was proved, in shaping the microclimate and thermal comfort levels of the urban environment.

Keywords: Urban spaces, paving materials, thermal comfort, thermal behavior of the materials

INVESTIGATION OF THERMAL COMFORT INDEX IN RELATION TO THE SURROUNDING AREA IN CENTRAL SQUARE OF THESSALONIKI

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ABSTRACT

This paper examined the bioclimatic upgrade of Aristotle square in Thessaloniki by combining scientific measurements of the area and by using sophisticated software. Originally simulated the existing condition of the square, with buildings and vegetation that exist and then modeled the region according to the principles of bioclimatic design. The purpose of the project is the simulation of the square and comparison of the present condition with upgraded for winter and summer by using the indicators of thermal comfort. The thermal comfort indices which have been used is the Predicted Mean Vote, (PMV) which provides the average response of a large sample of individuals, the Predicted Percentage Dissatisfied, (PPD) which provides the percentage of people in a large sample who do not feel comfortable in a space, and the Standard Effective Temperature, (SET).

Keywords: Thermal comfort, PMV - PET - SET, Thermal Comfort of exterior spaces, Microclimate

THERMAL COMFORT IN OUTDOOR SPACES AND URBAN CANYON MICROCLIMATE

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ABSTRACT

The paper presents the results of a thermal comfort analysis which was carried out in order to investigate the parameters that influence thermal comfort conditions in urban canyon environment. In order to perform the thermal comfort analysis a number of case models were created, in which certain parameters and their values were each time differentiated and examined separately. The analysis was carried out using the Rayman v.1.2 tool. The parameters examined were street orientation, height/ width ratio, the effect of trees, wind speed and albedo of the horizontal surface.

Also, a thermal comfort analysis was carried out in order to compare conditions in streets in two different sites, a traditional and a contemporary settlement, using input data from experimental measurements carried out in the two sites. The results are compared to shading simulations and thermal analysis results, as well as to experimental measurements results which have been carried out in urban canyons in the two sites.

The analysis' results prove that thermal comfort is mainly affected by exposure to solar radiation, since the difference between a shaded and an exposed to the sun point corresponds to 10^{o}C difference in PET values. Therefore, street orientation and h/w ratio can affect largely thermal comfort conditions. According to results for the centre of the street (fig.4) streets on E-W axis present the worst conditions for all h/w ratios. Thermal comfort conditions in streets on the N-S axis are the best for h/w 0.8, 1.0 and 1.3. For h/w ratios of 2.0 and 3.0 thermal comfort in N-S streets is similar to the diagonal streets. Covered streets present the best thermal comfort conditions of all cases. The analysis clearly demonstrates that trees have a much more considerable effect on E-W streets. The reduction of PET values is very significant, especially for the side of the street that faces south. The effect of wind speed on thermal comfort was proved to be the second most important parameter for thermal sensation after shading. The effect of ground albedo on thermal comfort was proved to be small compared to the effect of street geometry, and it is more substantial in streets with low h/w ratios.

The comparison of the streets in the two experimental sites for two days with different wind speed conditions, demonstrates that thermal comfort conditions in the centre of the street in the contemporary site are much worse than those in the streets at the traditional settlement. Therefore, in spite of the lower wind speed values, thermal comfort conditions are generally better in the traditional settlement, due to increased shading. During the hours of the day that all points examined are shaded, conditions at the contemporary site are better with lower PET values by about 2^{o}C, which is attributed to higher wind speeds in the contemporary site.

Keywords: thermal comfort outdoors, urban microclimate, urban canyon

BIOCLIMATIC DESIGN AND RESTORATION OF THE FORMER UNREGULATED DISPOSAL OF LANDFILL WASTE FOR THE RECOVERY OF THE RIVERSIDE AREA IN THE MUNICIPALITY OF XANTHI.

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ABSTRACT

The aim of this work is the study of microclimatic conditions in different parts of the riverside area in Xanthi, like the investigation of thermal sensation to the user configuration area will be conducted with a view to proposing an alternative landscaping, based on bioclimatic criteria.
For this purpose, the spot was recorded in four characteristic points of the scale measurements of temperature and humidity for thirty days in the period of March and April in the year 2014. This is to be compared with the data taken from the weather station of the Democritus University of Thrace, situated adjacent to the test area for the years 2012 and 2013, in order to confirm the accuracy of the model. Suitable portable instruments were used for measuring and recording meteorological and the processing of the results was performed with the software biometeorology Rayman pro 2.1. The model using the software ran for four time points of the year. On 23rd of September and March where we equinox and 21st of December and 21st of June we have the longest night and day respectively, when the path of the sun is at the lowest and highest orbit. The time chosen is 12:30, period of the day when the sun is at the highest point of its trajectory. The four points of the year were selected based on the item that is the most characteristic time points of the four seasons.

The configuration space extends to a length of 2.50 km on the riverbank Kosynthos and covers an area of 154 acres. It is a former wasteland that has been cleared and fenced and there is disposal of the City Council to establish a recreation area. The first results of the model related to the current situation and then performed the same procedure on the proposal configuration, one that seemed appropriate to study best configuration based on human thermal sensation throughout the year. This manner enabled improved comfort conditions of the users through the model.

The configure script of the riverside area into a recreation emerged from bioclimatic criteria that contribute to the improvement of thermal comfort in the field, while their performance is done through software RayMan pro 2.1.

Keywords: configuration, bioclimatic, model, RayMan.