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PREFACE

A special issue with the summaries of the conferences in English is published by the I.S.T since 1988, in order to enforce the international connections.

This present issue contains the summeries of the papers presented in the 4th National Conference on Renewable Energy Sources.

We hope that the edition of this booklet will facilitate the receivers to find the names and the scientific field of greek colleages, if they are interested to establish links.

B.A.Sotiropoulos

President of the I.S.T

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SOLAR RADIATION MEASUREMENTS IN "SOLAR VILLAGE 3", ATHENS

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Solar radiation data for the Athens area, have been provided untill today by the National Observatory of Anthens, where hourly measurements of the global insolation on horizontal plan have been made continuously since 1955. An initial evaluation of the measurements of solar radiation in the meteorological station of Solar Village 3, Athens is given in the present study. Among other data, the diffuse radiation on horizontal plan has been monitored, during the three-year period 1989-91. A number of checking routines have been used in order to locate and to discard erroneous measurements, such as negative values, values before sunrise and after sunset, etc. A number of data, exhibiting non-acceptable fractions of the diffuse radiation under some particular sky conditions, were also disregarded. A correlation between the diffuse radiation fraction and the clearness index, usually derived by most workers in such studies, revealed a very close proximity of the present correlation with those of a number of previous studies performed with data from various places all over the world. Slightly greater values for the diffuse radiation fraction were manifested for the morning hours in comparison to the afternoon hours. The above correlation is also shown to be dependent on the solar height. The overall measurements available indicate that the majority of the days fall into two main groups: (i) clear sky conditions, and (ii) overcast conditions. This classification may be used in order to perform quick, yet sufficiently accurate, simulation calculations for a particular system.

* * *

ENALUATION OF THE PREDOMINANT WIND DIRECTIONS AND THEIR IMPORTANCE IN DESIGNING A WIND FARM LAY-OUT

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The high wind potential of Greece is an experimentally verified fact and wind energy can and must contribute to the energy balance. The data collected show annual wind speeds measured at 10 m A.G.L. varying from 6m/s to 13m/s, depending upon the geographic location and morphology of the area. Failure to measure the wind speed correctly will lead to an error of the projected wind energy production. In order to arrange the wind turbines at a specific site, it is absolutely necessary to have measured wind directions for the area (wind rose) for a period not less than a year. Comparisons with neighbouring stations can help but caution must be exercised, since significant differences can exist due to the complex topography of a site (see the data on Chios, XIOS). The study shows that the predominated wind directions change, as we move from the North Aegean to the Cretan Sea. The Northerly winds become Westerlies. Significant variations do not take place for the same site on a yearly basis (see data for Skyros, ΣΚΥΡΟΣ). The work concludes with the lay-out of the wind farm in Chios-Melanios consisting of 11 wind turbines. A successful design takes into consideration all the practical limitations of the site, maximizing energy production and minimizing turbulence interference due to neighbouring wind turbines.

* * *

ANALYSIS OF WIND SPEED AND DIRECTION DATA FOR THE THESSALONIKI REGION

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A part of the results obtained from the analysis of wind data from the Thessaloniki region is presented in this work. Frequency distributions of the mean hourly values of wind speed and wind direction for all months have been derived from the analysis of data from the following stations: Micra Airport, Aristotle University, EKO Company and Cotton Institute. Average monthly values of the wind speed along with the calms and the main wind directions are also presented. The comparative analysis of the data from the fair stations used provides a comprehensive picture of the air movement over the Thessaloniki region.

* * *

SOLAR RADIATION IN THE SPECTRAL RANGE 250-525nm

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The Raleigh atmosphere, the water vapour and the air pollutants are responsible for the decrease of direct solar radiation in the city of Thessaloniki. In the present work, an attempt is made to present the reduced values of direct solar radiation measured inside the city for the spectral range 250-525nm, which are influenced from the solid aerosol particles. The Angstrom turbidity coefficient β and the transparency coefficient $P\lambda$ were computed using the direct solar radiation for the spectral range 250-525nm. The annual variation shows a significant attenuation of direct solar radiation, in the summer period, due to the increased concentration of solid aerosol particles and an increase of the diffuse solar radiation.

* * *

THE INFLUENCE OF HUMAN ACTIVITY UPON SOLAR RADIATION AT THE CITY OF THESSALONIKI

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It is known that in large cities, the intense human activity charges the atmospheric mass with great quantities of solid and gas materials as aerosols, which are not provided from the scientific definition of the atmosphere. The influence of atmosphere on solar radiation is quite known to the scientists because of the wide bibliography on that topic. Through this paper we try to give the size of this influence in the centre of Thessaloniki in relation to the solar radiation measured at the same time at a rural area, fifty kilometers west of Thessaloniki. After five years (1983-1987) continuous measurements of total solar radiation at at the centre of the city, as well as the village of Mavrovouni we took the results mentioned in the paper. The general results showed that in the city the total solar radiation is reduced by 15% during the warm period and by 26% during the cold period, in relation to the total radiation which was measured in the rural area. A comparison of the values of total solar radiation, at the two places, during the cloudless days gave the same rate of reduction. This fact was expected because the two sites belong to a geographic area with a mild bas-relief. In the paper there are the mathematical models which give the daily values of total solar radiation inside and outside the city for usual days and for those with cloudless sky.

* * *

ANALYSIS OF THE SUNSHINE DURATION AND SOLAR RADIATION VALUES OF THE AREA OF KASSANDRA, HALKIDIKI

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The variation of the mean daily values of sunshine duration and total solar radiation in Kassandra, Halkidiki, are examined in this study for the period 1984-1990. On the base of actual daily sunshine duration values, we calculated the corresponding solar radiation values using the well known empirical Angstrom's equation. The daily values of sunshine duration are grouped into 6 classes: 0,0.1-3.0,3.1-6.0,6.1-9.0,9.1-12.0 and >12.1hrs per day. The "sufficiently sunny" days (sunshine >6hrs per day) as category is, during the year, the predominant one. During the main summer period the percentages of these days are greater than 95%. Regarding the total solar radiation daily values, over the study area, has been found that these vary:

a) the mean values between 6.6 and 18.8 MJ/m^2,

b) the mean max. values between 9.1 and 20.8 MJ/m^2

c) the mean min. values between 3.3 and 14.9 MJ/m^2

The as above solar radiation values of Kassandra area are a little greater than those of Thessaloniki area.

* * *

INTERDIURNAL VARIABILITY OF SUNSHINE DURATION AND GROUPS OF "REALLY" SUNLESS SPELLS OVER GREECE

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The variations of the sunshine duration from one day to the next, which are known as interdiurnal variations, are studied for three meteorological stations of Greece, by using the same decade (1971-1980) data information. The used stations can satisfactorily cover the geographical area of Greece, since they lie on a meridional axis which extends along the longitudinal shape of Greece. The study consists of the examination of the steady conditions, the rises and falls, as well as the variations irrespective of sign. The interdiurnal variation of sunshine duration shows generally higher values in the cold period than in the warm one, and particularly, the months of April and May indicate higher values for the three meteorological stations. This finding is probably due to the interdiurnal cloud variation, which is more intense in the cold period and at the northern station than the warm period and the southern station, and has been resulted from the general atmospheric circulation over the Mediterranean area. In addition, the number of spells with "really" sunless days is studied. This is done for the cold period; that is, November to March, where the number of spell is quite large, and for the two months before and after the warm period. Considering the sum of the above mentioned nine months, it is found that the percentages of the sunless day are: 30% for Thessaloniki, 20% for Athens and 25% for Iraklion. The somehow estimated larger percentage at the southern station is probably due to its locality and to the affects of the Saharian dipressions, since the latter appear to have high frequencies during the period March to May, reducing thus the sunshine duration in the area.

* * *

AMBIENT TEMPERATURE ZONES CONCERNING THE DETERMINATION OF THE ELECTRICAL EQUIPMENT THERMAL STRESS

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The temperature of cooling mediums is a significant parameter for the determination of the loading and the thermal stress-ageing of the various components in an electric energy system. The cooling medium is usually the ambient air, whose temperature varies with the time (daily variation and annual cycle of the ambient air) and is different at the various regions. In this paper a comprehensive study of temperature data is made in order to establish criteria for thermal loading of electrical equipment. Temperature data for 70 meteorological stations of the country was obtained from the National Meteorological Service. This data is the mean maximum monthly ambient temperature of each location with periods of record varying from 15 to 40 years. The target of this study is the division of the country in ambient temperature zones concerning the determination of the electrical equipment thermal stress. The criterion of this division is the weighted maximum seasonal ambient temperature. This temperature is higher than the mean maximum temperature because the relation between the rate of ageing of the insulation materials and the temperature is non-linear. These weighted temperatures were plotted on the map of Greece and isoambient temperature lines were drawn using an advisory topographic relief map. Four maps were resulted, one for each season. These maps show that over Greece

- five temperature zones are designated for the winter: $7^{o}C$ - $9^{o}C$, $9^{o}C$ - $12^{o}C$, $12^{o}C$ - $14^{o}C$, $14^{o}C$ - $16^{o}C$, $16^{o}C$ - $18^{o}C$,
- two temperature zones are designated for the summer: $28^{o}C$ - $31^{o}C$, $31^{o}C$ - $33^{o}C$,
- three temperature zones are designated for the spring: $16^{o}C$ - $18^{o}C$, $18^{o}C$ - $20^{o}C$, $20^{o}C$ - $22^{o}C$,
- three temperature zones are designated for the autumn: $18^{o}C$ - $20^{o}C$, $20^{o}C$ - $22^{o}C$, $22^{o}C$ - $25^{o}C$.

The results of this paper can be used for the determination of the electrical equipment thermal stress and the loading above their nameplate rating.

* * *

A COMPARATIVE STUDY OF SUNSHINE DURATION BETWEEN ATHENS AND THESSALONIKI, DURING THE PERIOD 1931-1986

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The mean monthly sunshine duration values measured at two different locations, Athens National Observatory and Thessaloniki Univ. Campus, are examined for the common period 1931-1986.
We found statistically significant periodicities except the annual, of 28 and 14 years caused by extraterrestial phenomena.
We have found also decreasing trends which they attributed to the human activity.
Comparing though the sunshine duration at different geographical locations we can have a rough estimate on how the human activity affects the enviroment.

* * *

'SOLAR HEATING'. A PROGRAM FOR THE ENERGY AND ECONOMIC EVALUATION OF THE PASSIVE SOLAR HEATING SYSTEMS

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The presented program "Solar Heating" is based upon the algorithms of the LCR/SLR method for the energy analysis and on the life cycle cost method for the economic evaluation. The program includes nine reference sunspace designs and files with climatic data of Thessaloniki, Athens and Chandaka. It also comprises unit cost per item for estimating the cost of the sunspaces. Main outputs of the program are the annual solar saving fraction for every sunspace size and a total heating cost optimization.

* * *

THERMAL COMFORT AND ENERGY BALANCES: COMPARISON OF A PASSIVE SOLAR AND A CONVENTIONAL APARTMENT

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The thermal behaviour of a passive solar and a conventional apartment is being researched, by means of evaluation of energy balances and thermal comfort conditions. The residences are part of Solar Village III in Lykovrissi (nearby Athens). A data acquisition system (DAS) has been used to obtain a series of data over a four year period, that have been the base for this evaluation. A clear superiority of the passive solar apartment results, as for every 100 m^2 of plan area and every degree C of temperature difference to the enviroment only 1.73 KWh of auxiliary heating is needed, whereas 3.29 KWhs are needed for the conventional apartment. The established temperature conditions, both in winter and in summer, confirm the very good behaviour of the passive apartment. Its passive solar elements achieve high temperatures in winter, yet remain acceptably warm in summer, compared to the plain fabrique of the conventional apartment. Finally, the significant influence of the tenants' behaviour, as far as energy management and systems' utilization are concerned, is once again verified. Their interference can annualise the positive contribution of passive solar systems, to a great extent.

* * *

A FIRST APPROACH TO THERMOSIPHONING AIR PANEL WITH THE POSSIBILITY OF ITS APPLICATION ON GREEK REALITY AS A CRITERION

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The intention of this project is to present you, analytically and thoroughly, one not so well known Passive Solar System (the Thermosiphoning Air Panel), which has not been used in Greece yet with the broadness other systems have been used with, such as Thermal Storage Walls or Greenhouses e.t.c. The starting point for the presentation of this specific system was the estimation, which resulted after the experience of its use, that there are a lot of possibilities for its application on Greek reality the way this is determined by the peculiarities of building and climatic facts. The technical and morphological characteristics of the system are analysed in detail indicating in this way the advantages which the Thermosiphoning Air Panel gives in comparison to other systems. Such advantages (light weight, low cost, e.t.c.) make it suitable for the use on a lot of contemporary applications (such as tall buildings with front view of glass or industrial buildings) where other Passive Solar Systems would be difficult to be used. Special mentioning is done on the international experience about this specific or other simular systems which have already been applied abroad, so there is a more complete estimation for their performance which is based on a series of measurements and evaluations. This international experience in relation to greek experience from the use of T.A.P form the guide for the evolution and the improvement of the system. The ideas and propositions which result from this experience are analyzed at the last part of this presentation.

* * *

THE INFLUENCE OF THE ENERGY BEHAVIOUR OF THE INHABITANTS ON THE BUILDING THERMAL BALANCE

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The active participation of the inhabitants in the right and functional operation of the passive solar system and consequently of the passive solar heated apartment is a determining factor for the energy performance of the building. With the help of monitoring the SV3 at Lykovrissi, Athens, and the use of thermal simulation calculations with ESP programme, the quantitative and qualitative features of the impact of the positive or negative "energy" behaviour of the inhabitants on the energy performance of the apartment have been revealed. These findings are presented in this paper. During the heating season, the continuous ventilation of the apartment, even though the inhabitants are away, the use of the shading devices when the sun is shining and the misuse of the night thermal insulation of the Trombe walls are found to be decisive factors for the energy behaviour of the building. The amount of heat which is unjustifiably lost because of the wrong actions of the inhabitants has been found to be significant, and leads to the conclusion that even the best energy conscious design, without well informed and actively participating users does not bring the expected energy savings.

* * *

THERMAL INSULATION EVALUATION IN GREEK BUILDINGS

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This paper reports on the work carried out by the Institute for Technological Applications of the Greek Productivity Centre (ELKEPA) with ultimate aim to determine the quality of thermal insulation applied to greek buildings, constructed after the introduction of the Greek Thermal Insulation Code (1979).

The methodology comprised:

a) An in-situ optical observation of the buildings envelope to detect possible defects. The optical observation was systematic, based on a number of guidelines, developed as part of the work and containing the defects commonly encountered in greek building envelopes.
b) Imposition of constant air temperature of the internal space in conjunction with no-existence of solar radiation in order to approach steady-state conditions for the heat transfer through the building envelope phenomenon.
c) Measurements during the winter months, due to the appropriate temperature difference between internal and external space.

Based on the above, rooms with external envelope were heated by means of electrical air-convectors with thermostats for such a period of time that phenomena of heat storage were minimized. That was determined by the small deviation of the estimated thermal conductance values over certain succesive days. Heat flux sensors were installed in external and internal surfaces of walls, roofs, floors over pilotis and connected in parallel with surface temperature and air temperature sensors, to data loggers for continuous monitoring.
The measurement results revealed that in more than sixty five per cent on the examined points, the estimated thermal conductance estimated values deviated from the values calculated according to the existing Thermal Insulation Code and depicted in the relevant technical drawings. This deviation, of various degrees, could be traces to different reasons, like the complete absence of insulation, inadequate thermal insulation levels, tempered thermal insulation due to bad craftmanship, which had allowed moisture to penetrate the building envelope structure, e.t.c.
The methodology outlined is in a position to help establish on a non-destructive basis the level of thermal insulation and is recommended for the inspection of existing buildings or for the commissioning of new ones.

* * *

SOLAR HEAT IN A CODE OF RATIONAL USE OF ENERGY

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The building internal heat, due to absorbed solar radiation by the building surfaces, can be expressed as the sum of two products, each of which is made of a solar parameter and the solar radiation, direct and diffuse, respectively, falling on the horizontal surface. Each solar parameter is function of all the building geometrical, optical, material and topography characteristics. This solar heat expression is analogue to the expression of heat exchange through the building envelope, which is product of the building thermal conductance and the indoor-outdoor temperature difference. As in the case of a conventional thermal insulation code, the value of building thermal conductance is restricted by certain limit, the same could be adopted for the solar parameters in the solar heat expression: The solar parameters should be higher than certain limit values during the heating period and lower than other limit values during the cooling period. The adoption of a calculation method and of solar parameter limit values can be the subject of a new code of rational use of energy in which the solar heat is included. Furthermore, this way, the state can be assisted in evaluating the energy design of buildings and, depending on the positive difference between the design solar parameters and their limit values, in financially supporting those building designs which lead to energy savings and less polluted enviroment. The paper also reports on solar parameters calculated for different types of typical buildings and conditions.

* * *

COOLING POSSIBILITIES BY THERMAL RADIATION EMISSION USING HEAT EXCHANGERS OF THE TYPE OF SOLAR COLLECTORS

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The cooling possibilities by thermal radiation emission to the sky, of a heat exchanger of the type of solar collector were investigated experimentally. The radiator of the heat exchanger was made by copper tubes, aluminum fins, with glass-wool insulation at the rear side. The upper side of the radiator was painted with a high emissivity white paint and it was covered with a polyethylene film partially transparent to thermal radiation. Water was circulated through the radiator using a small power pump in a closed loop which included also a thermally insulated water tank. The possibilities of cooling warm water and producing cold water were examined as a function of the microclimate variables and particularly the downward night sky radiation, the water inlet temperature. The convective coefficient of the heat exchanger was determined experimentally as a function of the temperature difference between the water inlet and outside air. A definition of the radiator efficiency is proposed and a simple equation is given to calculate it. Radiator efficiency values are presented as they were determined experimentally.

* * *

THE INFLUENCE ON THE EFFICIENCY OF A DHWS OF AN EXTERNAL ELECTRICAL HEATER IN COMPARISON TO THE ELECTRICAL HEATER INCLUDED IN THE HOT WATER TANK

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In this article the optimization of a domestic hot water system is described. The method used in order to prove the optimization of the system was the study of a thermosyphon unit, for three years. We have measured, on weekly basis, the energy delivered due to the solar energy and the auxiliary heater, whenever used, either the heater was included in the water tank or when the heater was connected at the output of the thermosyphon unit. Therefore in the latter case, the thermosyphon was used as a preheater. The results represented in the diagrams No 1,2,3, show the improvements of the total performance of the system when the auxiliary heater is not included in the hot water tank. We may summarize the following advantages:

a. Energy saving, rationalistic use of energy

b. Improvements in the use of DHWS

c. The DHWS is trouble-free due to water mixing in the hot water tank or an erroneous estimation of the size of the hot water tank.

* * *

ON THE BENEFICIAL INTERCONNECTION OF TWO THERMOSIPHON DHW SOLAR SYSTEMS

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The employment of more than one thermosiphon solar water heating unit may often arise in an application when considerable hot water requirements exist. The significance of the type of interconnection between these units on the thermal performance of the resulting system is addressed, by examining a number of alternative coupling cases. For optimal performance, the overall system configuration in such cases should comply with the following criteria: (i) promotion of high temperature stratification within and between the storage tanks, and (ii) quick transfer of high grade thermal energy to the user. A number of alternative configurations may be employed, in case that more than one storage tanks are used on order to augment the system's capacity. Six cases are considered in this study and the features of each case are (in all cases the collector's loop are independent except for case 6 where the collectors are connected in series):

Case 1: two storage tanks parallel at the same level
Case 2: the tanks connected in series at the same level
Case 3: storage tanks connected in a mixed way with a height difference
Case 4: storage tanks parallel at different height level
Case 5: storage tanks in series at different height level
Case 6: collectors and storage a tanks in series with a height difference

A number of tests were run on three of the above cases (4, 5 and 6) have been in the Solar Village 3, Athens. The tests performed are listed below:

- short time tests
- daily tests
- operationunder real DHW consumption profile

Experimental results, obtained for three particular system configurations, are in sufficient agreement with the theoretical analysis. The system with the superior performance was that of case 6.

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THERMAL PERFORMANCE OF DHW SOLAR SYSTEMS UAB AND UAF OF "SOLAR VILLAGE 3", ATHENS

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The evaluation of the thermal performance of two similar Domestic Hot Water (DHW) central systems, along with the problems encountered during the early period of their operation, are discussed in the present work. The systems are installed in two identical 6 storey buildings of "Solar Village 3" Athens, i.e. buildings UAB and UAF, being themselves also identical, except for collector type: vacuum tubes in UAB and flat collectors in UAF. The collectors in each system are mounted on the roof of the building and the collected energy intransferred by forced circulation to the storage tanks in the building basement. Auxiliary heating is performed by an electrical heater fitted in the third tank. The hot water is delivered to the apartments of each floor by continuous forced recirculation through the latter tank. Following a brief description, the evaluation method employed, the main findings are reported to be:

(i) the presence of various problems in the collector fields, such as leakages, corrosion, loss of vacuum in some tubes, resulted a discontinuous operation in the early period.

(ii) the thermal efficiency of both collector fields has been lower than given by the manufacturer, particularly that of the vacuum tubes.

(iii) the considerable thermal inertia of the heat storage subsystem, combined with the lower than anticipated hot water consumptions, had a negative impact on the contribution of the solar system to the DHW demands.

(iv) the excessive heat losses in the DHW recirculation line had a severely adverse result, by increasing the auxiliary energy needs.

The beneficial effects on the thermal performance of system UAF brought by a modification in the DHW recirculation configuration are also presented. Finally, some criteria for the successful design and construction of large DHW solar system are provided.

* * *

CONCLUSIONS FROM THE OPERATION OF THE SYSTEM OF REGION UF OF THE SOLAR VILLAGE-LYKOVRISSI-ATHENS, DURING THE PERIOD 1989-91

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A Central Solar Heating Plant with Seasonal Storage in a large Water Tank has been installed in the Region "UF" of the Solar Village Project-Lykovrissi-Athens. This system consists of a Solar Collectors Array of 161.7m^2 of aperture area, a Seasonal Storage of 500m^3 water volume and it serves Domestic Hot Water and Space Heating to a 5-storey building. The operation of the overall system, has been monitored via a Data Acquisition System for three years (1988-1991). Data delivered during the monitoring phase have been processed and analysed, so that conclusions on the thermal performance of the overall system and their subsystems during this period have been derived. These conclusions are reported in this paper. Energy flows and Sybsystems Efficiencies calculated from data during the monitoring phase are presented and are compared to the design values. Operational problems during the evaluation period are also presented.

* * *

CONCLUSIONS FROM THE OPERATION OF DOMESTIC HOT WATER AND SPACE HEATING SYSTEMS WITH HEAT PUMPS IN SOLAR VILLAGE 3

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The settlement Solar Village 3 (SV-3), which is located in Lykovrissi, 18Km north of the center of Athens, occupies a total area of 90440m^2 and consists of 25 buildings that comprise 435 residential units, 12 Shops, a cafeteria, a library and a social center. Different Passive and Active Systems and other Alternative Energy Sources for Space Heating and Domestic Hot Water Services have been installed in the village buildings. Building UDB, a five storey block of flats with 30 apartments, is heated by two electrically driven air water heat pumps. A heating boiler is used as an auxiliary energy source. An electrically driven heat pump is used also, in a different circuit, for the preparation of the domestic hot water. An electrical heater is used, in the Domestic Hot Water System, as auxiliary energy source. During the winter, the heat pumps are driven by electric energy which is generated by a co-generation plant in the energy center of the Village. During the summer the heat pumps are driven by energy from the public grid. A Data Acquisition System acquires and processes approximately 1400 signals from representative areas of the SV-3 plant. Thirty process signals from the systems of building UDB and seventy process signals from inside the building are being monitored every 1 min and are intergrated to 5 min and then to 30 min values.
This paper gives a description of the systems of building UDB, the thermal performance evaluation method, the coeffient of performance of the heat pumps the total heat balances of the systems and the fraction of total energy supplied by the heat pumps for the period between Sep 89 and Aug 91. A comparison between the systems and other conventional DHW and SH systems is also given.

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SIMULATION OF SOLAR COOLING INSTALLATION OPERATING WITH THE VAPOR THERMAL COMPRESSION METHOD

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The performance of a jet compressor is estimated for various operating conditions. The results can be used for the simulation of a solar cooling installation operating with the vapor thermal compression method, in order to estimate the coefficient of Performance (C.O.P.) under different operating conditions and operating fluids. From the presented parametrical analysis, the performance of any jet compressor operating under different conditions can be forecasted through the use of an experimentally calculated curve. This curve can be used for any operating fluid where, instead of the normal operating pressures (motive, suction and discharge) the corresponding relative pressures are used. From this curve, also, and by using and experimentally proven equation, the mass ratio of the jet compressor can be calculated and as a result, the relevant coefficient of performance. This estimation can be done for any medium and for any operating conditions. The results of this novel procedure could not be achieved up todate, due to the fact that with the existing methods it was necessary, to experimentally find the relative curves between the operating pressures under no entrainment conditions separately and for every operating fluid under consideration.

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SOLAR SPACE HEATING: A SIMPLE EMPIRICAL SIZING METHOD

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Purpose of the present study was to present a quick and efficient sizing method for standardized solar heating systems. Based on many runs of a detailed simulation, in which the various parameters were varied within specific ranges imposed by practical considerations, simple relations are proposed for the prediction of the long-term thermal performance of the typical heating system. Using contemporary dimensional analysis and an interactive computer program specially developed for this purpose, a new dimensionless group is isolated which ultimately leads to generalized diagram of the f-Chart type, but with different form of curves. A simple regression equation is fitted to the curves of the plot, which are based on the results of the simulations and which are parametrized by the solar fraction (or relative contribution of the sun to the thermal load). The resulting correlation is utilized in a simple interactive computer program which estimates the solar fraction, giving results similar to those of the f-Chart. The necessary data base, which includes monthly-mean daily values of insolation, ambient temperature, degree-days, e.t.c., has been specifically prepared for this program and covers the entire country. Direct comparison of the simple empirical sizing method with the detailed simulation itself, produces typical deviations (rms error) of the order of 5% for various cities, while the execution time decreases by a factor of 600 to 1700, on various machines. Thus, in view of the limited accuracy of the available weather data- which is of the same order of magnitude- the simple empirical sizing method proposed can be considered as satisfactory for design purposes.

* * *

THE DEVELOPMENT OF A COMPUTER PROGRAM TO CALCULATE THE PARAMETERS FOR THE SOLAR HEATING PROCESS IN GREECE

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In this study a new computer program, to calculate the parameters of the solar heating process in Greece is presented. The program is based on a simulation where the collectors are flat plate ones, the storage is a water storage and the thermal loads are, either for space heating of for water heating or for any other thermal load application. The data of the program are:

1. The mean hourly per month total solar radiation for 25 cities in Greece and for a slope of 0, 30, 45 and 60.

2. The mean hourly per month air temperature for the same above cities.

3. Two necessary equations for the hourly calculation of the solar heating process throughout the year. These equations relate to all the solar heating process parameters. They are a function of a. Climatic data, b. Collector and collector curcuit characteristics, c. Storage characteristics and d. Building characteristics

4. The initial conditions and the limitations under which the above equations are valid.

Using these data, the program calculated hourly the following variables,

1. The last hour per month storage temperature, Ts,
2. The auxiliary energy, QA,
3. The total collected energy, Qt,
4. The storage heat losses, QL
5. The thermal load covered by the active solar system, Qag,
6. The thermal load Lt,
7. The fraction, Qag/Lt

and gives to the user monthly and yearly results.

To run the program, the user must enter the following:

1. The proper city, the nearest to the solar installation,-knowing that the climatic data of mean hourly per month total solar radiation for 25 cities in Greece and for a slope of 0, 30, 45 and 60 are in file-, the area and the solar collector slope, then the mean hourly per month air temperature is taking from the file. The water temperature which is useful, in case of calculation of the water heating load, is given by the program.

2. The technical characteristics of the collectors, their area and slope.

3. The technical characteristics of the storage i.e. the water mass, the thermal loss area-loss coefficient of the storage and its initial temperature.

4. In case of thermal water heating, the number of occupants and the thermal water mass per occupant needed daily. In case of space heating, the volume, the thermal skin and the average thermal transmittal of the building fabric.

5. The mean hourly per month thermal load, if the solar heating system is used for any other industrial or agricultural application.

OPERATION AND MAINTENANCE OF THE SOLAR SYSTEMS IN THE SOLAR VILLAGE IN PEFKI, GREECE

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A housing settlement with 435 dwellings, 12 shops and a social centre has been built near Athens, in the framework of a Greek-German bilateral demonstration project for renewable energies. The dwellings are equipped with different types of passive and active solar systems (such as trombe walls, sunspaces flat plate and vacuum liquid collectors, air collectors, interseasonal storages, etc.) as well as heat pumps for space heating and production of domestic hot water. The operation of the systems was monitored through a data acquisition system with 1279 measuring points (meteorological data, temperatures, volume flows etc.) and covers appr. three full annual cycles. The inhabitation of the settlement started in Autumn 1989.
The present paper describes the operational experiences gained through the operation. An operations and maintenance team looks after the systems and executes regular checks to assure the smooth operation of the solar systems. There have been no major damages or problems during the operation time with the exception of the vacuum loss and the pressure peaks during pump startup of the vacuum collectors installed. These collectors have been exchanged against selective flat plate ones. Furthermore the statistical data on damages of the various equipment used, show very low damage frequency with the exception of aluminium collector absorbers, exhibiting a leadage percentage of 16%.
Furthermore, information is given about the biling system for the energy costs. The inhabitants are charged with the costs for auxiliary and parasitic energy to operate the systems, on the basis of a common price for the KWh for space heating and domestic hot water. In the beginning of each annual period, a price for the KWh is calculated and the charging of inhabitants is made based on this price according to the readings of the heat meters and the domestic hot water ones. At the end of the period the total cost for auxiliary and parasitic energy is divided over the actual total annual amount of energy registered through the meters. The resutling figure represents the real price of the KWh. The different between real and calculated price is balanced in the subsequent billing periods. Last year the calculated value was 14.72dr/KWh and the real one 16.38dr/KWh.
It seems that the smooth operation of solar systems requires a supervision (on site or through telemonitoring) and that the charging of energy to the inhabitants is of utmost importance to achieve their approvement of the systems.

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SIZING OF SOLAR THERMAL SYSTEMS BY SIMPLIFIED METHOD USING THE P.C.

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The f-chart method is the most widely used design method for active solar thermal systems. This method requires repeated calculations and many values from tables which often are not available. The calculations can be worked out mathematically, but they can be tedious. A fully interactive computer program for P.C., has been developed in order to simplify the use of this method. The program is based on f-chart method in combination with life cycle economic analysis. The computer program uses the pull down menus technique, has on line help facilities and disposes a library with climatic data for many Greek cities. The values of design parameters that are outside the range of validity of the f-chart empirical correlations are not accepted by the program. The results are presented in tables and graphs in the screen. They can also be printed. The program can be used to predict the monthly solar fraction and thence the annual useful thermal energy delivery by solar heating systems of standard configurations, or to examine the effect of standard parameters upon the performance of solar heating system. Also, it determines the economic optimum collector area. The program is very user friendly, quick, easy to use and finally a powerful design tool.

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ELIMINATION OF REVERSE CIRCULATION IN THERMOSIPHON SOLAR SYSTEMS

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An undesirable characteristic, of the thermosiphon solar water heaters is the reverse circulation (RC) of the working liquid when the temperature of the collector is lower than that of the storage tank. The latter condition applies normally during night, but it may also prevail during intermittently sunny days. In a typical open loop unit with a storage capacity of 200 lt the total volume of water circulating overnight through the collector is in the range of 5 to 40lt, which is cooled down to temperatures close to that of the enviroment before entering the bottom of the tank. The causes of the reverse RC in thermosiphon solar water heaters, the geometry of the systems, and the effects of the noctural radiative cooling of the collector are discussed. A qualitative and intuitive approach, which can be used generally in order to deduce the possibility of a thermosiphon-induced flow in any liquid circuit, is employed. This is based on the hydrostatic pressure exerted during night conditions on both sides of an hypothetical diaphragm positioned at the lower point of the thermosiphon circuit. The main source of the RC is shown to be the unequal cooling down rates of the two pipe branches of the circuit.
A means of interconnecting collector and tank to drastically reduce and even eliminate reverse circulation in both open and closed loop thermosiphon systems is presented. The procedure proposed herein is to enclose a specific pipe section inside the tank, i.e., the segment connecting the collector outlet with the storage tank. In this case the cooling down rates of the two circuit branches are effectively the same. The effects of the sky temperature (unequal exposure to the sky of the collector plate and the downcorner pipe) are also discussed. Near zero RC heat losses could be obtained with the new configuration under clear sky, whereas under cloudly conditions the RC of the proposed design is totally eliminated, irrespectively of the details of the collector loop.
The novel arrangement proposed does not involve additional manufacturing cost, since it is simply materialized by enclosing part of the riser pipe inside the storage tank. Depending on the specific configuration of the collector loop, the heat losses due to RC in the proposed design are expected to be in the range of 0%-10% of those encountered in conventional configurations. Since a drastic reduction of the RC losses is thus obtained, persuing its complete elimination is not a critical matter.

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STANDARDIZATION OF ACTIVE SOLAR SYSTEMS IN GREECE CONTRIBUTION OF THE CENTER FOR RENEWABLE ENERGY SOURCES AND REVIEW OF RELEVENT STANDARDS

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In Greece, the Center for Renewable Energy Sources (CRES), in the framework of the CEC VALOREN program and in cooperation with the Greek Solar Industry Association, has issued proposals for twenty eight standards and six technical reports on solar products. The proposals have been submitted to the Greek Standardization Organization ELOT (TC-35 "Solar Energy"). International (ISO) and German (DIN) standards have been used as basic text for the Greek standards. A working group of 25-30 experts from industry, universities, government agencies e.t.c. prepared the proposals and CRES coordinated the whole effort. Four additional proposals have been adapted as ELOT standards (work coordinated by the Hellenic Productivity Center, ELKEPA). Titles of the standards and the relevant working groups are included in a series of six tables in this work.
The international Organization for Standardization (ISO) has assigned to CRES (through ELOT) the secretariat of sub-committee SC5 on "Solar Collectors" (chairman T.A.Pafelias) of technical committee ISO/TC-180 "Solar Energy".
CRES has contracts with the Solar Laboratory of the research center DEMOCRITOS for testing according to the three standards ELOT 879, 388.1+2, 388.3. The Center for Testing, Research and Standards of Public Power Cooperation has the ability to conduct a series of test according to the various standards on solar products.
Standards and testing laboratories are necessary for the certification of solar products. ELOT has established Certification Counsil and a certification procedure is planned to be developed for solar products.

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ENERGY OF WATER HEATING SYSTEMS WITH SOLAR AND AUXILIARY ENERGY IN GREECE

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In this paper the ISO 9459/Part 3 standard, which is referring to the procedure of evaluation of water heating systems with solar energy and auxiliary energy source, is applied. The procedure, the data acquisition system and the treatment of measurements are described. This paper with some additional needed measurements will provide a comparison tool for water heating systems with either combination of solar and auxiliary energy or conventional energy.

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PERFORMANCE OF DOMESTIC HOT WATER SYSTEMS RESULTS OF MEASUREMENTS FROM A LARGE NUMBER OF SYSTEMS ACCORDING TO THE STANDARD ELOT 879

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Many solar domestic hot water systems of the Greek Industry have been tested according to standard ELOT 879 concerning their performance. It is noted that ELOT 879 is equivalent to the international standard ISO/DIS 9459-2 "Solar Heating-Domestic Water Heating Systems. - Part 2: Procedures for System Performance Characterization and Yearly Performance Prediction".
This work contains a review of results of measurements from 21 solar domestic hot water systems. Relevant results provide useful information to the manufacturers of the solar products and have been used for improving performance of the solar systems and their cost.
Manufacturers intend to use these results for labelling their products in order to inform consumers in an accurate and standardized way about the DHW system performance. Furthermore, the Center for Renewable Energy Sources (CRES) and the Greek Solar Industry Association are planning a campaign to inform the consumers on the content of the label.
CRES provided financial support in the framework of CEC VALOREN program and the measurements were conducted at the Solar Laboratory of the research center DEMOCRITOS (manager V.Belessiotis). Two reports have been issued by CRES (author T.A.Pafelias) containing complete analysis of test results, and all laboratory test reports.

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EFFICIENCY TESTS IN SOLAR DOMESTIC HOT WATER SYSTEMS - RESULTS

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This work deals with the results of efficiency tests of Domestic Hot Water Systems, according to the greek standard ELOT 879. The tests were carried out in the Laboratory of Solar Collectors and Systems of NCSR "Democritos". The results refer to 29 solar systems, which are a representative sample of a large range of similar products of the greek industry. The results of the tests are relative to the efficiency, the thermal losses, the energy quality and the operating conditions of the systems. By evaluating the results of the tests, the manufacturers can significantly increase the system's efficiency implementing certain improvements in their design. The results of this work show that there is significant ground for optimization in a large range of Systems.

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EFFICIENCY TESTS IN SOLAR DOMESTIC HOT WATER SYSTEMS - REGRESSION ANALYSIS OF THE RESULTS

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As described in the companion paper [1] the method of the greek standard ELOT 879 characterizes a Solar DHW System by simple parameters (a1, a2, a3, Us, f(v)), which are predicted by short-term tests. These parameters give the ability of predicting the long-term performance of a system, under any known operation and meteorological conditions. In this paper we present the errors of the above parameters and their influence on the prediction of the long-term performance. The results refer to a large number of tests, carried out at the Solar Systems Laboratory of NCSR "Democritos". We conclude that the accuracy of the tests was satisfactory and we found that the requirements of ELOT 879 about the conditions and the duration of the tests can be simplified, without reducing the accuracy of the results.

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DEVELOPMENT OF A SIMPLE MODEL FOR PERFORMANCE EVALUATION OF SEASONAL SOLAR SYSTEM - DETERMINATION OF PARAMETERS OPTIMUM DESIGN

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In this paper we present a simple method intended to predict the day by day thermal performance of individual and collective Seasonal Solar System (S.S.S). We also analyze its basic characteristics. Analytical equations for the instantaneous simulation of the SSS, during the quasistable conditions are derived. These equations are integrated over the quasistable period. It was verified that their final form (after integration) coincided with the general equations of the INPUT - OUTPUT method for SDHW systems. Finally we present the results of simulation for SSS of "Solar Village". This method in now being validated in comparison to two SSS.

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CONCLUSIONS FROM THE OPERATION OF THE SYSTEMS OF REGION "E" IN SOLAR VILLAGE 3 - LYKOVRISSI - ATHENS DURING PERIOD "1989-1990"

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The evaluation of the thermal performance of three similar central solar systems for the production of Domestic Hot Water (DHW) and Space Heating (SH), along with the problems encountered during the early period of their operation, are discussed in the present paper. The systems are installed in three buildings (UEA, UEB, UEC) of Region "E" of Solar Villlage 3, Lykovrissi, Athens. The total domestic area of Region "E" is 3140 m2 and consists of four (4) buildings (UEA, UEB, UEC and UED). Building UEA is a six storey block of flats, UEB is a two storey typical rowhouse and buildings UEC and UED are two storey 80m^2 apartments (equipped with one central solar system installed in the substation of building UEC)
The collectors in each system are mounted on the roof of the building and the collected energy is transferred by forced circulation to the DHW or SH storage tanks in the building basement. A priority control is envisaged in the storage systems for DHW and SH. Electric heating insets are provided as back-up for the DHW during summer. An oil-fire boiler plant is installed as back-up for the SH. At the same time, it boosts the heating of the DHW during winter operation. The operation of the systems, has been monitored via a Data Acquisition System and the data delivered have been processed, analysed and the conclusions of the thermal performance evaluation of the systems are reported in this paper.
Following a brief description the evaluation method employed, the main findings are reported to be:

(i) the presence of various problems in the collectors fields, such as leakages, corrosion, loss of vacuum in some tubes, uneven flow distribution, dust and humidity on the rear side of the screen of the flat plate collectors.

(ii) the thermal efficiency of both collector fields has been lower than given by the manufacturer

(iii) the considerable thermal inertia of the heat storage subsystem, combined with the lower than anticipated hot water consumption, had a negative impact on the contribution of the solar system to the DHW demands.

(iv) the excessive heat losses in the DHW recirculation line had a severely adverse result, by increasing the auxiliary energy needs.

(v) the contribution of all solar systems to covering SH load was "poor". It is evident the necessity: (a) of optimizing the design control strategy to the load priority SH/DHW, giving more loading possibilities to SH storage tanks and (b) of a design change of the control for separation boiler and SH tanks.

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THERMAL PERFORMANCE OF A SOLAR PHOTOTHERMAL SYSTEM - ELECTRIC ENERGY

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The thermal behaviour of a solar photothermal system is analyzed. The solar radiation is focused at flow through solar heat pipes which are placed across the focus line of parabolic through collectors. The thermal losses equations and the working fluid outlet temperature equation is calculated. The performance of this system is presented according to the results of a simulation program.
The presented graphs show the performance of the efficiency in reference to the length of the flow through heat pipe for various values of working fluid flow rate, the diameters of the heat pipe, the aperture of the collector and the density of solar radiation. It is also presented a graph which shows the performance of the working fluid outlet temperature in reference to the length of the heat pipe for various values of the working fluid flow rate.
It is founded that at the higher flow rates of the working fluid the efficiency is better. Although, it is not possible the continuous increasement of the flow rate because of the need to obtain high temperatures. It is also founded that the efficiency is being improved as the aperture of the collectors and the density of the solar energy become higher, and as the diameter of the heat pipe becomes smaller.
For the production of electric energy by the use of solar photothermal systems, high outlet temperatures of the working fluid must be obtained. The above characteristic makes ideal for such applications the vacuum heat pipes of large length which receive the solar radiation by the use of concentrating mirrors.

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RECENT DEVELOPMENTS ON STIRLING ENGINES, NEW TYPES OF ENGINES AND CURRENT WORK ON SOLAR SYSTEMS WITH S.ENGINES

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The developments of the Stirling engines during the last 20 years have been important and continuous. After a brief historical review on Solar Stirling engines, the free piston engines are presented as well as the free cylinder ones. Also the Ross linkage is described which presents a significant contribution to the development of modern Stirlings. Continuing is a reference to the Thermomechanical generator (TMG) and the low temperature difference engines of Kolin and Senft. Finally, a brief list is presented of the various institutions and researchers worldwide, that are involved in Solar Stirling, and have published relevant papers during the recent years.

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RESIDENTIAL HOT WATER PATTERNS

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The settlement Solar Village 3 (SV 3), which is located in Lykovrissi, 18 km north of the center of Athens, occupies a total area of 90440 m^2 and consists of 25 buildings that comprise 435 residential units, 12 shops, a cafeteria, a library and a social center. Different Passive and Active solar systems and other Alternative Energy Sources for Space Heating and Domestic Hot Water Services have been installed in the village buildings. A Data Acquisition System acquires and processes approximately 1400 signal from representative areas of the SV-3 plant.
This paper gives the results from actual measurements of hot water use in three of the buildings of Solar Village 3. The domestic hot water is prepared in one building by an air to water heat pump and in other two building by central solar plants. The main objective of the paper is the development of residential hot water patterns in Greece, conducted over the period June 90 - May 91. Average hourly, daily and year profiles are presented and discussed. Patterns illustrating the average hot water consumption "per person" are also developed. In addition, the effect of "family size" in hot water use is examined. It was found that the majority of the families consumes between 30 and 40 liters per person and day.
The results of this paper is of great importance in the design and development of future water heating systems.

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HEAT PUMPS: SEASONAL PERFORMANCE FACTOR SPF AND ITS RELATION TO THEIR ECONOMIC EVALUATION

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In this report the seasonal performance factor SPF is proposed as the best evaluation parameter than COA (or COP) coefficient, that characterizes the heat pumps in the case they use the ambient air as heat source. The seasonal performance factor intergrates the ambient air temperature variation during the winter heating period as well as the total time needed for defrosting of the outdoor coil.
The results are presented in tables, where the SPF variation is given for different greek towns and climatic regions (Heraklion, Athens, Thessaloniki, Kavala). We observe that SPF rises up when we go from cold climates (Kavala) to hoter (Heraklion)
In opposite we observe that the global time needed for heating when we go from cold to hoter climates rises down.
As far as we charge parameters that influence the SPF we get the sensitivity test of the SPF factor: using air to air of air to water heat pumps, using FCU of floor heating exchanger, using or not temperature compensation,...
Specific calculations are made for different heating schedules and for the various existing schedules of low cost electrical energy that is absorbed by the heat pump.
The results of this paper, given by the Interclima's computation programs show that the heat pumps give their better thermo-economic operation in regions with moderate SPF factor and moderate annual operation time, like Athens.

* * *

EFFECTS OF THE POOR APPLICATION OF THE INSULATION CODE: A COMMON EXAMPLE

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This paper refers to the application of the Greek Insulation Code (GIC) of 1979 in the current building practice in Greece. As experience shows, the provisions included in the thermal insulation design of most projects are rarely followed to the letter, if not totally ignored. The official control is usually limited to the bureaucratic requirements dictated by the regulations before issuing a building permit, with little care about the actual application of the approved design. This has encouraged a wide-scale indifference amongst builders, especially as it is difficult to inspect the proper level of insulation when it has already been covered by other building layers. Thus energy spending in both household and national level remains higher than expected, in spite of the GIC. A typical case presented in these pages, focusing on a real project on the island of Rhodes where the quest for profit supported by the lack of official control and "excused" by the mild climatic conditions, has produced another example of insulation levels below the legal requirements.

The building under study consists of two similar two-storey flats with basement, heated and cooled by an air-conditioning system via air-ducts. The thermal balance of those flats is greatly affected by their east & west facades, in which the mean thermal loss coeffient is 76% higher than the permitted maximum value (2.82 instead of 1.6Kcal/m2h C), as shown by some simple calculations. The insufficient insulation allows an extra amount of heat flow through the building envelope, which is the subject of further calculations (not considering ventilation losses, raw and solar gains, or the effects of thermal mass, since the GIC does not refer to these factors).

The actual fabric losses are compared to the "legal" ones, i.e. with the overall heat loss coefficient of both facades equal to the maximum value, 1.6. The overall difference indicates the amount of additional energy to compensate for the poor insulation. The calculation of the extra heating of cooling load is performed on an hourly basis for each month. The hourly ambient temperature is taken as a cosinoid function of the montly "mean average" and "mean maximum" temperature of the location, whilst the comfort zone is assumed between 18-25 C. The additional energy which is daily required to raise-lower the indoor temperature up-down to the closest to ambient of those limits, is estimated according to the degree-hours of each day. The annual total is about 2700kWh per flat per year, 3/4 of which is for heating and 1/4 for cooling. Assuming a 70% performance of the mechanical installation and a gross cost of 30 GDR per kWh of electricity (9/1991), the extra burden on the annual household budget is 115.000 GDR per flat (about 800 GDR per sqm. of floor area) a sum nearly 4% of the average family annual income.

It should be underlined that these figures include the effects of the two facades only, which are just 40% of the total envelope. A (hypothetical) attempt to reduce losses by increasing insulation on the horizontal surfaces (=roof or basement floor) might had improved the total energy balance, but the danger of uneven temperature distribution in the various parts of the flats would have been quite probable.

This simple case study highlights the financial dimension of the strict adherence to the GIC requirements, especially in areas with climatic conditions less favourable than Rhodes. It is obvious that public awareness on the financial aspects of insulation should be increased. Furthermore, some thorough control of the building process should be established -e.g. with random inspection using special equipment, in order to reduce money thrown down the drain by ignorance and greed.

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VENTILATION MEASUREMENTS BY TRACER GAS DECAY METHODS

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In this report, a series of ventilation rate measurements by tracer gas decay method, are presented.
The experiment was carried out in a room of a simple isolated building with a mechanical ventilation system consisting of three fans. It involves measurements of the ventilation rate for both the natural and the mechanical system.

The equipment which was used included:

- Foxboro, MIRAN 1B2 infrared tracer gas analyzer
- Three thermometers with Pt100 B temperature sensors
- A Vector Instruments, A100 anemometer
- The tracer gas used was SF6

During the experiment the meteorological conditions were calm with mean ambient temperature about 25.3 C and mean wind velocity about 1.07m/s.
The mean air temperature inside the room was approximately 23.7 C
The time, from the release of the tracer gas until the elimination of its concentration inside the room, was approximately 2h.
The result, calculated from the gradient of the ln(c) versus time, was found to be: 0.59ac/h.

The same method applied to the room, with the mechanical system operating, gave the following results:

3 fans: 10.58ac/h
2 fans: 7.63ac/h
1 fan: 3.84ac/h

This experiment is probably the fist of its kind to take place inGreece. It is the first of a series of similar measurements that have been scheduled for ventilation rate measurements in buildings by the Center for Renewable Energy Sources.

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LABORATORY MEASUREMENT RESULTS ON HEAT PUMP UNITS FOR SPACE HEATING OF THE OTE SA LOCALS

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OTE SA, that is the telecommunication organism, in Greece, has realised a small program (300 pieces) for space heating and cooling using air to air heat pumps. Those units are split type, floor standing units, air discharge at the top of the indoor unit and possibility for fresh air intake at the back side of the indoor unit.
The units are specially designed according to standards presented by OTE SA concerning unit performances during winter and summer, noise emission from both units and concerning the design of the refrigerant side circuit. Heat exchangers used in those units are common type finned tube heat exchangers.
The air flow rate at the indoor unit is 3100 m3/h for a static available of 125 Pa. Its size is, for summer operation, a 5RT air cooler.
In this paper we observe the good meteorological level of the INTERCLIMA's labs as well as the very good approach of the measurements made to the calculation results given by computation programs.

* * *

THE PINCH TECHNOLOGY AND THE ENERGY ECONOMY IN THE INDUSTRY

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The "Pinch Technology" is over twelve years old. It is a method of analysis of combined heat and power systems by an energy bottleneck or "pinch" technique. In particular pinch technology has demonstrated that good process intergration pays off through simplicity of plant design and good use of energy and capital.
The principle is to predict what should be achieved (targeting) and to then set out to achieve it (design).
This technique identifies the minimum process energy demand for a given value of ΔT, where ΔT is the minimum approach temperature in any heat exchanger. It is possible to determine the optimum value of ΔT for a given fuel cost and equipment cost. For the best sugar process a low value was used, 5 C.
Three cases of sugar factories, where the pinch technology and the process integration was applied are discussed.
The 5 C difference leads to six evaporator stages using overall falling film evaporators. For a higher fuel cost, the choice of a 4 C difference leads to seven evaporator stages using again falling film evaporators. For plate heat exchangers a ΔT of 2,5-3 C is already feasible. The use of small ΔT at heat exchangers or evaporators is advocated by the second thermodynamic law.

* * *

EUROPEAN GUIDELINES FOR SOLAR THERMAL PLANT ASSESSMENT

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A new set of Guidelines for the assessment of active and passive solar technologies has recently been published by the Commission of European Commmunities (CEC) Joint Research Centre at Ispra. The new Guidelines contain advice and format sheets for the technical description of projects and for the presentation of results, together with detailed guidance on the selection, installation, and use of instrumentation. They do not include advice on how to assess cost-effectiveness.

They were developed with the help of a group of European experts primarily to assist the CEC with the technical management of its THERMIE Programme, which is aimed at the promotion of energy technologies. The document covers each of the main applications of active and passive solar technologies, and permit the performance of projects in different locations and operating conditions to be compared on a common basis. They will therefore also be of use for promoting solar technologies through national programmes and in developing countries.

* * *

BLACK PAINT SELECTION FOR SOLAR COLLECTORS

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A number of plain black matt paints widely used in the solar collector Greek market have been tested on a specially prepared test ring. The stagnation temperature and the thermal performance of each sample were studied under both covered (with a transparent material) and uncovered conditions. Samples exposed to the outdoor conditions for 5 years were subsequently tested against reference samples kept for the same period indoors. In the presence of a transparent cover the paints of SYNTEX, CHROTEX and MINOS have been shown to perform better, whereas for unprotected absorber the paints of CHROTEX, MINOS and SMALTOLUX exhibited a reliable performance.

* * *

FLAT PLATE COLLECTOR FOR AGRICULTURAL USE

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A low cost flat plate solar collector for agricultural heating and drying processes has been constructed by the Agricultural Mechanics Laboratory. The absorber plate made from steel guides the air in the meander-like path, which enhances its thermal performance. A metallic mesh fitted in the collector outlet provides further turbulence in the air movement.
The experimental tests performed in accordance to the Greek Standard 388-1 have shown that a temperature rise of 20 C may be achieved across the collector. Collector efficiencies over 80% have been observed for air flow rates above 135m^3/h. The variation of the collector efficiency with various operational parameters is also presented in accordance to the NBS method.

* * *

THERMOSIPHON WATER HEATING UNITS WITH FLAT PLATE SOLAR AIR COLLECTORS

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We have studied, constructed and tested solar collectors in which water is heated through natural convention of air. These units are drastically different than the flat plate water heaters, since the flat surface, through which water is circulating, is absent. Instead, the water is heated indirectly by the natural convection of the hot air from an air solar collector. In this way, the system becomes light, less expensive, with increased life.
The basic unit consists of an absorber, the transparent cover, a hot water tank, thermal insulation and the closed loop for the natural circulation of air from the absorber to the water tank. The radiation absorber is smooth on the lighted area, but is supplied with fins on upstream of air. The hot air delivers a large fraction of its heat content to the tank and descents in the space between the absorber and the transparent cover, losing an amount of heat to the ambient. During normal operation, the temperature difference between the hot ascending air on the back side of the absorber and the descending, less hot air on its front side, is sufficient to achieve satisfactory natural circulation of air.
We present certain cases of design, construction and testing of such models, in comparison to the corresponding thermosiphon flat plate units, operating with natural circulation of water. The results show that the proposed solar water heaters with flat plate air collectors are suitable for practical use.

* * *

STATIONARY CONCENTRATING SOLAR AIR COLLECTORS

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We have studied improved types of stationary concentrating solar collectors which are suitable for applications up to 100 C or more, as for example space heating, drying of agricultural products and thermal needs for the industry.
The design of the proposed air collectors is such that a trapped hot air space is formed between the stationary mirror and the absorber. This reduces the convection heat losses from the absorber to the ambient. On the other hand, the direct interception of part of the incoming solar radiation, without previous reflection by the mirror, is enough to achieve satisfactory optical efficiency.
The construction of prototypes was guided by the following principles: efficient air heating for low and intermediate temperatures, low cost and reasonable size of the final installations.
The tests were performed by forced air circulation and the results show that the proposed types of stationary concentrating air collectors are efficient in the temperature range of operation. Moreover, the simple construction and the ease of linear development make them ideally useful for the case of large solar installations.

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THERMAL PERFORMANCE CRITERION OF SOLAR COLLECTORS

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The thermal efficiency of solar collectors depends on environmental and working conditions. In order to be comparable the collector efficiencies, standard test methods can be used to determine it.
The experimental test results are treated to give the first and second order equation of instantaneous efficiency. For comparison of the thermal performance of different solar collectors, the values of coefficients from these equations are used. There are two (η, U) and three (η, a, a_1) coefficients for each equation respectively.
In this work a new parameter is used as a criterion of collector performance. The experimental results of a tested collectors group are used to compute the new parameter.
The advantage of this presentation is the characterization of collectors performances with only one number.

* * *

IMPLEMENTATION OF ADVANCED TELEMONITORING TECHNIQUES IN SOLAR ACTIVE SYSTEMS IN GREECE AND THE PRINCIPLE OF GUARANTEED ENERGY DELIVERY

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It has been observed in Greece and also in international level that often the large systems do not operate under optimal conditions for the lack of adequate maintenance, regulation systems and warning alarms in case of failures. The implementation of advanced monitoring techniques, principally based on telemonitoring systems, can significantly increase the efficiency of operation of solar systems and contribute to further development of the solar market.
In the framework of the CEC VALUE program of DGXIII (transfer of technology) and in cooperation with CEC Joint Center at Ispra, telemonitoring systems have been installed in five active solar systems in hotels and two at domestic hot water systems. A short description of the basic principles of telemonitoring and typical results are included in this work.
The use of telemonitoring techniques can provide, at reasonable cost, information about the operation of the solar systems for hot water, leading to improvement of the performance of existing systems and to revised design practices for new systems.
Telemonitoring techniques can provide an installer/manufacturer with the possibility to offer "guaranteed performance". The user can expect a minimum amount of solar contribution to his monthly energy needs.

* * *

QUALIFICATION TEST PROCEDURES FOR SOLAR COLLECTORS. RESULTS OF TESTING FROM A LARGE NUMBER OF COLLECTORS ACCORDING TO THE STANDARD ELOT 388.3

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Many solar liquid heating collectors of the Greek industry have been tested according to standard ELOT 388.3 concerning durability testing. It is noted that ELOT 388.3 is equivalent to the international standard ISO/DIS 9806-2 "Solar collectors. - Part 2: Qualification test procedures.
This work contains a review of results of testing from 11 solar collectors. Relevant results provide useful information to the manufacturers of the solar collectors and have been used for improving the reliability and durability of the solar collectors. These results are the first available in international level.
CRES provided financial support in the framework of CEC VALOREN program and the qualification tests were conducted at the Solar Laboratory of the research center DEMOCRITOS (manager V.Belessiotis).
A report has been issued by CRES (author T.A.Pafelias) containing complete analysis of test results and all laboratory test reports.

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THERMAL PERFORMANCE OF LIQUID HEATING SOLAR COLLECTORS. RESULTS OF MEASUREMENTS FROM A LARGE NUMBER OF COLLECTORS ACCORDING TO THE STANDARD ELOT 388.1+2

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Many solar liquid heating collectors of the Greek industry have been tested according to standard ELOT 388.1+2 concerning their thermal performance. It is noted that ELOT 388.1+2 is equivalent to the international standard ISO/DIS 9806-1 "Solar Collectors. - Part 1: Methods of test for the thermal performance of liquid heating collectors".
This work contains a review of results of measurements from 15 solar collectors. Relevant results provide useful information to the manufacturers of the solar collectors and have been used for improving their thermal performance. Collectors are grouped in three categories (sandwitch, copper tube with good conduct with the fin and copper tube with Ω type fin) and instantaneous efficiency curves are provided.
CRES provided support in the framework of CEC VALOREN program and the measurements were conducted at the Solar Laboratory of the research center DEMOCRITOS (manager V.Belessiotis). A report has been issued by CRES (author T.A.Pafelias) containing complete analysis of measurements and all laboratory test reports.

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INSTANTANEOUS EFFICIENCY MEASUREMENTS OF AN AIR COLLECTOR

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Measurements of the instantaneous efficiency curve of an air collector were taken at the Technological Institute of Thessaloniki. The test apparatus and test procedure have been prescribed and have been recommended to ISO as an international standard by the European Solar Collector and System Testing Group at ISPRA.
Based on these recommendations, the test apparatus was designed and constructed for the measurement of the instantaneous efficiency curve of an air collector. This air collector was constructed by a group of mechanical engineering students at the Technological Institute of Thessaloniki.
Special attention was given to the calibration of the two orifice plates which were constructed to measure the air flow. For this purpose, a separate calibration apparatus was designed and constructed in which a standard VDI nozzle and several standard pitot tubes were utilized to calibrate the orifice plates.
Measurements were made of the efficiency curve. The results were presented in the standard form: one curve of efficiency versus the quantity T^* for a given air flowrate and a second curve of efficiency versus air flowrate for a given air inlet temperature.
This research was funded by the European Community program VALOREN through the Center of Renewable Energy Sources in Athens.

* * *

AN APPLICATION OF EXPERT SYSTEMS ON THE DESIGN OF SOLAR COLLECTORS

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The optimization of solar collector design includes selection of different materials, as well as a variety of manufacturing techniques. At this point the consideration of manufacturers experience and scientists knowledge would lead to longer lifetimes and lower installation costs.
A very reliable method facing this problem is the development of an expert system, being able to provide guidelines concerning the design of solar collectors according to already tested and used in practice systems.
Expert Systems form a special class of computer programs being able to advise, analyse, communicate and deal with problems normally requiring human experts. What is expected from an expert system is to deal with problems of specific scientific domain and to provide, in reasonable time, accurate solutions, under conditions of uncertainty, if required.

An expert system is consisted of the following three basic components:

- A knowledge Base
- An Inference Mechanism
- A User Inerface

In this paper an expert system has been developed for the design of the optimum solar collector, based on ELOT 388.1+2 standard. For this purpose, a great amount of informations describing existing solar collectors have been gathered and stored in the appropriate knowledge base. During the program execution the user is asked to identify, for every parameter, the standards affecting the collector design, from a given list with many different options. The program is trying to match the user's selections and the relevant already stored information. If the procedure is successful, the computer will provide the user with all possible selections, that can be applied. In the opposite case the user should rearrange the selections and try again for a solution through this development expert system.

* * *

THERMAL PERFORMANCE OF LIQUID HEATING SOLAR COLLECTORS - TEST RESULTS

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The aim of this paper is to present the Thermal Performance Test Results of 30 liquid heating collectors.The tests were conducted at the "SOLAR COLLECTOR AND SYSTEM LABORATORY" of the NCSR "DEMOCRITOS", in accordance to STANDARD ELOT 388.1+2, which is equivalent to ISO/DP 9806-1. The performance of solar heating systems depends largely on the performance of the solar collectors employed and it is therefore particularly important for manufacturers and customers to know how well a collector will perform. These 30 collectors are a representative sample of a large range of similar products of the greek industry. The results are relative to the collector efficiency, effective thermal capacity, pressure drop and the operating conditions of the collectors. The collectors were tested outdoors, with water as the heat transfer fluid. By evaluating the results of the tests, there can be an increase on the collectors' performance.

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DEVELOPMENT AND TESTING OF HYBRID "WATER-AIR" COLLECTOR

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In the last years air heating collectors have gained significance especially in the field of industrial and agricultural applications but not in Greece. In this paper we present the experimental results of the thermal behaviour of a hybrid "Water-Air" Collector and we also analyse its basic characteristics. Results are presented.

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THE THERMAL PERFORMANCE OF AN ARRAY OF EVACUATED HEAT PIPES IN THE REGION OF THE SOLAR VILLAGE-LYKOVRISSI-ATHENS

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A Solar Collector Array of 1296 PHILIPS VTR361 Evacuated Heat Pipes has been installed, as a part of a Central Solar Heating Plant with Seasonal Storage in the Region "UF" of the Solar Village Project-Lykovrissi-Athens. The array, of 161,7m2 aperture area, is one of the greatest of this type installed. The operation of the array, as well as the operation of the overall system, has been monitored via a Data Acquisition System for three years (1988-1991). Data delivered during the monitoring phase have been processed and analysed, so that conclusions on the thermal performance of the array during this period have been extracted. These conclusions are reported in this paper. The instantaneous and long term array efficiency parameters, calculated from data during the monitoring phase, are presented and are compared to the design parameters. Comments on the energy flows in the Solar Collectors Subsystem and on the operational problems during the evaluation period are also presented.

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COMPARABLE THERMAL PERFORMANCE OF FLAT PLATE SOLAR COLLECTOR SUBFIELDS IN SYSTEMS UEB AND UEC OF SOLAR VILLAGE-LYKOVRISSI-ATHENS

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The paper describes comparative results from the operation of five different flat plate collector subfields (BP-CALPAC, SIEMENS, STIEBEL-ELTRON and THERMOSOLAR). These collectors are installed to two system for space heating and domestic hot water at Region "E" (building UEB and UEC) of Solar Village 3 (SV-3), which is located at Lykovrissi, Attiki, Athens, Greece. The comparative analysis of the different diagrams, partly by means of energy bar charts. The results are based on three evaluation periods (1989-1991). The diagrams and regression analysis show that SET flat-plate collector has the most efficient curves. THERMOSOLAR flat-plate collectors, which are installed recently to system UEC, in the place of SET vacuum tubes with boosters has shown efficiency close enough to that expected by their design. SIEMENS and STIEBEL-ELTRON flat plate collectors behave similarly and small differences can be attributed to different designs. The operation of solar collectors manufactured by BP-CALPAC has been impaired by problems such as condensation inside the collectors and accumulation of dust and humidity on the rear side of the screen. The condensate prevented the early start of this collector loop in the morning and together with dust impaired the BP-CALPAC collector efficiency and especially the optical or zero-loss efficiency. All collector subfield efficiency curves are shown to be clearly lower than that given by manufacturer for a single collector.

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THERMAL ANALYSIS OF THE PHASE CHANGE PHENOMENON (in spherical geometry capsules)

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Different kinds of models can be used for the study of latent heat storage using phase materials (PCM). In this study we look into the phase change of a material with well-defined and distinct point of melting (or freezing), which is shaped in a spherical capsule. The one-dimensional model can be described by three differential equations: two for the conductivity of liquid and solid phase and one equation governing the interface motion between two phases. In order to have full comprehension of the phenomenon we use non-dimensional analysis. Using the finite difference method and Thomas algorithm we solve the implicit linear system. Finally, we present diagrams where temperature profiles, interface motion, effect of the convection coefficient on the outer surface on the sphere, effect of the PCM latent heat and time required to complete the phase change, are shown.

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TRANSIENT THERMAL PERFORMANCE OF A HEAT STORAGE PACKED BED OF ENCAPSULATED PHASE CHANGE MATERIALS (P.C.M.)

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A computer simulation model has been developed for the transient thermal performance of a latent heat storage, cylindrical packed bed. The packed bed is intended as a heat storage unit in which an inert fluid (air) flowing through the bed exchanges heat with the encapsulated spherical shells of the Phase Change Material (PCM, melting and freezing). The transient response of this thermal storage packed bed is governed by three partial differential equations one for the working fluid (air), one for the thermal storage material (one for the solid and one for the liquid region) and a coupling equation for the phase change interface. The set of coupled differential equations are solved numerically, and the numerical method chosen in the present study is the finite difference, fully implicit formulation approach. An attempt was made to include consideration of terms such as despersion effects, intra-particle conduction which is a more physically correct treatment. The model has been developed for the prediction of melting/freezing time, melting/freezing front location in the bed, and the temperature history of both the working fluid and the two phases (solid/liquid) of PCM. The model is shown to provide accurate results when compared with experimental data in the published literature.

* * *

STORAGE TANKS INTERCONNECTION IN LARGE SOLAR SYSTEMS

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Storing thermal energy in large DHW solar systems as sensible heat may require more than one storage tank. This increases the thermal inertia of the storage subsystem and may produce, in certain cases, an adverse result on the temperature stratification, with severe consequences on its thermal performance. Since various control systems are mostly common in such systems (needed for the operation of pumps, valves, etc.), the mode of their operation and the inter connection of the storage tanks should be chosen for maximum performance of the overall system. This has been investigated in the present work by developing a mathematical model (PROTANK-3) for the thermal performance analysis of a solar system for a number of alternative configurations and operation modes of the storage subsystem.
As a reference case for this analysis, the present storage configuration of a number of DHW solar systems installed in Solar Village 3, Lykovrissi, Athens, has been employed. The effects on the thermal performance of these solar systems of the following changes in their storage configuration have been studied: (i) Improving the thermal insulation in the DHW recirculation line, (ii) Loading both storage tanks from the heat exchanger, (iii)Changing the DHW recirculation mode, and (iv) Applying various types of water consumption profiles.
Combining the four changes outlined above seven alternative cases of operation have been formulated and further studied. Following the model predictions for these cases, one case was promoted for an experimental investigation. The enhancement of the thermal performance achieved by the new configuration, in comparison to that of the non modified system, has been much more significant than expected. According to the model predictions, further improvements could be achieved.
For optimal performance, the overall system configuration in such cases should comply with the following criteria: (i) promotion of high temperature stratification within and between the storage tanks, and (ii) quick transfer of high grade thermal energy to the user. Adequate corroboration to the model predictions has been provided by experimental results obtained from two particular systems.

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SOLAR PONDS

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A solar pond is a system of collecting and storing solar energy in the form of heat. It has been used for the production of electrical energy and for the production of hot water for industrial and agricultural usage. For the last thirty years its development has been very rapid from the standpoint of both its applications and its technological improvements. In this presentation we will refer to salty solar ponds, to shallow non-salty solar ponds and to non-salty solar ponds with considerable depth. We will specifically refer to our own experience, that is, to non-salty solar ponds studied in a laboratory scale, i.e.

1. Solar pond covered by a layer of paraffin oil.
2. Solar pond with horizontal plastic transparent partitions.
3. Solar pond containing plastic transparent containers full of water.

* * *

APPLICATIONS OF SOLAR PONDS

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The principles of the solar pond and a number of such applications are discussed in the present work. The considerable number of thermal applications in low and medium temperatures provides a significant potential for the application of solar ponds in Greece.

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EARTH TO AIR HEAT EXCHANGERS FOR HEATING AND COOLING OF ANIMAL BUILDINGS

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Earth to air heat exchangers or "earth tubes" intent to investigate the effectiveness heat exchangers composed of commercially constructed pipes burried in the soil. Depending on the season, incoming ventilation air is heated or cooled as it passes through a burried tube. The soil serves as a heat sink in the summer and as a heat source in the winter, thus giving almost year round temperature modification. It has the potential to significantly reduce heating costs during winter and provide zone cooling during summer. So earth tube heat exchanger system have been an alternate method for preconditioning the incoming air in animal buildings-warming in the winter and cooling in summer.
The installation of the earth tube system is located on the experimental field of the laboratory of Agricultural Constructions at the Agricultural University of Athens. The heat exchanger system composed of two pipes of a length of 15m, 0.2 in diameter and 3mm of wall thickness, burried at a depth of 1.5m. Pipes can be made of any material because the total system conductivity is dominated by the conductivity of the soil. The two pipes studied in the present work consist of plastic p.v.c. and steel respectively. A simple ventilator is the equipment needed to assure the movement of the air through the pipes.

In the present work the following parameters are evaluated:

--- the average and local convection coefficients at the inlet and outlet of each heat exchanger
--- the total heat transfer rates for the purpose of quantifying the thermal performance
--- the exchanger effectiveness at different air velicities in order t determine the optimum operation range of each heat exchanger in summer and winter, respectively

Further are given in comparison between the average and local convection coefficients and in comparison between the performance of the p.v.c. and galvenished steel pipes respectively.
Results on the effectiveness of the system are presented and performance indicates favorable winter heating and summer cooling from heat exchangers. Also the use of plastic p.v.c. tube makes the system even more feasible because of the lower material and installation costs.

* * *

SUN ENERGY IN CROP PROTECTION OF THE CULTIVATED PLANTS

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The use of sun energy for the control of soil-borne pests, diseases and weeds in cultivated plants is becoming more and more interesting. The method consists of solarization of the previously carefully ploughed and irrigated soil with the aid of transparent polyethylene sheets for at least four weeks. The prolonged hydrothermical effect combined with the increased release of CO2 limits the population and the infectivity of the pathogens while, in contrast, the activities of antagonistic microorganisms are increased. In addition, the growth of weeds is limited and the soil fertility is improved. This physiobiological method, is called to reduce the use of the wide spectrum soil desinfectants which have recently been accused for the appearance of many unpleasant ecological phenomena such as, the biological gap, trophobiosis, soil tiredness and disease changing.

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STORAGE OF SOLAR ENERGY AND SOLAR DISINFECTION IN GREENHOUSE SOIL

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The purpose of this project is storage of solar energy and soil disinfection in greenhouse. The whole effort is characterized by two main procedures:
For the purpose of heat Storage the greenhouse soil is divided into six plots of 2x2m dimensions. Heat transfer is improved by means of combinations of the two. Among the other plots one is the reference and another one is covered by insulation film during night (for minimization of heat losses of long-wave radiation). The temperature is measured, in all six plots every 5min, by means of thermocouple Copper-Constantan sensors in the depths of 0, 6, 12, 18, 24, 30, 50 and 100cm below the surface. The soil is kept dry all the year round for the purpose of modellisation of the system.
During the second year the cultivation of tomato plants is applied. In collaboration with the Laboratory of General and Agricultural Micribiology of Agricultural University of Athens we study the possibility of disinfection because of pathogens living in the root zone in the soil. The results of this effort will to be completed at the end of the Summer of 1992.

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SOLAR HEATING OF A LIVESTOCK WASTE DIGESTER

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The work is an evaluation of the operation of a solar heating system at a an anaerobic digester of swine wastes. The digester is built up on Naxos island, Greece, for treating the wastes of a swine farm of 100 sows and producing biogas. The plant was part of the project "Integrated Energy System of Egars - Naxos". The solar system was added at the existing digester.

The heating of the digester ($45m^3$ useful volume) is obtained by circulating hot water through a heating coil, heated by a solar collector of total surface $32m^2$. The collector replaces the roof of the digester, has a slope of 20 and due South orientation.

The digester average temperature during the period of April to October was 31 C. The absorbed solar heating, in the same period, was twice the one absorbed during the period from November to March. The average efficiency of the system was 0.21, during the period from September to January. The low efficiency due to the small surface of the heating coil and the slope of the solar collector.

The solar heating system can obtain satisfactory heating if the surface of the heat exchanger, the slope of the solar collector and its surface will be studied for the local conditions.

The system is operationaly simple and without human labor needs, so it is proper for agricultural use. It can save a significant quantity of fuel for digester heating.

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A HEAT PUMP SYSTEM FOR HEATING FISHERY TANKS IN THESSALONIKI

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A 880 Kw Heat Pump System was designed for a fishery in Thessaloniki, Greece. The system combines the waste heat recovery with the operation of two water heat pump systems and with a short-time thermal storage in water tank. It was calculated that about 2500 MWh of thermal energy is required from the heating system to achieve the minimum production demands. According to the design calculations 1270MWh will be covered from the waste heat recovery systems and about 1160mWh will be met from the operation of the two main pumps. Only 207MWh will be needed as auxiliary (electric) energy input.

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SYSTEM TECHNOLOGY OF PHOTOVOLTAIC PLANTS

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There is a great number of different applications for PV-power supply units. This versitility puts high demands on the systems engineering required. High costs for the plant design and the adapted hardware arise, and often there are many difficulties. The entire field of PV-applications can be subdivided into the fields of single load supply, isolated grid supply and feeding into high power grids.
Different types of inverters, suitable for stand-alone and grid-connected applications, are described. Basically, the communication and the clocking of a converter are to be distinguished. Different ways of influencing the characteristics, efficiency costs will be shown.
The approach to advanced systems technology is charactirized by modularization and standardization, development of flexible integrateable components for series production and computer aided methods for tailor made design. The use of device-orientated simulation will lead to an increase in the functional reliability and a decrease in the development risks.

* * *

EVALUATION OF ARKI PV STATION OPERATION. FUTURE PRESPECTIVES

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In the framework of Solar Energy development in Greece, PPC in cooperation with CEC installed P/V Stations in Aegean islands. These stations operate either grid connected (Island of Kythnos) or autonomously in small islands (Islands of Gavdos, Antikythira & Arki). Following the 4 year operation of the Arki P/V station many useful conclusions have been drawn from its operation at the potential for electrification of these islands. A study for the extension of the station was carried out considering its connection to a W/T in order to examine the operation at the hybrid system (P/V - W/T - Batteries - Diesel).

* * *

VESSEL DRIVEN BY SOLAR ENERGY

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Through the present introduction, a presentation is made of a vessel driven by solar energy, of which the study, the assembly and the construction, have been achieved and realized in Greece, with materials and means disposed of by "TELEPAN" Commercial Technical Enterprises.
The initial target pursued for the creation of the solar energy driven vessel, was to demonstrate that solar energy can be utilized for also driving small vessels and to make this known to a wider range, so that it will be enabled to assist in the effort for exploitation of the solar energy, with as a result the sparing of conventional energies, the ideal environmental behaviour and the costless operation, in Greece and elsewhere. The final target aimed at, is the exploitation of the solar energy driven vessel ideal.
The vessel utilized is a small sailing boat. The system of energy and motion supply, consists of:
A SOLEC high power photovoltaic generator with a high efficiency photovoltaic cells, a battery of small losses and of deep discharge and an electric motor of a high efficiency.
The materialization of the idea and the relevant tests, have confirmed the expected results as to the satisfactory operation and output of the solar-electric motion system of the vessel in question, such results being expressed by:
highest speed of 6 knots, autonomy of 1,1/2 hour/day and a range of 9-15 nautical miles.
A relevant pattent has been assured.
Conclusion: The use of solar electric systems is feasible for driving small vessels-boats, for recreational, amateur fishing, for fish-cultivation etc.

* * *

STUDY OF HETEROJUNCTIONS a-Si:H/μc-Si:H FOR PHOTOVOLTAIC DEVICES

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Amourphous Hydrogenated Silicon and Microcrystalline Hydrogenated Silicon structures and heterostructures were grown by utilizing the Magnetron Sputtering technique. The Optimum growth conditions for the a-Si:H films were: rf power 1200W, temperature range 200 C to 325 C and P_{Ar}/P_{H2}=10 at a substrate to target separation of 11cm. For the corresponding μc-Si:H films the rf power was 400W, temperature in the 200 C to 250 C range, P_{Ar}~4-5mTorr and P_{Ar}/P_{H2}=1/2. Films were deposited on different substrates (glass, corning, c-Si etc.). The structures were characterized by utilizing electrical, optical, spectroscopic and structural techniques. More specifically, the dc conductivity of the films was studied as a function of temperature in the range of 20 C to 180 C. Furthermore, the ration of photoconductivity (δ_{Ph}) under AM1 illumination to the dark conductivity (δ_{dark}) was studied and values were in the 104 order for sample thickness of 0.1 to 1μm for a-Si:H. The energy gap (Eg) was calculated by optical absorption measurements in the visible range and it varied from 1.76 to 1.9 eV. Absorption in the Infrared region was applied to determine the number of vibrational bonds between Si and H thus determine also the amount of bonded hydrogen in the films. By applying the non distractive techniques of Spectroscopic Ellipsometry and Raman it was possible to calculate the parameters which control the quality and the type of the layer structures, the number and density of voids as well as the percentage of the crystalline structure for the films. The variation of the dielectric constant, the crystallinity and the density of the films was studied also by thermal annealing experiments at temperatures up to 850 C. Structural analysis of the films and the heterostructures was made by applying cross-section transmission electron micriscopy (XTEM). It was found that μc-Si:H structures grow on a columnar mode perpendicular to the growth surface. Voids were observed between the columnar structures with 2-2.5 mm sizes. However, the optical and electrical characteristics are very little affected by these structural changes, thus contributing to the expectation that the a-Si/μc-Si heterostructures can be utilized in future photovoltaic applications.

* * *

PURIFICATION OF METALLURGICAL GRADE SILICON BY A MULTIPHASE PLASMA PROCESS. PHYSICAL AND CHEMICAL CHARACTERIZATION OF THE PHOTOVOLTAIC MATERIAL

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In order to produce photovoltaic silicon, we have chosen the purification of metallurgical grade silicon by a plasma technique. The properties of the plasma (transport properties and chemical reactivity) ensure a purification factor close to 100.000. This route permites to avoid a lot of intermediate steps such as gaseous chemical intermediates of classical methods which involve large equipments (1mole of solicon = 12cc solid or liquid phase-22.41 in gaseous processes). At the laboratory, the pilot plant allows the production of 200g to 400g silicon per hour by the use of a plasma purification apparatus. The material obtained, has been characterized by ESCA, neutronic and protonic anaysis, ICP-AES and IR transmission. Raman Laser measurements give us the cristallinity of the final material. Resistivity and PV efficiency have been measured too. The plasma process allows a purification of S1 MG up to 1ppm impurity level with a PV efficiency which reaches now 7.2%. The recycling of obsolete Si Eg increases the efficiency from 0 to 11.5%. The control of the plasma process is realized by the use of an optic fiber and a spectrometer through atomic emission signals of impurities evaporating at the plasma/liquid silicon interface. The correlation between the evaporation phenomenon and the resistivity of the solid material after the treatment authorized a real time control of the plasma process.

* * *

CHEMIPLATED AND ALL-VACUUM EVAPORATED Cu_xS/CdS THIN FILM SOLAR CELLS

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An investigation was made on how two different fabrication procedures of the upper Cu_xS layer of thin film Cu_xS/CdS solar cells affect their performance and long term stability. The Cu_xS layer was formed either by using modifications of the conventional chemiplating technique or by vacuum evaporation from a Cu_xS source.

Cd layers had been used as substrates which had been deposited at 220 C using deposition rates of 0.6μm/min. These layers had preferred orientation of the individual crystallites normal to the substrate and grain size of around 3-4μm. The electrical resistivity of these films between 2-8Ωcm and the carrier concentration was $8x10^{17}cm^{-3}$.

The chemiplated Cu_xS layers were formed by immersing the CdS films in a CuCl solution. The reaction was found to be milder and much more well controlled using low temperature and acidity solutions, with much less penetration of Cu_xS into the CdS grain boundaries than those obtained at high solution temperatures. Under these conditions (53 C, Ph=5) the resultant cells, after annealing in a hydrogen atmosphere of after depositing a protective copper overlayer followed by an air annealing treatment, showed improved photovoltaic characteristics when compared to those formed using more conventional conditions; they were more reproducible, less subject to short circuiting (yielding an expected increase in operational lifetime) and an increase in open-circuit voltage of up to 25mV was achieved when unetched CdS substrates were used.

Following a general investigation into the properties of the evaporated Cu_xS layers, it was found that highly stoichiometric Cu_xS layers without excess copper could be obtained with thickness of up to 100nm using hot substrates (220 C) and a deposition rate of less than 15nm/min. These layers were found to provide near-planar junctions with the underlying CdS layers, leading to high open-circuit voltage values, consistent with the theoretical predictions, and solar energy conversion efficiencies of 8%. A further increase in the efficiency was observed when the samples were annealed in hydrogen after being exposed to the ambient for several months. This was associated most probably with the development of an interfacial oxide layer which gave an efficiency of almost 9.5% for these cells.

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SCHOTTKY DIODES ON POLYCRYSTALLINE SILICON THIN FILMS AS PHOTOVOLTAIC SOLAR CELLS

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In this paper, the electrical and photovoltaic properties of aluminun Schottky diodes on 0 type thim film polycrystalline silicon (Poly-Si) were investigated, together with the structural and electrical properties of these films. Poly-Si thin films of 0,1-5μm thickness were vacuun deposited onto Al coated stainless steel and corning glass substrates, using electron beam evaporation, at 0,1-1μm/min deposition rates and about 500 C substrate temperature. For p type Poly-Si, boron was used as a dopant. Thermal annealing was carried out at 700 C for two hours. Al Schottky diodes were fabricated on unannealed as well as annealed p type Poly-Si thin films. The introduction of boron into Poly-Si decreases the electrical resistivity from $5x10^5\Omega cm$ to $450\Omega cm$. Transmission electron micriscopy studies showed that the grain size increases from 0,1-0,3 to 0,7-1,0μm, after annealing. The electrical resistivity decreases (after annealing) from $450\Omega cm$ to $110\Omega cm$. The current-voltage characteristics of Al/Poly-Si Schottky diodes showed that, for low forward bias voltages, thermionic emission is the main carrier conduction mechanism, with significant recombination correct, due to the grain boundaries which act as recombination centers. The barrier height was found to be 0,61eV adn 0,67eV, before and after annealing of Poly-Si, respectively. The Al/Poly-Si Schottky diodes, on annealed Poly-Si thin films, exhibit significant photovoltaic effect, and more specifically, an open circuit voltage $V_{oc}=0,25V$ and a density of short circuit current $I_{sc}=14mA/cm^2$.

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a-SiC/c-Si HETEROJUNCTIONS AS PHOTOVOLTAIC SOLAR CELLS

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In this paper, the dependence of optical properties of a-SiC/c-Si(p) heterojunctions on amorphous semiconductor film thickness is presented for the first time, the aim being to use these heterojunctions as photovoltaic solar cells. a-SiC thin films were deposited by rf sputtering on p-type c-Si (10Ωcm) substrates with ohmic contacts (Au) on their back sides. Aluminum film evaporated onto a-SiC thin films formed the top electrode of the device. Characterization of a-SiC/c-Si(p) heterojunctions, included in structures of the form Al/a-SiC/c-Si(p)/Au, was carried out by spectral response and photovoltaic response measurements. The experimental results revealed that the spectral response of Al/a-SiC/c-Si(p)/Au structures, for a-SiC thickness >1500A exhibits two maxima: one at 350nm and another at 850 nm. These maxima are attributed to photon absorption mainly in the depletion regions of Al/a-SiC and a-SiC and a-SiC/c-Si(p) junctions, respectively. In the middle range of wavelengths, and more specifically from 400nm up to 650 nm, a "loss" mechanism is observed, due to recombination of photogenerated electron-hole pairs in the neutral region of a-SiC, resulting in small values of quantum efficiency. For a-SiC thicknesses <1500A, when the amorphous semiconductor is fully depleted, the spectral response of Al/a-SiC/c-Si(p)/Au structures does exhibit the above "loss" mechanism, due to the collection of all photogenerated carriers into the depletion regions of Al/a-SiC adn a-SiC and a-SiC/c-Si(p) junctions. The structures Al/a-SiC/c-Si(p)/Au, for a-SiC thickness <1500A, exhibit satisfactory photovoltaic effect, with a photovoltaic energy conversion efficiency equal to 4.5% under illumination conditions of 80mW/cm^2.

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AUTONOMOUS P/V UNITS IN REMOTE ISLANDS IN THE AEGEAN SEA

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In the framework of the HORS QUOTA programme, PPC has installed 70 autonomous P/V units with rated power output 700 Wp each, in small remote islands in the Aegean sea and in inaccessible regions with limited possibility of maintenance. The purpose of this project was the supply of power to remote houses in these islands for social and national reasons. The P/V units operate autonomously supplying the houses with 24V D.C output voltage. Presently, the first conclusions from the operation of the separate components as well as the whole P/V unit have been drawn. Also, it is the paper's object to propose solutions to the problems created during the installation and the operation of P/V units. Finally, the general conclusions from the operation of the P/V systems and a forecast of their future deployment in GREECE are presented in this paper.

* * *

WIND ENERGY: INTERNATIONAL EXPERIENCE, CURRENT SITUATION AND DEVELOPMENT IN GREECE

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The "oil crisis" of the 1970's led to a reawakening of international interest in wind energy and in the development of a new technology, which, 15 years later, is in a position to produce electricity at prices competitive with many other conventional energy sources.
The environmental impact and the social cost of conventional sources of energy has begun to be considered and added to the cost of production; as a result wind energy is becoming even more competitive.
This development is reflected in the national strategy goals of the various European Countries, as well as the U.S.A and third countries.
The prospects for development are considerable and the message from the scientific community optimistic. Furthermore, a 20 to 30% reduction in the cost of wind energy is foreseen in the near future due to the improvement of the related technology and the accumulation of experience from the use of wind energy world wide.
Greece is interested and is actively taking part in developing wind energy, beginning with the exploitation of the tremendous wind potential of the Aegean Islands and Crete. With the government and the European Community's support, PPC is planning to develop wind energy in a bigger scale, having set a target of 150MW for the year 2000. Inevitably the accomplishment of this target has its own limiting factors of technical and legal nature (extremely low prices ruling the sale of the energy surplus from private users to the PPC, small grid sizes, uncertainty in the degree of penetration due to the very autonomy of the local power stations and the load variations between summer and winter periods, luck of infrastructure, limiting legal framework e.t.c.), but people involved in wind energy in Greece are confident that despite all these difficulties wind energy will play a crucial role in the Greek energy system in the years to come.

* * *

WIND ENERGY AND WIND POWER AT OLYMPUS MOUNTAIN

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Our purpose of this study was to evaluate the wind power over a well-exposed summit of Olympus Mountain. In all wind sectors there are no trees or little vegetation at the summit, so the roughness factor Zo should be low in these quadrants. Winds measured by a cup counter anemometer for five summer periods, July to September, from 1968 to 1972, at Saint Antonios summit, situated at 2817 meters above sea level, gave a period mean wind speed of 7.76 m/sec, at 2 meters above the ground. The measured seasonal average speeds were 7.99(1968), 7.20(1970), 8.33(1971) and 8.01(1972). The means were computed from the sum of the individual values Vn. Then the Weibull probability density functions were calculated for the summer periods as well as the five observation times (0800, 1100, 1400, 1700 and 2000). The parameters k and C, the shape and scale factors, respectively, were well fitted with the available data. All the results are represented by Weibull curves, one for each period and each observation time. The survivor functions were also estimated. Finally, the wind power potential was estimated by mean of the power equation $P=0.5\ p\ A\ V^3$, where firstly the third power of the wind speed was used and secondly by mean of the theoretical wind speed resulting from the empirical formula: $V^3 = C^3 \times \Gamma(1+3/k)$.

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PPC'S CONTRIBUTION IN THE STANDARIZATION OF THE TECHNICAL SPECIFICATIONS FOR WIND TURBINES AND WIND PARKS

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PPC, in the frame of MIP-VALOREN programs has proceeded with the installations of 7 Wind Parks of a 20 MW total capacity at the islands of Andros, Euboia, Crete, Lesvos, Samos, Chios and Psara. The procedure followed in the realization of the project was the inquiry for the supply and the installation of the Wind Parks. Since the up-to-now experience proved that no well established technical specifications for wind turbines exist, new specifications, both for wind turbines as a machine and wind parks as a total project, had to be written. This was the task of a group of engineers working for the relevant section in PPC. The target was the composition of technical specifications that had taken into account of all requirements (trends, recommendations and standards) adapted to the Greek environmental conditions. The paper describes the most important points of the technical specifications, with emphasis to these points which were discussed during the implementation of the specifications in the inquiry and the realization of the project.

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SYNTHETIC GENERATION OF WIND SPEED TIME-SERIES FOR THE LOGISTIC MODELLING OF AUTONOMOUS DIESEL-WIND POWER SYSTEMS

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Public Power Corporation and National Technnical University of Athens have developed a logistic model in order to analyse the parallel operation of diesel generators and wind turbine generators in terms of power quality and fuel savings. One minute data has been used in order to study the influence of the wind and load fluctuations on system performance. An important problem met during the simulation was the lack of real time data recordings for the demand load and the wind speed. The model uses one-minute data as inputs but both wind and load are usually available only on an hourly basis. This means amines a special technique used for the construction of wind speed time-series with one-minute data. This technique utilizes statistical analysis, taking into account the mean hourly wind speed and the corresponding standard deviation. A normal distribution is considered for the wind speed in one hour basis and an autocorrelation factor is used. Finally, real wind speed measurements from Andros island are used for the validation of the method.

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AVAILABLE WIND POTENTIAL DETERMINATION IN THE ISLANDS OF CRETE, ANDROS, TINOS, MYCONOS AND SYROS

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PPC has announced a 150MW wind energy programme, to be implemented by the year 2000. The Greek islands, with the high wind potential they possess, are ideal candidates for wind utilization. Locating the areas where wind farms will be placed is a key issue for the future development of wind energy.
The paper presents the results obtained for the islands of Andros, Tinos, Myconos and Syros that will be interconnected with the mainland grid by the year 1994 and for Crete.
Each location was chosen based upon experimental and theoretical values of wind speed, from maps scaled 1:50000. The on site visits that followed helped to classify each place into one of three categories:

(A) sites of high priority since they meet most of the evaluation criteria

(B) sites that can only accomodate a small number of wind turbines. Experimental verification is needed to evaluate the potential of the site and they require high infrastructure cost:

(C) very high infrastructure costs are needed for the sites to become accessible, proximity to propulated areas or ancient monuments.

Assuming two different wind farm lay-outs and considering only sites in category A, the possible power installed in the five islands varies from 163.9 to 582.3 MW.

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PRELIMINARY DESIGN OF A WIND PARK

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Recently, a Wind Park Optimal design tool (WP-OPT) has been developed at NTUA, Fluids Section. The dominate phenomenon in wind parks is the "shading" due to the operation of the wind turbines in the wake of the upstream machines. The shading affects not only the energy production of the park by reducing the inflow of the machines, but also the lifetime of the machines as a result of the flow fluctuations within the wakes. Via an approximate version of a gradient method, WP-OPT code selects those positions within the site of interest that minimize the "shading". As input data are: (a) the wind rose and the topography of the site, (b) the power curve and the geometric characteristics of the wind turbine WT. The kernel part of WP-OPT is a simplified wake model (Simple WAKE). Based on the mixing theory of turbulent jets, this wake model provides in closed form the velocity field in the wake.
In the present paper the aforementioned numerical tool is applied to the case of a cluster consisted of 17 machines to be installed by the P.P.C. in the islands of Criti. The analysis focuses on two aspects of the design problem: (a) the optimal design of the lay-out of the park (i.e. the determination of the configuration that maximizes the power output), and (b) the estimation of the reliability of the installation.
The analysis is divided in two parts. In the first part, the lay-out of the park is prescribed. More specifically, the 17 wind turbines are arranged in either one or two rows. In order to better understand the effect of the shading, a parametric analysis is conducted with respect to the following parameters: (a) the spacing of the wind turbines in the rows, (b) the distance of the rows, (c) the orientation of the rows with respect to the principal wind direction, (d) the ambient turbulence intensity. The analysis shows that, according to the prescriptions set for the installation as regards the operational conditions or economic issues (e.g. annual energy production, land availability etc.), there is an optimal configuration of the wind park are determined by means of the WP-OPT code and the results are compared with those of the first part. Parameter in these calculations is the dimension of the region wherein the park is to be installed. The results show that in all cases the shading in the optimal designed parks is lower than that of the uniformly spaced configuration. This results in higher energy efficiency and longer lifetime.

* * *

REMOTE CONTROL AND DATA ACQUISITION FOR THE WIND ENERGY CONVERTERS OF GREEK TELECOMMUNICATIONS ORGANIZATION

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The control and data acquisition system of 3 Wind Generators (WG), sited in the islands Kea, Paros and Syros in the Telecommunication Stations of the Greek Telecommunications Organization. The system is built as follows:
In each site there is a controller attached to the WG. An IBM compatible computer (386) collects all pertinent meteorological and operational data and makes a preliminary analysis. This computer operates under a multitasking and multiuser operating system called UNIX. It communicates via data line, with a remote power monitoring and control system installed in the local Power Station of Public Power Corporation. A further communication is made via dial up lines, with computers installed in remote sites where data can be automatically transferred and analysed. A remote from these computers is also possible.

* * *

INSTALLATION OF WIND ENERGY CONVERTERS AT OTE RADIO TELECOMMUNICATION STATIONS ON THE ISLANDS OF KEA, PAROS & SYROS

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O.T.E. has installed wind-generators (W/G) at the radio telecommunication stations (R/T stations) on the islands of Kea, Paros and Syros, with a power of 60KW, 100KW and 100KW respectively.
Comments are provided upon the technical problems and limitations regarding the installation of the above W/G´s.
The way in which the problems were dealt with and the results from their initial operation are outlined, including a description of the installations. Predictions, as well as the actual cost and performance of the W/G´s are being given.

* * *

TARIFFS FOR THE PROVISION OF ELECTRICAL ENERGY TO CONSUMERS-PRODUCERS OWNERS OF WIND-GENERATORS

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The Electric Power Company (PPC) obliges the consumers of electrical energy produced by own wind-generators (W/G) to take reactive power from its network for the operation of the W/G´s, for safety reasons.
For the billing of the electric power consumed by the producer, DEI takes into account the mean power factor (cosφ).
Cosφ, however, is estimated wrongly, thus occasionally resulting in overpriced billing invoices.
This report analyzes the way in which cosφ is miscalculated, with examples taken from the operation of the W/G´s at OTE´s R/T Stations on the islands of Paros and Kea.

* * *

PROBABILISTIC LOAD FLOW IN DISTRIBUTION SYSTEMS CONTAINING DISPERSED WIND POWER GENERATION

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Systems which include energy production from renewable power sources require a probabilistic modeling of the generation and the demand. The generation from such sources normally follows the statistical nature of the atmospheric conditions and is therefore widely random.
From statistical data the wind velocity can be predicted for a specific day and time within the 24 hour cycle. The forecasted wind velocity is assume to follow the normal, Gaussian type distribution with an expected mean value V and standard deviation $\sigma v\%$. In order to evaluate the probability density function of the active power produced by the WTs, fp(Pw) when the probability density distribution of the wind is known, the fundamental theorem is applied. Thus, by dividing the interval in which the active power produced by the WT assumes values in N-2 intervals, the probability density function of Pw can be modelled as a discrete values. In addition, the corresponding N values for the reactive power consumed can be obtained, having the same as above probabilities, i.e. a linear dependence of the reactive from the active component of power is assumed.
The model developed is incorporated into the probabilistic load flow analysis program for radial distribution networks and can be used to provide power flows and voltage profiles at any time during the 24-hour cycle of a specific day and season including the effects of the voltage regulator at the feeder origin. Thus, the program can be used for short-term predictions of MV distribution feeder loadings, e.g. the peak loading of the current year can be obtained.
A typical three phase 20KV rural feeder is considered having a total length of 208Km and supplying 25 distribution substations of 25 to 500 KVA nominal capacity. Three types of loads and 14WTs of two types are connected at different nodes of the feeder. Typical wind speed data obtained from measurements in a Greek island are used. The results obtained show the advantages of the probabilistic approach in assisting the effects of substantial wind energy penetration on the operating performance of the distribution network and in assuring secure operation of the network in hourly operation planning.

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PERFORMANCE EVALUATION OF A 76KW WIND TURBINE IN NAXOS ISLAND

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A research programme titled "Integrated Energy System" has been conducted in the region of Egares-Galini of the island of Naxos. One of the main targets of the programme is the energy saving applications and the use of the renewable sources available in the region.
A wind turbine which consists of two generators of 65 kW and 11kW has been installed in this region. A data acquisition system has been used to measure the wind speed, wind direction and the energy produced by the two generators. Treated experimental results are presented in diagrams.
The load factor of small generator is very low and consequently its contribution to energy produced very poor. Finally the electricity produced is 209000 kWh for one year of operation.

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SMALL AND MEDIUM SIZE WIND TURBINE INSTALLATIONS. A PROMISING ENERGY SOLUTION FOR THE AEGEAN ARCHIPELAGO

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The economic viability of wind turbine installations at various characteristic sizes, which can be used to fulfil the energy requirements of several islands of the Aegean Archipelago, is investigated in the present work.
According to our previous work the investment pay-back period is strongly depending on the annual net energy output. Therefore the contribution of the mean power coefficient on the economic viability of small and medium size wind turbine installations is investigated.
In order to estimate realistically the mean power coefficient the experimental powercurves of selected advanced wind turbines, covering a wide range of nominal power, are combined with the measured wind potential data of three regions of the Aegean Archipelago.
Accordingly, the wind potential data are analyzed and the corresponding Weibull function is defined for each region. Comparison between the calculated energy production using the experimental wind speed data and the corresponding Weibull distribution is presented. The possibility to ameliorate the agreement of these two values is also demonstrated.
Subsequently, the influence of the exact value of the equivalent cost of the replaced conventional energy on the predicted pay-back period is examined. Typical cases concerning self-utilization of the produced energy, small enterprises which sold the remaining surplus energy to the national grid or even private investors interested in getting into the electric energy commercial are examined. Finally, a sensitivity analysis is carried out.
For all the test cases examined here, the pay-back period is less than four years. Since these regions are not only regions of the Aegean Archipelago with significant wind potential, it is necessary to encourage the application of small and medium size wind turbine installations as one of the most promising solutions for the energy requirements of the greek islands.

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A COMPLETE METHOD FOR THE CALCULATION OF THE ECONOMIC VIABILITY OF WIND TURBINE INSTALLATIONS

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The economic viability of wind turbine installations which can be used to fulfil the energy requirements of several islands of the Aegean Archipelago is investigated in the present work.
To demonstrate that the wind turbine installations can be economical viable, a complete form of cost-benefit analysis is applied based on the concept of the pay-back period, properly adopted for the Greek socio-economic enviroment.
For this purpose, an extensive analysis is carried out in order to investigate the impact of the capital cost., the inflation, the fuel escalation, the equivalent cost of the replaced conventional energy and the fixed and variable maintenance and operation cost on the pay-back period of the investment under consideration.
Accordingly, the influence of the size and the operational characteristics of any proposed wind turbine along with the influence of the local wind potential parameters on the economic viability of the complete wind turbine installation is clarified.
The resulting analysis, including an improved wind turbine price-power correlation for the Greek market, proves that the pay-back period is strongly depending on various factors like the capital cost, the fuel escalation, the technological status and the quality of the local wind potential. The numerical results being very promising, especially for the Greek islands, underline the need of an appropriate national competitive strategy in the area of the wind power applications.

* * *

TECHNOECONOMIC EVALUATION OF A 1500 KW WIND FARM IN LESVOS

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This work presents the results obtained by a team of students participating in a seminar, organized by ELKEPA, on wind energy. The purpose was to evaluate where an application of wind implementation in Lesvos was a sound economic investment or not.

- wind data of the area has shown a rich wind resource
- a 250KW wind turbine was selected meeting current engineering criteria
- energy calculations show an annual production per turbine of the order of 1,179,000KWh
- with a total cost per KW of 1564$ all economic indices show favourable numbers
- benefit to Cost ratio = 1,19

The results show that wind energy is a viable solution and must be used in the island of Lesvos.

* * *

OPTIMUM PENETRATION OF WIND ENERGY IN SMALL AUTONOMOUS POWER SYSTEMS

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This paper presents a method for evaluating the optimum penetration and the cost of wind energy in small autonomous systems with diesel generators as conventional energy sources. The conditions and constrains imposed on the operation of wind-diesel energy systems are technical, economical and mainly operational for diesel generators, and may be grouped as follows:

1. Grid voltage and frequency fluctuation should not exceed low and upper limits.
2. The transient behaviour of wind turbine generators (WTG), should not lead to harmful situations on diesel generators
3. During WTGs operation the commitment of diesel generators should be independent from the number of connected WTGs to the grid.
4. Diesel generators should operate between low and upper power limits.
5. The operational cost of diesel generators should not exceed a maximum, otherwise some or all the WTGs that are connected to the grid should be disconnected.

The developed method has been tested for various small autonomous power systems, which are typical in many Greek islands, under various load and wind conditions. Time series for wind speed were derived with the implementation of a simulation algorithm that uses random number generation techniques. Also various WTG combinations were examined.

An example of obtaining the optimum wind penetration to the power system of islands Kea is presented.

The results presented show that:

- The wind energy penetration depends on the size of the installed WTGs, i.e. an 100 KW WTG may permit a greater penetration than a 300 KW WTG.
- There is an optimum combination of installed WTGs that gives maximum penetration and minimum installation and operation cost.
- The penetration that occurs is different if the constraints 3,4,5 are not taken into account.

* * *

METEOROLOGICAL AND FUNCTIONAL DATA OF WIND TURBINES OF THE GREEK TELECOMMUNICATIONS ORGANIZATION IN KEA, PAROS AND SYROS

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This paper reports on measurements in steady state condition on three Windturbines with fixed pitch, in Kea (60KW), Paros (100KW) and Syros (100KW). The measuring period covers one year from 20th April 91 to 20th April 92. Data acquisition and evaluation is done with special devices and software developed in this project and standards are used as proposed by European Windturbines Laboratories Ris, Peten e.t.c.
The WT output was in Kea 147.000, in Paros 213.400 and in Syros 261.000KWh. The estimated energy which was not exploited because of deficiencies or errors was in Kea 2.700, in Paros 43.400 and in Syros 17.600KWh. The relatively high availability was also due to the remote sensing and monitoring of the installations. The annual average wind velocities were in Kea 6.5, in Syros 7.3 and in Paros 9.1m/sec.

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TRANSIENT STATE MEASUREMENTS IN WIND TURBINES

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The measurements of a number of mechanical and electric properties of wind turbined during starting and shut-down periods were analysed. The energy exchanged between the wind, the rotating mass and the electric grid were also studied. Self-excitation phenomena were also studied by deliberate cuting off of the wind turbine. The electric currents during shut-down period were observed to be higher than the respective starting up ones. The high values of the self-excitation electric currents require the employment of compensation capacitors.

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COMPERATIVE STUDY OF WIND TURBINE POWER REGULATION POLICIES

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Wind Energy became very attractive for electricity generation, especially during the last two decades. The interest derives both from the energy crisis of the 70's and the recent problems in nuclear plants, when it became obvious that energy generation using conventional fuel is not always economical and safe.
The trend in the field of wind energy is nowadays mainly focused on the development of larger wind turbines. The design features such as the 3-blade upwine rotor, the horizontal axis and the rigid tower seem to be the background for this research and development.
Wind turbines require a careful study and design before their way into market acceptance. Wind is from its nature stohastic is behaviour. Therefore, the power output of a a wind turbine presents a significant variation, following the changes in wind speed.
Wind power regulation of wind turbines is an interesting subject for study. Nowadays, several techniques have been developed and applied to commercial machines, showing very satisfactory results and supplying the local grid with acceptable power quality.
The aim of this paper is to present a comparative study of the prevailing options for wind turbine power regulation. The interest is mainly focused on the stall and pitch regulation, which are the actual methods for the control of commercial size machines. Their design features are described and the results of their application to wind turbines are given and discussed in detail.

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A HORIZONTAL SHAFT VARIABLE SPEED WIND GENERATOR OF SKYROS ISLAND

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The Horizontal shaft Wind Generator (W/G) named OA/100KW, is a 3/fixed type blade Rotor, with 175KW 3/phase 50HzAC squirel Cage Generator and is installed in the Island of Skyros, Greece, from last November 1991. From then on it is connected to the electric grid of the island and it is under preliminary tests.
The unit is designed in the Lab. of Aerodynamics of the NTUA during the years 1985-87 and it is manufactured in a Greek factory at 1991. Its main a hydraulic low speed disk brake, a planetary 1:26 speed ratio 2/stage gear box, an electric high speed disk brake and the generator. This major mechanical system is housed in a nacelle, the yawing of which is achieved by an electric motor acting on a 1000:1 reduction year. The nacelle is fixed on the crane type ball bearing with internal toothing for its rotation, which sits on the top of a steel tower. The 24m high cylindrical tower has a botton 2m dia., an intermediate part 1.2m dia, and the last part 1m dia., 10m height.
The innovation in the design of this unit is that it can work with variable speed according to the wind conditions, by means of an Inverter placed, electrically, between the electric net of the island and the generator. It is therefore possible to change the frequency of the current of the generator and so to change its speed. The frequency apperture is extended from 5,5Hz for low starting current, to 50Hz (1500 RPM synchronous). This operation is achieved by a Programmable Logic Controller (PLC) which, acting on the inverter controlls the frequency of the system, so to run with variable speed according to the wind conditions and to the abilities of the generator to absorbe the related torque or power of the rotor, each time, corresponding to these wind conditions.
The programable logic controller, acts as a real "very capable human operator" who is able to regulate the speed of the unit on starting with 5,5Hz, during working conditions from about 18 to 50Hz monitoring the best possible efficiencies and stop the unit for wind velocities either under 4m/sec. or over 22m/sec. Also, to prevent any over-torque and therefore over-current load at the inverter and the generator, by a on time reduction of the speed. The max power to the electric net is about 140KW.
Working on preliminary test until now, we try to select a suitable program for our PLC and to fix the parameters for an efficient and safe operation of the unit.
In the same place we have to install a second wind generator the KA/100KW of vertical shaft, Darrieus type, of about the same size, which is designed from the same staff of engineers and is now under construction in the same factory in Greece.

* * *

FEASIBILITY STUDY OF THE INSTALLATION OF A SMALL HYDROPOWER IN THE MAIN DRINKING WATER SUPPLY PIPE OF MESOROPI VILLAGE

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The village of Mesoropi is located at an altitude of 375m on the mountain of Pagueo. A new supply pipe, 1000m long will transmit potable water from a fountain, located at an altitude of 625m to the village of Mesoropi.
The annual average discharge of the fountain is about 31liters/s and the variation of the discharge is from 10 to so liters/s.
The basic objective of this paper is to examine the economic and technical feasibility of exploiting the excess potential energy in main water pipes; this excess energy is usually dissipated by installing energy dissipation devices along the main water pipe.
It is clear that the design of the main water supply pipe from the fountain to the village must take into account the new objective i.e. the diameter of the pipe should be large enough, not only to carry the discharge, but also to give small friction losses. It is also clear that a very large diameter is very expensive, and therefore an analysis is needed to estimate the proper diameter which maximizes the economics of the installation.
We advocate that the harnessing of the excess potential energy in this project (and in other similar projects) can be attractive with proper design i.e. by minimizing the civil engineering works.
For our case study, we found that a pipe of 20cm, a Pelton turbine 80KW and an asychronous generator (total cost 20million drachmas) is a reasonable design.
We estimated that annually will be produced 400.000KWh of energy.

* * *

DESIGN OF AN "S" TYPE MODEL WATER TURBINE

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Axial flow turbines are best suited for the exploitation of low head hydraulic potential. Especially for the case of small hydroelectric plants, of nominal power up to 10MW, the tubular turbine has many advantages technical and economical. Its main feature is the nearly straight passage from the turbine intake to the draft tube outlet. The straight water passage gives good hydraulic efficiencies and a high discharge volume.
Such a model of tube turbine was designed and is already constructed by the L.H.T.M. of N.T.U.A. Its best efficiency operation point is the following:
Head H=16.8m, Flow Rate Q=18.75m^3/sec, speed of Rotation n=300r.p.m., which is the nominal operation point of Stratos II Small Hydroelectric Plant, for comparison with its operation curves. According to F.Schwinger and J.Gregory (In.Water Power and Dam Construction, Sept. 1988), the external runner diameter is Do=1.9m, although for the model it is Doe=0.35m, according to the international standards of modelling. Using the similarity laws the model's best efficiency point of the model must be: Head H=12.412m, Flow Rate Q=1969.03m^3/sec, Speed of Rotation n=1400r.p.m.
After the completion of the design of the meridional (hydraulic) profile, of the turbine, the code GL3D was applied for the numerical solution of the meridional flow. The results of the numerical solution used for the design of the runner blades according the "one dimensional" flow method, which is based on the cascade theory.
The model is equipped with adjustable runner blades and wicket gates for optimum annual output and it is consisted of the following main parts: intake, wicket gates mechanism, runner, discharge ring and draft tube and shaft with sealing and bearing. The intake part and the draft tube are welded constructions. The wicket gate which is forged bronze material is provided with bearings at both ends. The runner consists of the hub and the blades which are made of cast of bronze.

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PRESENT STATE OF SMALL HYDROELECTRIC POWER PLANTS IN THE WORLD AND IN GREECE

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The rational management of the hydraulic potential and its use for energy production has emerged as a significant regulator for the development of a community. Hydroelectric exploitation of surface waters is usually persued in close consideration of other usages of waters, such as irrigation and water supply. Small hydro plants have been globally proved to be reliable and competitive to other conventional sources of energy, while being rather imperior to other renewable energy sources. The hydraulic potential of Greece is quite considerable and most of it is still running to the seas unexpected, when local fossil fuels are depleted and oil imports are constantly draining the national economy.
The present state of small hydroelectric plants is presented in this paper. Both international trends and the greek development are addressed, with a particular interest for the southern countries, where most small hydro plants are found.

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SMALL HYDROELECTRIC AND AEOLIC PLANTS: A COMMON APPROACH OF CINETIC ENERGY CONVERSION

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Hydraulic and aeolic energy found an early application for energy production through the evolution of the human race. Despite the differences in the present technology for wind and hydro turbines, the flow field of the respective working fluids may be studied in a similar manner. The similarities of the exploitation of the cinetic energy of the water and the wind by employing the same type of turbine with different dimensions are analysed in the present work. The influence of the density difference of the two fluids on the choice of the overall dimensions are examined for two cases: Darrieus, Savonious, propeler. Useful conclusions are drawn from a comparative examination.

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GEOTHERMAL ENERGY, ITS ORIGINS, ITS USE IN EUROPE AND THE ROLE OF THE EUROPEAN COMMISSION IN ITS DEVEOPMENT

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Directorate General XII of the European Communities has been stimulating the research in Geothermal Energy since 1975. The principles of the extraction of Geothermal Energy and a brief description of the research activities (including the geothermal field of Milos) and their main results are presented.

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HEATING-COOLING OF BUILDINGS WITH SHALLOW GEOTHERMAL ENERGY IN GREECE

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The heating and cooling demands of buildings in Greece can be profitably covered with the thermal energy contained in the 20-150m deep ground waters or rock strata underneath of adjacent to the building. For this purpose respectively underwater pumps or vertical earth heat probes in boreholes can be used in conjunction with heat pumps to transport the low temperature ground energy and transform it to a heating and cooling energy appropriate to the building's demands. Part of the thermal energy of the upper ground zone is heat of solar origin stored in the ground waters and rocks. The profitable exploitation of the shallow thermal energy with the mentioned systems in central Europe, where the shallow earth temperature range from 8 to 12 C, makes sure, that in Greece, where the corresponding temperatures reach 16 to 22 C, these systems will work even more efficiently. But except these higher shallow earth temperatures, also the energy demands of the buildings under greek climatic conditions favor a higher efficiency. Namely, the lower heating demands, as well as the alternating heating and cooling processes needed for the buildings in Greece are not expected to produce any unpleasant disturbances in the natural thermal conditions of the ground, as can be the case in which, therefore, through the earth heat based heating systems may cause serious ground temperature distrurbances with impacts on the vegetation growth. Temperature measurments in shallow ground waters and rocks of the Attica region have given favourable values of 19-22 C. In Agios Dimitrios of Koropi a 60m deep vertical earth heat probe has been recently installed and connected with a heat pump for heating and cooling of a new house. In the borehole and at intervals of 15m 5 temperature feelers have been incorporated. They will serve for studying the installation's operation. The results together with results from measurements of the operational parameters of the system will be used to study the thermal behaviour of the ground and of the vertical earth heat probe during the heating and cooling periods.

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QUALITATIVE AND QUANTITATIVE ANALYSIS OF THE TWO PHASES FROM SIX PRODUCTION WELLS IN THE GEOTHERMAL FIELD OF N.KESSANI

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The present work deals with analyses of samples and measurement of flow rate of both phases, which separate from six geothermal production wells in N.Kessani, Xanthi. Five of them gave fluids with temperature above 70 C ("hot wells"), while the temperature of the fluid from the sixth "cold" well was 38 C. A special phase separation unit was designed and constructed to facilitate flow rate measurements and the collection of representative samples. The unit consists of the main separator, the condenser, the condensate separator and the flow meters for the gas (orifice system) and the liquid stream (turbine meter). The gases were collected from the exit section of the unit in special plastic bags (Aldrich) or in stainless steel sample vessels. The gases were analyzed by gas chromatography and several columns were employed for the separation of gases. The main constituent of all gases was CO_2 (almost 99% vol.). N_2 (~1%) and CH_4 (0.04%) were also measured in all samples. The H_2S content, which was monitored by a DRAEGER H_2S ECOLYZER detector was less than 10ppmv in the non-condensable gases of the cold wells. No H_2S was detected in the gases from the cold well. The TDS of all liquids varied from 4.5g/dm^3 to 4.8g/dm^3 and their pH was about 7. The ratio of gas (non-condensable) to liquid volume flow rate varied from 1.5 to 1.65 for the five cold wells (1.2 for the cold well), and remained constant under changes of the liquid flow rate.

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SOFTWARE FOR TECHNICAL AND ECONOMIC ASSESSMENT OF LOW ENTHALPY GEOTHERMAL ENERGY APPLICATIONS

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New software is proposed for the economic evaluation of various potential applications of low enthalpy (T<90 C) geothermal fluids. Input data include temperature, flow rate of geothermal fluid, distance between wellhead and area of fluid utilization, well depth, year the utilization starts price of conventional energy source (petroleum) and of electrical energy (KWh). Three applications are covered by this software; i.e. domestic heating of communities, space cooling and drying of agricultural products. The climatic conditions (two options,) the area covered by a community, the quality of agricultural products (e.g. corn) and the available liquid flow rate are significant parameters in the calculations. To obtain the total annual expenses for each application, preliminary calculations are carried out, including equipment cost estimation, and determination of total investment. Finally, the difference in total annual expenses is computed, when geothermal fluids and conventional energy sources are used.
For each application the required (optimum) geothermal fluid flow rate is obtained. To fully utilize the available geothermal field (or well) capacity, more than one parallel applications may be considered. Thus, expenses related to field development and exploitation are distributed to all applications proportionately. Indicative calculations with the new software provide very encouraging results for the economic success of the aforementioned three applications.
The software is written in MS Basic, Advanced Development System v.7.0 for DOS TM. It is user friendly and quite efficient. Furthermore, it can be easily expanded (in modular fashion) by adding more applications and can be convenienty adapted to the needs of technical/economic optimization calculations.

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SEPARATION OF NON-CONDENSABLES FROM GEOTHERMAL STEAM BY DIRECT-CONTACT CONDENSERS

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Upstream separation of non-condensables (mainly CO^2 and H^2S) from geothermal steam is generally considered a viable H^2S abatement option which, additionally, mitigates turbine corrosion and scaling problems and improves thermodynamic efficiency. High-pressure steam reboilers have been proposed in the literature as suitable for this task. In particular, devices based on direct contact of steam with recycled condensate combine a lower capital investment with very high transfer coefficients.
In this work, a detailed computational procedure for the design of such condensers is presented and results for a typical steam supply are obtained. The main results concern the size of the device and the extent of non-condensables dissolution in the condensate. This last quality is of paramount importance because, once dissolved, non-condensables re-appear in the evaporated steam.
Design parameters whose influence is investigated are the operating pressure and the percent of steam vented with the gases. The outcome of the simulations indicates that higher operating pressure leads to smaller condenser volume. The percent of non-condensables dissolved in the condensate is shown, at first, to decrease very fast with increasing pressure and then to reach a plateau value (~5% for 0.95 condensation efficiency), which remains practically constant at higher pressures. Increasing the vent rate leads to a shorter condenser and, more important, significantly reduces the amount of non-condensables dissolved in the condensate.

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ORGANISATION AND MANAGEMENT PROBLEMS IN THE DEVELOPMENT AND EXPLOITATION OF GEOTHERMAL RESOURCES

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Appropriate organization and management is essential for the development and optimum exploitation of geothermal resources. In order to decide on the proper organisational scheme, several aspects and requirement should be taken into consideration such as the technical difficulties, the high risk of the enterprise and the attitude of the local population.
The various activities associated with the development and exploitation of a geothermal field can be grouped into four categories with distinct characteristics:

(a) Geothermal research, which includes activities associated with the location and assessment of the geothermal field. Although, these activities will have to be controlled and financed by the state to support its policy for the development of national resources, technical services and advice can be rendered by contract to the enterprises responsible for the development and exploitation of the field.

(b) Geothermal field development, which includes activities such as feasibility studies, designing, financing and supervising the construction of the installation, technical assistance to the users, trouble-shooting, research and development etc. The diversity and complexity of these activities require an enterprise with sound technical and administrative capabilities. It is considered that a national company owned by the state but self sustained financially is best suited in this case.

(c) Geothermal field exploitation, includes activities related to the production and distribution of geothermal fluids. Since each field is exploited mainly for local use, an independent local company can be created as a joint venture of the l local authorities and the national development company described above.

(d) Use of geothermal fluids. The fluids are used as an energy source in various applications (in homes, industrial, agricultural or other uses). The users are the "clients" of the company responsible for the exploitation of the geothermal field.

All the above enterprises should operate under the rules of a free market economy with clear financial agreements between them. While social and environmental impact or national policies should be taking into consideration in decision making, sound economic analysis and competitive pricing is essential to ensure the financing and viability of geothermal energy exploitation.

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DESIGNING THE INTEGRATED EXPLOITATION OF LOW ENTHALPY GEOTHERMAL FIELDS: BASIC TECHNOLOGICAL AND ECONOMIC PROBLEMS

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The effective exploitation of low enthalpy geothermal fields, a considerable natural energy source in Greece, should be based on the application of a unique, intergrated development programme.
The fundamental technological problems encountered, which drastically influence the exploitation economics and are finally elucidated in the technoeconomical feasibility study may be classified into four categories:

1. Scaling and Corrosion
2. Enviromental aspects
3. Selection of uses
4. Design & optimization of the geothermal plant network

Following a specified research procedure for N.Kessani's geothermal field, under the most advanced development programme applied in Greece by the Hellenic Bank of Industrial Development (ETBA), the above problems were studied and specific proposals are brought to realization.
Scaling and Corrosion problem is approached through the thermodynamic analysis of the fluids, the calculation of their physicochemical trends and the selection & design of the best antiscalent-anticorrosive protection method. N.Kessani's fluids are characterized by their high supersaturation factors of $CaCO_3$ (calcite) leading to severe and exclusive carbonate deposits. A chemical inhibitor injection system was studied, installed and tested succesfully.
Enviromental protection is mainly focused on the selection of technoeconomically optimal method for the management and disposal of liquid gaseous geothermal waste. For the rich biotic enviroment of N.Kessani area, reinjection proved the safest disposal method. The economically best application scheme was then designed.
Selection of uses, among all applicable in each field, is based on a complicated evaluation procedure. Levelling of selection criteria in the case of N.Kessani has lead to the development and study of investment plans referring to intensive agriculture plants, innovative greenhouse culture plants and a corn drying geothermal plant.
The design and optimization of the geothermal plant network are implemented, depending on the managerial status of the field, through multi-criteria or probability based methods. The application of the latter resulted to the selection of the optimal network and the development of the best scenario for the integrated exploitation of N.Kessani geothermal field.

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MAPPING GEOTHERMAL ANOMALIES WITH THE MAGNETOTELLYRIC METHOD

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Geophysical mapping of areas which show anomalously high geothermal gradient (geothermal fields) is succeeded by studying the physical properties of the earth. This process enables to undertake the mechanism of formation of such anomalies and make inferences for the geothermal reservoir. A characteristic property of rocks is the electrical resestivity measured in Ohm.m. Electrical resestivity is temperature dependant and therefore very important in areas of geothermal interest. Among a wide variety if geophysical techniques which are used for the subsurface electrical resestivity determination, are these known as electromagnetic induction methods. In the present work the method called magnetotellyric (MT) is particularly examined. The basic theory and instrumentation are described in brief. The magntotellyric study of the high enthalpy geothermal field of Milos island, Greece (geothermal fluid temperature 320 C at 0.8-1 km depth) is given as example. On Milos, MT measurements were carried out in the period range 10^{-2}-10^{+2} s of the natural electromagnetic spectrum using a network of 37 stations (Hutton et al., 1989; Galanopoulos et al., 1991).The Milos geophysical study is already completed within the 3rd EEC Geothermal Programme (1986-1988) and a geothermal model has already been prepared by Fytikas et al. (1989) with important contribution of the MT results (Beauce et al., 1989; Haak et al.,1989; Hutton et al., 1989). Characteristic results are shown for Zefiria region and in particular - (a) map of pseudo-two dimensional variation of electrical resistivity for 1km depth - (b) one dimensional section of electrical resistivity. Calculations were made by using the Niblett-Bostick one dimensional transformation. The results are compared with data related to a geothermal gradient map and the stratigraphy of test borehole M2. The area and shpe of the region which shows very low resistivities (smaller than 4 Ohm.m) coincide with those of the high thermal gradient region (greater than 8 C/10m). The efficiency of the MT method to map geothermal anomalies is compared with those of the D.C Resistivity method by considering technical specifications and research costs. It is concluded that the MT method is faster in fieldwork, it has lower fieldwork expenses, but its relative instrumentation is very expensive compared to that one of the D.C Resistivity method.

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GREENHOUSE HEATING AND WATER SUPPLY FOR IRRIGATION BY GEOSTILL

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A device, named a geostill, was fabricated and tested for supplying greenhouse heating and pure water for irrigation, from salty geothermal water. The geostill (fig.1) consists of a gutter with a central and two side channels made from fibre glass and a wire frame stand that supports a cover of polyethylene sheet. It is placed on the ground (prepared with a slope of 1.5%), between the rows of the plants (practically every second row) in the greenhouse. The geothermal water is pumped inat the inlet of the central channel and moves by gravity through the central channel to the outlet. Water is evaporated from the free surface of the geothermal water and condenses on the inside surface of the plastic film (cover of the geostill) because of its lower temperature. The condensed water runs down directly into the side fibreglass channels and is collected at the end. The installation of this system does not damage the plants and it is removable to allow access to the soil for soil tillage and soil sterilisation.
A thermal analysis for the geostill is presented and was tested experimentally, using geothermal water of different temperatures between 20 C and 68 C. A computer model was derived for calculation of water and heat yield of the geostill.
Good agreement was found between theoretical results derived from the proposed model and experimental observation. It is concluded that the geostill makes a useful contribution to greenhouse heating and pure water production. For a layout of 0.5m of geostill per m^2 of greenhouse floor area and using geothermal water of 60 C and mean greenhouse air temperature of 10 C, geostill transfers heat of 135W per m^2 of greenhouse and during a 12h night, yields 1.2kg water per m^2 of greenhouse.

* * *

ECONOMICAL ANALYSIS OF GEOTHERMAL DISTRICT HEATING SYSTEMS

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Geothermal district heating systems have significant advantages, when development and energy saving are only considered. However, through a convenient specification of the project, they may present attractive economical results as well. Apart from the technical specifications, financial and managerial solutions should also be defined. Within this frame, the ways to cover the initial investment, the selection of the managing agent, the economical contribution of the users and the contracts among the agent and the users should be conveniently decided.
A model elaborating integrated economical analysis could supply with relevant guidelines for the above aspects. Such a model should enbody economical parameters effecting the system and moreover should have the possibility to investigate total and energy inflation in the way the effect the contracts between the agent and the users, and examine the results of a stagial connection of the users. Although market studies consist a prerequisite for secure estimations, effect of marketing should not be ignored, since it could accelerate and increase the number of connected users.
In order to investigate the profitability of geothermal destrict heating systems in Greece, the authors developed a model for economical analysis and another one model for designing and optimizing geothermal district heating systems, to supply with data the first one. The above models were confirmed, compared to relevant published results. Even for the least favour case of Nea Apollonia geothermal field (perfecture of Thessaloniki), where the temperature of the fluids is only 48 C and the heating load too dense (420 houses/km^2), encouraging results arised.

A flow rate of 100m^3/h is sufficient to supply 63% of the settlement, if heat pump and a back-up boiler were used. At this case, geothermal energy serves 85% of the annual heating load saving 810 TOE. The necessary investment is 840.000 ECU. If a discount rate of 40% is applied, the agent and the users succeed a depreciation period of 7 years. If only 60% of the restricted region will be connected to the network, then geothermal energy still remains 20% cheaper than conventional ones at the consumption sites.
For a 2% real inflation of energy prices, a 35% debt with 3% interest and a 25% subsidy, the above mentioned 60% of the users should be connected within the first three years of operation, in order the agent to depreciate its investment within 11 years. In this case, users succeed a 6,5 years depreciation period.

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LOW ENTHALPY GEOTHERMAL ENERGY IN THE REGION OF MAGANA - NEW ERASMIO OF XANTHI. APPLICATION OF GEOTHERMAL FLUIDS IN THE ASPARANGUS CULTIVATION

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In the region west of Magana, Xanthi and around N.Erasmio village, an interesting geothermal area 16-20Km^2 was located, where the suitable geological and stratigraphic conditions have allowed the creation of a geothermal anomaly and the establishment of a hydrothermlal system of low enthalpy with the accumulation of hydrothermal fluids in Pliocene sandy sediments and in the base of the sedimentary series in combination with the intensively fractured gneissic and granitic basement. The, up to now, evaluation of exploration boreholes shows that geothermal fluids with temperatures ranging between 40 C and 70 C exist in water-bearing formations lying in depths of 200 to 400m.
It is well known that geothermal energy has direct applications in greenhouse heating, in drying of agricultural products and in fish ponds.
Having in mind that hte asparagus cultivation has began in the area, a very significant product for foreign exchange input, we tried for the first time in experimental plants heating of these plantations with target the early crop and selling with high prices in the European market.
The experimental data from the application of geothermal energy of the area are very encouraging for the installation of model plantations and the application of the use of low enthalpy geothermal energy in this significant cultivation for exchange input.
In this paper the experimental data resulted from the application of the use of geothermal energy in the in-floor heating of asparagus saddles are presented in addition to the geological - geothermic features of this new geothermal field.

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EXPLOITATION POTENTIAL OF GEOTHERMAL FLUIDS IN MITITLINI

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Preliminary research has shown the significant potential of geothermal energy in Mitilini. Temperatures of up to 36 C were observed during small depth drilling. According to the geochemical estimations temperatures of up to 60 C are expected in increased depths. The above geothermal field being in the outskirts of the Mitilini town, i.e. 500-1500m, are of great importance for thermal exploitation, since a number of applications may be materialized, e.g. space heating of part of the town (preferable large and public buildings) swimming pool heating, greenhouse and fishery heating e.t.c.

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BIOMASS PRODUCTION OF POPLAR CLONES PLANTATIONS (MIXED OR PURE) WITH ROTATION TIME 2 YEARS

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Seven poplar clones were planted in monoclonal plots and in mixture following honeycomb design, with distance 1m. and rotation time 2 years.
The results obtained after three successive harvesting cycles appear in diagramms 1 and 2. It comes out, that biomass production of the mixed plantation in superior to the pure one, reaching to about 30% in the second harvest from sprouts.
The clones reacted differently to the intragenotypic competition as well as to intergenotypic. In the last one the clones can be classified in three categories: good competitors (R-440, R-75, He-X/3) neutral (I-214, He-X/10, R-266) and week competitors (I-262).
The question is whether the three best competitors, with high yield will express overcompensation or not in future mixed plantations.

* * *

BIOMASS: POSSIBILITIES IN THE GREEK AREA

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Biomass as well as other mild energy forms, are sufficient in Greece and there are enough possibilities for making it productive. We can find biomass everywhere, in the gardens, in the fields, on the mountains. The inhabitants since their existence used the biomass to get warm, for food preparation and for washing, in such a way that they wasted too much biomass, because its greater part was lost. And it is obvious that by this way the biomass was spent much more. Anyway, in this period there was no other combustible material.
But with the evolution of the society, discovering other combustibles, the biomass remained more unexploitable. And we meet its very big part in the forests. In the last years they take one part of the lumber especially the firewood and the more biomass remains on the mountains and there rots. And even worse, the probability for conflagration increases. If we make productive this biomass in the scientific way, as noted in my report and if the system of cutting wood changes, there is a possibility for resolving a great part of the energy problem in Greece.
This phenomenon is proven by the calculations presented in the report.

* * *

HYDRODYNAMICS IN A CIRCULATING FLUIDIZED BED REACTOR FOR THE FLASH PYROLYSIS OF BIOMASS

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In order to study the hydrodynamics in a circulating fluidized bed reactor system, which was designed to maximized liquid yields from flash pyrolysis of biomass, a cold model of similar dimensions was designed, constructed and tested. This model comprises a circulation loop, in which the solids are being transferred between two vessels by means of aeration via a non-mechanical valve (L-Valve). Due to the fast that the obtained results must be used in a hot reactor, the present study is focused on the influence of the different operating parameters such as solids inventory, fluidizing gas flowrate and aeration gas flowrate exert on solids circulation rate and voidage profile. It was proven that for a given solids inventory and fluidizing gas flowrate, the aeration gas flowrate exclusively determines both solids circulation rate and voidage profile along the riser. The variation of solids circulation rate, does not influence the quantity of thermal production by the combustion of char produced by pyrolysis, because the feeding of biomass is constant. However, this variation influences the quantity of energy given to the biomass in the riser section, in order to carry out biomass devolatilization and consequently, it leads the reaction to more or less production of liquid or gases products.

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THE AGRICULTURAL WASTES AS FUEL (RDF). THE UNIT OF LIME PRODUCTION IN TRIKALA

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This research concerns the implementation of the agricultural wastes and byproducts use as combustibles for lime production. The unit was constructed at Petroto Trikala and had used the wastes of cotton, almonds, peels, sawdust e.t.c.
The plan is composed by 4 units:

a) the lime cutting
b) the agricultural wastes elaboration (drying up, cutting)
c) the lime combustion and production
d) the treatment system of dust and gas

During the experimental process, the unit had certain problems as: the creation of compact masse at the main combustion source and the firebricks erosion. The main reason of those problems was the inaccurate control of the temperature at the main source. The consequence was the dust and the limestone admixtures to be melt.
The limekiln function is described as succesful since it has substituted the agricultural wastes for the classic combustible mazout. During the agricultural wastes use no problem showed up either at the lime quality or at the enviroment because the limeklin itself acts as a dry cleaning system of gas. In that way we manage to save energy (we succeed in the saving of energy) and on the other hand we protect the enviroment of a possible uncotrolled agricultural wastes rejection.

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THE ENERGY POTENTIAL OF THE WASTES OF CATTLE FARMS IN THE AREA OF CHANIA

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In the area of Chania-Kreta there are few cattle-farms for cows, porks and poultry. The wastes from these farms can be processed either aerobically of anaerobically. In the case of anaerobic treatment biogas is produced which can be used for energy production.

There are 8 cow-farms and the energy potential of the wastes is $4.8 * 10^8$Kcal/year

18 pork-farms where the energy potential of the wastes is $7 * 10^8$kcal/year and 12

poultry-farms where the energy potential of the wastes is $3.08 * 10^9$Kcal/year.

The total volume of all the wastes from the cattle-farms in Chania is $43m^3$/day and the total energy potential is 426 T.E.O./year, only a small percentage of the energy potential of these wastes in Greece.

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THE ENERGY POTENTIAL OF BIOMASS IN CRETA

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Renewable energy sources are going to play an important role in the near future. Among these sources biomass can be used easily for the production of electricity or heat in various places in Greece.
In Creta there is a lot of biomass as byproduct of agriculture, or in forest areas. There is also available inurban or other wastes.
Energy can be produced from the biomass by different ways.

1. By burning
2. By pyrolysis
3. By fermentation
4. By hydrolysis

If we consider the biomass in Creta there is a lot from the forests (742.000 tn/year) and from the olive trees (368.854 tn/year) as well as from other sources.
The biomass can be used either for the production of heat by burning it in small quantities or by pyrolysis (biogas + oil + solid material).
The total energy that can be produced by burning the biomass in Creta 5.17 * 10^{11}kcal/year.
Energy can also be produced from biomass in Creta if some areas will be cultivated with trees that can be used for alcohol production.
Finally, some efforts for the production of biogas from the wastes of the olive oil processing plants in Creta did not obtain good results.

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UTILIZATION OF PROCESSED URBAN WASTES FOR THE IRRIGATION OF ENERGY CROPS, THE CASE OF CHANIA

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The biologically treated urban wastes of a seaside city can either be sent in the sea or can be used for the irrigation of a cultivated land. If there is available uncultivated land and energy crop can be developed and irregated. The biomass that is produced can be used for energy production. In the case of Chania-Creta, the processed wastes can be used for the irrigation of uncultivated land that is nearby the biological treatment plant.
It is estimated that 750 acres of land can be irrigated from the processed wastes of Chania and the production of biomass depends on the plants that will be cultivated. The energy that could be produced from the biomass is more than ten times higher from the energy that is consumed during the operation of the biological treatment plant of the city.

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CREATION OF ENERGY CROPS IN CRETA PRODUCTION OF ALCOHOL FROM CAROB

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The use of carbohydrate rich plants for the production of ethanol which can be used with the mix of petrol as auto fuel, has been pointed out from many researchers.
The production of ethanol is taking place in three stages:

1. Extraction of the carbohydrates from the plants
2. Fermentation of the carbohydrates
3. Distillation of the ethanol

In Creta there are many areas where the carb tree can grow easily. The utilization of the carb can give many products from the pod (rich in carbohydrates) and the seed (rich in proteins).
The yield of the carob tree depends on many factors like the age of the tree, the type of the land and the use of water or not. The carob is rich in carbohydrates which can be fermented to ethanol.
In the case of the low yield of the carob tree, the production of ethanol is comparable with the ethanol production from other plants rich in carbohydrates, and when the yield is higher the ethanol production is high.
It is expected that if in the uncultivated land in Creta the carob tree is grown the production of ethanol will be considerable, in a price competitive with the price of the ordinary auto fuel.

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THE ECONOMICS AND ENERGETICS OF A METHOD FOR HARVESTING COTTON STALKS FOR ENERGY PRODUCTION BY BURNING

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In the paper, a novel method of harvesting cotton stalks for energy production by burning is briefly presented. The method, which is suitable for the clime of Thessaly, Greece, collects only the aerial part of the plant and packs it in large round base. An economic and an energetic analysis of the method is presented.
In the economic analysis, the cost estimation is based on prices taken by contractors for hay harvesting. The time needed for the baling and the handling of the bales was measured and the cost is calculated. The result is compared to the cost of the diesel substituted for heating spaces taking into account the difference of the efficiency of the conversion (90% for diesel and 65% for biomass).
For the energy budget of the method, values from the literature were used based again on hay harvesting.
Both results give a good advantage to the method and indicate that cotton stalks can be used for energy production, as a substitute for fossil fuels, on sites near the cotton producing fields.

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PROTECTION OF THE ENVIRONMENT BY UTILIZATION OF BIOGAS FROM WASTE DEPOSITS

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The controlled production of biogas from the degradation of municipal waste is necessary for a modern waste deposit not only for environmental reason but also as a source of energy. In the Federal Republic of Germany currently in about 45 cases the biogas is used as fuel energy for operating has motor engines to produce electrical energy. The paper deals with the origin of gas from biochemically disolving waste, the consequences in case the biogas distributes into the environment and, in order to prevent this, the techniques to collect biogas from the waste deposits. Eventually, the utilization of biogas is demonstrated by an example in the Rhine-Ruhr-area of an on-site electrical power producing unit using the gas from a deposit near the city of Dortmund. The small scale power plant was planned by the engineering company Dr.-Ing.Steffen, Essen and can be visited on demand.
Biogas is the result of the biological degradation of untreated municipal waste, which is collected in encapsuled earth deposits. In case gas escapes from the inside of the deposits odors, damages to the near plant formation, danger of explosion will occur and due to the distribution in the atmosphere the process will contribute to global warming.

The above mentioned waste deposit (ground area: 580.000m^2, volume: 14Mill.m^3 waste) is used by the city of Dortmund for more than 45 years and will close down in the end of June 1992. The deposit will be sealed of, covered with a soil layer, planted with green and bushes and finally it will be used as a recreational area. Inside the deposit the biogas is collected in horizontal and vertical gas collection systems (perforated pipelines). At the moment 3000m^3/h biogas is taken from the deposit, 670m^3/h are used as fuel for three gas motor engines to produce about 860KW electrical energy and 2330m^3/h are used directly in a nearby industrial plant. The amount of 3000m^3 biogas is the equivalent of 1500 liters of fuel oil.

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THE UTILIZATION OF BIOMASS AT THE INTERFACES BETWEEN AGRICULTURE, INDUSTRY, ENVIRONMENT AND ENERGY: EUROPEAN PERSPECTIVE AND GREEK OPPORTUNITIES

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Present trends in the European Community (EC) appear particularly favourable for large scale industrial utilization of biomass, especially of agricultural origin, in non-food uses: energy, fibres, plastics, chemicals, composts.
This results from the action of two main factors:

(1) Common Agricultural Policy (CAP) reforms, reducing prices and encouraging use of set aside land for new applications,

(2) an increasing pressure for environmental protection in many relevant areas, including

- control of carbon dixide emmissions (Greenhouse effects) through utilization of renewable resources, e.g.bioenergy and

- improvement of air quality conditions in metropolitan areas through use of "clean" transportation fuels - liquid biofuels are prime candidates.

The synergistic potential of the above factors has already become visible, e.g. inrecent EC initiatives for a carbon tax and other tax measures favouring biomass-derived fuels.
In view of such European developments, Greece faces the challenge to formulate an appropriate National Strategy, since (traditional) bioenergy presently constitutes the third national energy source, and new biomass applications could significantly contribute in a series of critical areas, i.e.

- restructuring of agricultural production
- industrial modernization and development of new agriculture-industry links
- differentation of energy sources and import reduction
- environmental protection in rural and urban areas

If nothing happens, who is to be blamed for the (significant) costs of one more case of national "negligence"?

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BIOMASS DEPOSITS IN GREECE

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In this paper a qualitative and quantitative presentation of the disposed biomass in Greece is given, concerning the period 1986-1988 and the plant biomass mainly. The data were collected from different sources (1,2,3). An appropriate data base was established with files including region, kind and production date data. A statistical analysis was performed to yield qualitative and quantitative figures and maps with the relevant production.

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LIQUID DOMESTIC WASTE EXPLOITATION IN A FAST GROWING FOREST PLANTATION

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The results of an experimental study on the use of liquid domestic waste in a forestial plantation with fast growing species are presented. The Imhoff system has been used for the tank, in conjunction with an absorbtion pond with three plant species: Pyramidoid poplar-tree (K-281 and K-17), poplar-tree (He-X/3) and weeping willow. The highest biomass production was achieved by the poplar-tree He-X/3 (40ton/hectave-year)followed by the weeping willow (27ton/hectave-year).
A number of physical properties and the calorific value of the wood have been determined. It has been estimated that the heating load of a single house may be met by a poplar-tree He-X/3 plantation of an area five times that of the heated floor.

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ADSORPTION OF Li ON WS_2(0001) AT 85K AND 300K WITH SYNCHROTRON RADIATION

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The interaction of Li in layered materials has outstanding properties for electrochemical energy storage (Li batteries). Therefore, the mechanism of Li insertion into layered compounds is of fundamental interest. The interaction of deposited Li with cleaved ven der Waals surfaces of the layered compound WS_2 has been investigated by photoelectron spectroscopy (SXPS) and low energy electron diffraction (LEED). At low temperature part of the adsorbed Li is intercalated. Above a certain high coverage the remaining on the surface Li interacts with WS_2 and transforms to metallic W and Li_xS. At room temperature most of the adsorbed Li is simply intercalated in WS_2. Electronic change transfer from Li to WS_2 changes the latter to metallic.

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THE INSTITUTIONAL FRAMEWORK FOR THE PROMOTION OF RENEWABLE ENERGY SOURCES IN GREECE

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GENERAL

Renewable energy sources play a growing role at the locl and global scale because their technology, cost and reliability are improving, teh environmental impact from other sources is becoming more threatening and their flexibility in size and speed of installation makes them suitable for a wide range of applications including those in developing countries.
From the total CO2 emissions 70% is attributed to energy processes while the world population increase and the improvement of the living standards of 2/3 of the population presently living at low standards will put extremely high pressures in the energy resources and the environmental conditions at the global scale.
The Greek energy balance shows that 93% of total primary energy is covered by fossil fuels (lignite and oil), with oil covering 56,2% and renewables 6% of which 2.6% represents hydroelectric energy.

SURVEY OF INTERNATIONAL EXPERIENCE

The example of California is cited having 16,000 wind generators with 150MW total nominal power providing 2,400GWh of electricity at 7 cents per KWh expected to come to 5 cents by 1995.
The installed wind power in different European member countries for 1990 is given with a total of about 500MW. Subsequently, the incentives given in the different European countries for renewable energies are presented.
Finally, the methods followed in Germany, U.K., France, U.S.A. and Japan to predict energy demand development, energy supply structure and environmental impact together with the measures taken to keep CO2 emissions at about 1990 levels are described.

THE GREEK LEGAL INSTITUTIONAL FRAMEWORK

The creation of teh National Energy Council with law 84/75 as a response to the first energy crisis and the laws 814/78 and 1473/84 giving tax incentives for the purchase of solar collectors are presented. Subsequently, the law 1475/84 for geothermal energy, and 1599/85 setting the framework for production of electricity by private concerns are given, together with the Ministerial Degrees S.E. 2689/87, 2708/87, 7214/88, 2752/88, 2764/88, 2841/88, arranging different aspects of wind machine installations e.t.c.
The reasons for the non-functioning of these laws are discussed. They are mainly due to the many bureaucratic procedures the low price given by the Public Power Corporation for the electricity purchased from individual procedures and the non-allowance for renting P.P.C lines to transmit electricity from one location suitable for example for wind parks to another where a load, for example a factory, exists.
The regulations of the General Building Code, law 1577/85 allowing excess height for the installation of solar collectors and requesting a building permit for the installation of wind machines are discussed.
The incentives given by the Development Law 1892/90 are presented adn teh law 1310/82 for the implementation of teh Solar Village project, the Presidential Degree 375/87 establishing the Center for Renewable Energies adn the Presidential Decision issued by the General Secretariat of Research and Technology 1233/POL/Feb. 91 creating the Energy Coordinator Committee for the coordination of the entire energy area are shown.
The research laws 706/1977 and 1514/85 are presented and their contribution to the promotion of renewable is discussed.

PROGRAMMES IN THE DIFFERENT SECTORS OF RENEWABLE ENERGIES

Different projects implemented in the different sectors of renewable energies are presented.

Solar Energy

The standards developed for Solar Collectors as a result of cooperation of the Center for Renewable Energies, the Democritos Research Center, the Greek Standards Organization adn the Association of Manufacturers of Solar Collector Systems are given.

Passive Solar Systems

The solar village passive design and passive elements and the installation by the Center of Renewable Energies of two cells for measuring passive elements under the E.E.C. programme PASSYS are mentioned.

Photovoltaic Systems

The two photovoltaic plants of 100KW adn 50KW in Kythnos and Crete islands respectively and individual units indifferent locations are presented. A brief account of Italian and Spanish efforts in this area is given.

Wind energy

The research activities and the P.P.C. installations amounting to a total of about 20MW are described.
The inclusion of 150MW in the 10 years P.P.C. programme is presented.

Biomass

The Center for Renewable Energies, the Agricultural University of Athens and the National Technical University of Athens (N.T.U.A.) carry out important work in biomass which is briefly described

Small Hydroelectric

The activities by the Center of Renewable Energies and the N.T.U.A. are outlined.

Geothermal

The problems encountered in the Milos and Nissyros plants are presented and research activities on two phase-flow, corrosion and scaling are mentioned.

Rational Use of Energy

The different studies in the field of energy conservation and the measures taken are summarized and some research and demonstration projects are presented..

PROBLEMS OF THE INSTITUTIONAL FRAMEWORK AND POSSIBILITIES FOR IMPROVEMENTS

The cumbersome bureaucratic procedures must be simplified and the difference between the low price given by P.P.C. to individual energy producers and the price necessary to make the investment profitable should be covered by government incentives as it is done in other countries. For this purpose the 5 drachmas extra charge per litter of gasoline imposed for environmental purposes could be used.
The institutional framework must start in a simplified manner making attractive for investors to start individual energy producing activities with privileges given to the first efforts, facing a higher risk and then on the basis of the experiences gained this framework must be gradually improved leaving the original already granted privileges to the pioneers.

CONCLUSIONS

There are quite a few activities in renewable energies in Greece but there are also considerable difficulties and weaknesses especially for the development of production activities where, however, most of the benefits lie.
The institutional framework must be simplified, the first efforts must be encouraged and the framework improved, on the basis of the experiences gained.

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NATIONAL STANDARDS IN ACTIVE SOLAR SYSTEMS THE WORK OF TECHNICAL COMMITTEE 35 "SOLAR ENERGY"

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In response to the needs for standards in the field of solar energy, the Technical Committee 35, "Solar Energy", (TC-35) of the Hellenic Organization for Standardization (ELOT) has undertaken during the last five years the development of a large number of national standards and technical reports. These standards and technical reports concern:

- Solar terminology and definitions
- Tests for thermal performance prediction of liquid solar collectors and domestic solar systems
- Qualification tests for liquid solar collectors and domestic solar systems
- Specifications of materials for the construction of solar collectors and other solar components (excluding metallic and insulation materials)
- Design and installation of large solar systems for heating swimming pools water and service water.
- Welding in solar components
- Solar systems conformity certification

The succesive TC-35 work is the result of a collective effort of various greek organizations, like the Institute for Technological Applications (ITE) of the Greek Productivity Centre (ELKEPA), which operates the TC-35, the Centre for Renewable Energy Sources (KAPE), the Greek Solar Industry Confederation, the Solar Systems Laboratory of Greek Nuclear Centre "Democritos", Greek Universities and others. The standardization work reinforces the greek industry in its effort to produce and export products of higher efficiency and better reliability.

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DETERMINATION OF ABSOLUTE COST OF ENERGY

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An attempt to assess the absolute cost of energy is made in the present work, taking into accounts various parameters, such as the cost of the various sources of energy, the necessary technological conversions, the environmental impacts and a social appreciation of the energy as a consumer's item. The charging policies for the various types of energy are also adressed along with an energy strategy concerning renewable energy sources.

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HETEROGENEOUS PHOTOCATALYTIC DEGRADIATION OF THE CATIONIC SURFACTANT DODECYL-PYRIDINUMCHLORIDE

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The photodegradiation of the cationic surfactant dodecylpyridinum chloride (N-DPCl) in aqueous heterogeneous dispersions of TiO_2 and ZnO semiconductor particles, is studied. The cationic surfactant N-DPCl has undergone an environmentally acceptable decomposition within 8 hours exposure to white light ($85mW/cm^2$). A photodegradiation destroying the aromatic ring is followed by a slower oxidation of the aliphatic chain as it appears from UV and surface tension measurements. Considering the low intensity of the light used, the degradiation is satisfactory and very promising.

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ENVIRONMENTAL COST/BENEFIT DUE TO SOLAR ENERGY UTILIZATION FOR DOMESTIC HOT WATER PRODUCTION IN GREECE

D.HARALAMBOPOULOS, D.PAPAKONSTANTINOU

G.PAPARSENOS

The environmental problens associated with electricity production are outlined in teh present paper. Solar energy for domestic hot water production has been of growing concern inGreece during the last decade. A brief description of the Public Power Corporations electricity production system is given and the marginal substituted fuel is identified as lignite and diesel oil. Given the penetration of solar collectors in teh domestic market and the emission coefficients of power plants, the corresponding quantities of air born pollutants that are not produced have been calculated. The corresponding substituted conventional fuel quantities, i.e. lignite and diesel oil, are also presented. It is concluded that solar energy makes in Greece a significant contribution towards the reduction of the relevant air pollutants.

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TELEHEATING, AN IDEAL SOLUTION FOR THE EXPLOITATION OF BIOMASS, URBAN WASTES AND HOT WATER SPRINGS.

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My present work presents a rich experience of other countries with concrete elements from the exploitation of biomass, urban wastes and hot water springs. It is refered in certain countries which have made productive the heat sources not only for the heat saving, but also for the production of electric power. It is analysed by mathematic calculations the profit of our national economics and the duty with the making productive of the teleheating system with coproduction. And this solution is cheaper.

There are explained the reasons for which the teleheating is not yet made productive in Greece and their consequences and which possibilities exist for this making productive in our country.

There are also explained that this making productive of the teleheating in Athens and Thessaloniki is the most indispensable and ideal solution for striking out the cloud of smog.

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GEOTHERMAL ENERGY AND ENVIRONMENT THE INTERNATIONAL EXPERIENCE

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A review is presented regarding the impact on the environment from geothermal energy exploitation. The latter has been intensified internationally over the past thirty years, and considerable experience has been gained. Comparisons are also made with geothermal fluids from greek fields adn useful conclusions are drawn.
Low enthalpy geothermal fluids do not present significant problems. Only the final disposal of used water requires careful study (on a case-by-case basis) with the additional objective to maximize the overall economic benefit from its utilization.
Regarding high enthalpy fluids, there is substantial and positive experience from its exploitation internationally. Offgases from any geothermal installation can satisfy strict specifications, with the addition of an appropriate H_2S abatement unit. Proven methods are available for this purpose, while new methods are in the stage of development for better adaptation to the peculiarities of geothermal installations. For the final disposal of geothermal brine, reinjection is the generally preferred method, preventing any ground pollution problems. Controlled handling of brine in open ponds is also possible in a relatively limited scale. A case of ground subsidence has been observed in a geothermal field in New Zealand, and it is attributed to the weak rock formation in that particular reservoir. It should not be of concern, however, in the case of greek reservoir exploitation.
Finally, in the paper a methodology is proposed for systematically carrying out reliable environmental impact studies. Such studies, including measures to minimize and possibly eliminate any impact, should be prepared well ahead of field exploitation.

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GEOTHERMAL ENERGY PRODUCTION REFER TO THE ENVIRONMENT AND TO THE REGIONAL DEVELOPMENT

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Early this century, the Italians first, started exploiting the geothermal energy for electricity production. The exploitation of this national resource spread over soon and its use for electricity production consists today a national energy resource for all those countries having geothermal potential. As a sequence, more than 5000MW of geothermoelectric power are nowadays installed all over the world.
The relevant technology, that gradually grew, is combined also with the environmental protection and the regional development. This way, the operation of the geothermoelectric units relieves the environmental pollution from the conventional fuels combustion pollutants, giving at the same time regional development possibilities at the places it is found.
These possibilities could be combined with the electricity production and are mainly referring to greenhouses, fish-farming, district heating, touristic develpment etc.

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DESIGN AND CONSTRUCTION OF BUILDINGS: THE ENVIRONMENTAL IMPACT (1)

SOLAR ENERGY UTILIZATION IN TWO ENVIRONMENTALLY CONSIOUS BUILDINGS (2)

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(1) Viotopos House. A pilot house with integrated environmental and morphological qualities in Denmark. Evaluation, suitability examination and final selection of the design, the construction materials and the technology applied, in order to:

- exploit solar energy
- minimize conventional energy consumption in the production of construction materials
- avoid hazardous materials and technologies
- achieve a high degree of recycling in the construction materials

(2) Bioclimatic house constructed with clad and wood in Kimmeria, Xanthi. It utilizes solar energy, exhibits low energy cost, being friendly to the environment, the constructor and the house holder. Its materials may be recycled and it offers a high quality domestic environment at low cost. Its shell is made of clad in two layers: a heat storing internal layer and a thermal insulating external layer. No conventional insulating materials are used.
The thermal behaviour of this shell structure is investigated for various wall thicknesses, taking into account both the solar gains and the heat stored in the wall.

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THE ROLE OF EDUCATION IN PROMOTING THE USE OF RENEWABLE ENERGY SOURCES

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Renewable energy sources will play a gradually increasing role especially at the local level. The promotion of an energy system based on conservation, recycling of material and optimum exploitation of local resources is desirable for a number of reasons, economic as well as social e.g. regional development, security inenergy supply, improved living conditions, environmentally friendly energy utilization. The challenge is greater for the developing countries that lack the educational and technical background to support an energy system based on new technologies.
In this presentation, the various implications (direct and secondary) of such a transition and the role of education in supporting a national policy aimed at maximizing the expected benefits is briefly discussed. More specifically several aspects of the educational process are examined, namely:

(a) Instruction and information of the public

In a decentralized energy system the decision should be made at the local l evel, since it is up to the local population to decide on issues concerning their well being. This active participation of the general public, however, requires educated and conscientious citizens, able to listen to different views and respect democratic processes. With this in mind, primary and secondary school education should direct its efforts in developing the ability to think and judge by exposing the student to the contemporary social, economic and environmental problems. To this end, the teaching process can be enriched with lectures by invited guests, discussions, movies, special projects etc.

(b) Technical Education

Special consideration should be directed to the education of technical experts of all levels (technicians, engineers, specialists). Bearing in mind the rapid evolution of technical knowledge, emphasis should be placed on the creation of a sound scientific background while at the same time cultivating the ability of the student to adapt to the future requirements of his/her profession and create new knowledge.

(c) Research and technical innovation

By promoting research and technical innovation, the best exploitation of soft energy sources can be combined with a parallel increase in economic activities creating opportunities for new goods and services. In most cases the technology is not highly complex and our country should be able to compete successfully in the international market. It is essential that the research effort is coordinated and directed to specific goals set by a carefully planned national policy. The financial support of the EEC is helping in this direction.

Finally the role of the Institute of Solar Technology in supporting all the above educational efforts is pointed out.

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LAND PLANNING OF THE GREEK AREAS AS TO THE DEMANDS AND SUPPLY OF ELECTRICAL ENERGY WITH THE HELP OF DATA ANALYSIS METHODS

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The present paper constitutes en effort of land planning of the greek areas, with the application of the data analysis method, on the basis of the demand and supply of electrical from P.P.C having as target the future installation of wind parks in those, for the covering of their energy demands.
For this reason the following data is used according to the uses and areas for the low and middle frequency.

1. The number of the connected consumers

2. The sold energy in MWh.

3. The income of the sold energy in Drs.

In the first part of the paper the charting of Greece is performed, and in the second the selection of the most suitable areas according to the needs of the electric energy of each territory, in order to take advantage of the conclusions of this analysis of the alternative energy sources.

Finally the differences between the areas of the above land planning are discussed.

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MARKET PENETRATION OF GEOTHERMAL FLUIDS

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The exploitation of Greek geothermal sources will result to the appearance of a "new" product (the geothermal fluids), which is being introduced into the local energy market to replace mainly liquid fuels.
The successful planning to promote geothermal energy presumes research for the determination of potential users, investigation of their intentions and estimation of the penetration rate of the product into the market.
Critical parameters of the whole problem are the specific characteristics of geothermal fluids and the criteria that potential uses/applications should fullfil.
The primary problems arising towards the penetration of the product into the market include the attitude/conviction of the residents and other potential users in the area, the establishment or not of a trustworthy organization for the management and supply of energy and the existence of handy and costless equipment for the exploitation and application of the fluids.
Finally, critical is the role of pricing as a means of penetration into the market. Fundamental axis of this policy should include the aim of recovering the maximal possible of the energy content of the fluids as well as the support to the users to feel justly and equally handled.

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ENERGY CONSERVATION POWER PLANT IN CRETE

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Today the electricity demand in Crete island is increasing with a very high rate (8% annually), due to tourism and economic development, and the coverage of the demand is marginal. It is almost impossible today for Public Power Corporation (PPC) to find a place to install new generating units in Crete because of the strong NIMBY (not in my back-yard) opposition of the local people. The planned 132MW combined cycle power plant, with investment cost about $105 millions, which cover electric demand with oil and later with natural gas, will cover electric demand only up to 1995 (with high production cost). There are also special difficulties in the planned for 1996-97 interconnection of Crete to the Greek National Grid through submarine high voltage DC cable because of the high investment cost and significant technical barriers.
Therefore it is proposed to proceed to the implementation of an integrated ecological development energy plan in Crete. That plan will be similar to the "conservation power plant" in Austin, Texas. The main principles of the proposed local action (including only viable projects) are the following:

1. Energy conservation and rational use of energy

2. Reduction of the peak electric demand through demand side management, substitution of electric energy that is generated in PPC stations from non-utility generated electricity, and from intensive use of Renewable Energy Sources (RES), active and passive solar systems, limitations in the use of electric heat storage, use of low energy consumption home appliances etc.

3. Promotion of energy parks and decentralised non-utility energy systems with i intensive exploitation of the strong RES potential in Crete or with imported fossil fuels at industries, industrial estates, hospitals, supermarkets, hotels etc.

4. Encouraging the local people to improve their energy behaviour, that is to use energy in a more economic manner.

With the implementation of the above proposal the planned interconnection of Crete to the National Grid as well as the locally planned PPC conventional power stations could be initially postponed and finally cancelled. It is clear that the above proposal is the only means "to buy time" and study better the whole energy problem of Crete.

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PROPOSAL FOR AN INTEGRATED STRATEGY FOR THE PROMOTION OF THE ACTIVE SOLAR SYSTEM

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Although an approximate percentage of 50% of the total European solar collector area is installed in Greece, there is a potential for additional penetration of Active Solar Systems (ASS).
At first, the benefits from the use of Solar Heaters (SH) are quantified for national economy, for Public Power Corporation (PPC) and for the individual user (consumer). Then the various barriers (legislative, legal, economic) that prevent the increase concluded that the main problem for the intensive promotion of the SH is the relevant high investment cost.
An integrated strategy is proposed for the promotion of ASS in Greece. The main measure to be taken for the implementation of this strategy is to allocate the investment cost of each individual Sh to all the parties that derive benefits from its operation (national economy, PPC and individual user.) Each party will have to pay its own share proportionally based on the benefit derived from the operation of SH. PPC will finance each SH installation and the individual user of SH will pay off through the electricity bill. The strategy also included economic incentives (return of VAT and tax credit for the individual user).
In order to obtain the necessary funds to subside (investment grants, grants for the interest expenses, VAT return and tax credit) individual SH installations a special energy (environmental) tax is proposed to be imposed on all fossil fuels and electric energy used.
Finally, it is stated that the promotion of the individual SH is the first step to be taken for the promotion of ASS in space heating which today is based only on polluting energy sources.

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IS THE USE OF WIND ENERGY PROFITABLE? THE CASE OF RHODES ISLAND

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The possible use of wind energy for electricity production is investigated given emphasis at the case of Rhodes Island. An economic feasibility study for the installation of wind mills is undertaken for the production of electricity with substitution of wind energy to liquid flues. The factors affecting the profitability of the project are studied.
The possibility of the wind energy support and the policies and instruments that could contribute to achieving the desired penetration rate are:

- The use of the wind energy for electricity production is prosperous and its profitability is assured to all possible changes of the market conditions.
- The instruments that could seize the penetration rate of wind mills are financial ones.
- The price-list of the Public Power Corporation (PPC) for the excess electricity of the self-producers are affected mainly by the avoided cost (the cost of the fuel saved for electricity production).
- If the electricity produced by wind mills covered a significant portion of the final demand (at the level where the security of the network permits such as a substitution) the operational cost of PPC (at regional level) would be positively affected. Furthermore, the PPC would be eager to pay more in order to purchase electricity produced by wind mills.

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RENEWABLE ENERGY SOURCES EDUCATIONAL PARKS (RES-EP) THE CASE OF XANTHI

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Energy availability is of crucial importance for a country's strategic planning. If promoting RES is chosen as a means towards energy self sufficiency, then nation wide education, along with research and resources monitoring, is necessary.
In the field of continuous education, the existence of RES Educational Parks could prove to be fruitful tool.
In Europe, there are many places of varying character and scope where the public is offered an opportunity to come in close contact with the principles and applications of RES. Some RES-EP currently in operation are:

1. An Organic Farm near Wellington, England
2. The Windmill Museum in Gifhorn, Germany and
3. The Center for Alternative Technology near Machynleth, Wales

which could be an excellent living example to adopt, adapt and build elsewhere.

Of the sequential phases necessary to set up and operate such a RES-EP, the Preliminary of Feasibility Study seems to be the most demanding one. Of particular importance is the size, the composition and the origin of the group to be in charge of the Park.
In Xanthi, Greece, the establishment of a RES-EP seems to be feasible due to: Availability of ample space endowed with RES, the existence of Xanthi School of Engineering and the commitment of the Municipal Authorities for such an endeavour.

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THE EUROPEAN "THERMIE" PROGRAMME FOR SOLAR THERMAL TECHNOLOGIES

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The THERMIE programme is an important Community instrument designed to promote greater use of European energy efficient technologies. An overview is given of the different types of activities in the programme and how persons and undertakings can participate in the programme, especially in the field of solar passive and active solar technologies.

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ACTIVITIES AND PROGRAMMING OF PPC IN THE ALTERNATIVE ENERGY FORMS SECTOR

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The paper presents the up-to-date activities of the PPC's Alternative Forms Department (DEME), as well as its present activities which are funded by EEC programmes. The further targets of PPC's Development Program are also analysed in the alternative energy forms sector and relevant consideration is given.

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HEAT RECOVERY FROM THE POWER PLANT IN CHANIA

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The power plant in Chania is operating with very low efficiency aprox 20%. Today another unit is under construction in the same area which will operate with higher efficiency aprox 45%. A lot of energy can be recovered from these power plants with heat exchangers, and the hot water or the steam that will be produced, can be used in the area for heating houses, greenhouses or can be consumed from various small-sized industries that will be installed in the industrial park that is under construction in the same area.

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