

**INSTITUTE  
OF  
SOLAR TECHNOLOGY**



# **3rd National Conference**

## **On Renewable Energy sources**

**Special issue**

### **SUMMARIES**

**of papers presented**

**Thessaloniki, Greece, 9-11 November 1988**

**Institute of Solar Technology**

**Thessaloniki 1992**

The 3rd National Conference on Renewable Energy Sources was sponsored by:

- Ministry of Industry, Energy and Technology
- Ministry of Culture
- Ministry of Macedonia-Thrace
- General Secretary of Research and Technology
- Greek Productivity Center
- Municipality of Thessaloniki
- National Technical University of Athens
- Democritus University of Thrace
- The Public Power Corporation of Greece
- Telecommunication Organisation of Greece
- Union of Solar Energy Industries
- British Council
- American Center

Edited by: G.Tsilingiridis  
Aristotle University of Thessaloniki, 54006

Assisted by: M.Stoyianni

Printed By: "Yapoulis-Yahoudis"  
Melenikou 15 st., Thessaloniki 54006, Greece

## PREFACE

The Institute of Solar Technology (IST) was founded in 1980, in Thessaloniki, Greece.

Since then, the IST has more than 120 members, among them Professors of Universities, scientists of various Greek research institutes, scientists and engineers from the solar energy industry etc.

The present board of administration of the IST is as follows:

Prof. B.Sotiropoulos,	President
Prof. K.Panetsos,	Vice President (1)
Prof. K.Pattas,	Vice President (2)
G. Tsilingiridis	General Secretary

### MEMBERS:

Prof. N.Koumoutsos,	Prof. I.Ganoulis
Prof. A.Thanailakis,	Prof. N.Georgoulas
Prof. S.Nychas,	Dr. I.Pafelias
Prof. A.Karabelas,	E.Tsingas

The aims of the IST are:

1. Development of methods and technologies to use solar energy.
2. Information through Conferences, Seminars, Publications etc. on the use of solar energy.
3. International connections and technology exchange, concerning the use of solar energy.
4. Elaboration of proposals for energy policy combining renewable energies utilization.

For the realisation of the above aims, the IST has organised in 1982, 1985 and 1988, the first, second and third National Conference on the alternative energies. In each conference, with about 500 participants, more than 100 papers were presented.

The conferences are held in the national level, thus appealing to all scientists and engineers in Greece interested in the alternative energies.

The proceedings are in greek language with only a brief summary in English.

The aim of the present issue is to initialize an international connection, by providing the summaries of the papers presented in the 3rd conference.

We hope that the receivers of this booklet, will have a starting point for finding the names and the field of occupation of the greek colleagues, if they are interested to establish links.

The "feed back" of this attempt, will give us the information and the confidence to "jump" from national to international level in the future conferences.

B.A.Sotiropoulos

President of the IST



## CONTENTS

### 1. MEASUREMENT AND ELABORATION OF METEOROLOGICAL DATA

1. Nocturnal, sky radiation in the summertime in Athens. Influence of the atmospheric pollutants.  
G.Papadakis, G.Voulgaris, A.Fragoudakis, S.Kyritsis  
pp. 1
2. Comparison of models of solar radiation-sunshine duration  
F.A.Batzias, S.G.Arnautis  
pp. 2
3. A study on the residuals of solar radiation-sunshine duration correlation  
F.A.Batzias, S.G.Arnautis  
pp. 3
4. Correlation between sunshine duration and total solar radiation for Thessaloniki  
Ch.Sachsamanoglou, T.Makrogiannis  
pp. 4
5. Relation between cloud cover and sunshine duration in Thessaloniki  
Ch.Sachsamanoglou, D.Chatjioakim  
pp. 5
6. On the estimation of monthly average hourly values of global irradiation over Greece  
A.A.Flocas, A.A.Bloutsos, P.J.Pennas  
pp. 6
7. Measurements and computation method for total solar irradiance flux through inclined surfaces with arbitrary orientation  
H.Cambetzidis, N.Papanikolaou  
pp. 7

### 2. PASSIVE SOLAR SYSTEMS

1. Techniques of Passive Cooling of Buildings  
A.Dimoudi, P.Liveris  
pp. 8
2. 4 (four) examples of pathetic solar planning-modern-postmodern and contemporary enviromental lococentric planning  
M. Souvatzidis  
pp. 9
3. The solar Town Hall of Paleo Phaliro  
G.Kontoroupis, T.Biris, D.Biris, G.Christofilis, P.Kokoris, P.Voudiclaris  
pp. 10
4. Energy efficiency of peripheral units in modern poultry processing plants  
M.J.Konstantinou, J.L.Souflis, A.V.Machias  
pp. 11

## VIII

5. Effects of the building construction on the primary energy conservation in Greece.  
V.Sotiropoulos, K.Papakostas  
pp. 12
6. The revival of stone architecture  
G.Batjilis  
pp. 13
7. Energy conservation in buildings with plants and green at their roofs and facades  
K.Evmorfopoulou  
pp. 14
8. Application of passive solar systems in two schools in Crete and calculation of their performance  
Y.Kalligeris, Dr.M.Santamouris  
pp. 15
9. A demonstration project in passive solar architecture of the commission of the European Communities  
G. Berndt, M.Papadopoulos  
pp. 16

### 3. ACTIVE SOLAR SYSTEMS

1. Determination of population density and building regulations with geometrical methods. House orientation  
A.Anastasiadis  
pp. 17
2. Solar hot water central systems of an open loop/single pass type  
G.Kostoulas, A.Efthimiadis, V.Belessiotis  
pp. 18
3. Thermo-Hydraulic simulation of a Solar Domestic Hot Water System under pseudo steady-state conditions  
V.Belessiotis, A.Efthimiadis, P.Andronikos  
pp. 19
4. Performance monitoring of a thermosyphonic unit installed at a customer's house and daily water consumption profiles  
T.A.Pafelias  
pp. 20
5. Use of Hot Water in Solar DHW in Greece  
T.A.Pafelias  
pp. 21
6. Testing methodologies for the determination of the thermal performance of Solar Domestic Hot Water Systems  
D.Gilliaert, P.Tebaldi  
pp. 22
7. European research activities on test methods for solar collectors and Solar Water Heating Systems  
W.B.Gillett, J.E.Bates, E.Aranovitch, D.Gillieart, M. Antinucci  
pp. 23
8. Collector combining solar heating and radiative cooling  
A.Fragoudakis, G.Papadakis, S.Kyritsis  
pp. 24



9. Theoretical and experimental determination of the DHWS parameters. Long term thermal performance of DHWS  
V.Belessiotis, P.Andronikos, K.Papathanasopoulos  
pp. 25

#### 4. ENERGY CONSERVATION IN BUILDINGS

1. Effects of the external surface convection coefficient of the thermal performance of a building  
D.Bozis, V.Sotiropoulos  
pp. 26
2. A model for the determination of 2-dimensional temperature distribution in rectangular building elements.  
K.Dimoulas, N.Papadopoulos, D.Bozis, V.Sotiropoulos  
pp. 27
3. Energy conservation in the domestic- (Application in the Department of Lesbos)  
T.Goumas, M.Christou  
pp. 28
4. A comparison of solar driven  $\text{NH}_3/\text{H}_2\text{O}$  and  $\text{H}_2\text{O}/\text{LiBr}$  absorption refrigerators  
D.A.Kouremenos, K.A.Antonopoulos, E.Rogdakis  
pp. 29
5. Constant heat storage and pumping based on the Zeolite-Water adsorption intermittent cycle  
M.Karagiorgas, F.Meunier  
pp. 30

#### 5. SOLAR COLLECTORS

1. Reliability analysis of Domestic Hot Water Solar Collectors installed in Greece  
S.Panteliou, G.Bouziotis, T.Chondros, A.Dimarogonas  
pp. 31
2. Numerical Simulation of Heat Transfer to a Water Jet from a flat solar collector  
A.Bagtzoglou  
pp. 32
3. Non tracking concerning solar collectors with improved efficiency  
J.Trypanagnostopoulos, P.Yanoulis  
pp. 33
4. Qualification tests for solar collectors  
V.Belessiotis, P.Andronikos, A.Spyridonos, K.Papathanasopoulos  
pp. 34
5. Analysis of performance of solar system DHW systems and portable instrumentation for checking it  
T.A.Pafelias, E.Vaseos  
pp. 35

## 6. SOLAR HEAT PRODUCTION AND PROCESSES

1. Economo-technical optimization of solar energy utilization in a desalination plant  
F.A.Batzias, J.S.Sigalas  
pp. 36
2. Improved cycle of  $\text{NH}_3/\text{H}_2\text{O}$  high pressure solar aided absorption  
S.K.Chatzidakis  
pp. 37
3. Concentration of Hygroscopic solutions with solar energy  
S.Yaniotis, E.Foudoukidis  
pp. 38
4. Universal optimal control of a solar hot water system of a single pass type under constrain  
P.Mantzari, A.Efthimiadis, D.Marinou-Kouris  
pp. 39
5. Performance of solar driven  $\text{NH}_3/\text{H}_2\text{O}$  and  $\text{H}_2\text{O}/\text{LiBr}$  Absorption heat transformers  
D.A.Kouremenos, E.Rogdakis, K.A.Antonopoulos  
pp. 40
6. Honeycomb solar pond  
C.D.Rakopoulos, E.Vaseos, D.N.Gabriil  
pp. 41
7. Solar driven ice-machine with adsorption of Ethanol on active carbon  
M.Karagiorgas, A.Boubakri  
pp. 42

## 7. HEAT STORAGE TECHNOLOGY

1. Dynamic thermal behaviour of a rock bed heat storage  
K.Dimitriadis, N.Papageorgiou, A.Christoforidis, V.Sotiropoulos  
pp. 43
2. On the thermal behaviour of a saltless pond  
A.V.Spyridonos  
pp. 44

## 8. APPLICATION OF PHOTOVOLTAICS

1. Use of Photovoltaic cells for the cathodic protection of steel piping for natural gas distribution  
G.Batis, N.Kouloumbi, D.Dimitropoulos  
pp. 45
2. Study of electrical and optimal properties of a-SiC:H for Photovoltaic conversion  
L.Magafas, N.Georgoulas, D.Girginoudi, A.Thanailakis  
pp. 46
3. Growth and characterisation of a-Si<sub>1-x</sub>Sn<sub>x</sub> thin films as photovoltaic materials  
A.Mittas, N.Georgoulas, D.Girginoudi, A.Thanailakis  
pp. 47

4. Cost considerations of photovoltaic electricity generating stations  
P.Koutras, G.Tsilingiridis  
pp. 48
5. Photoelectrochemical Behaviour of n-InSe single crystals  
I.Poulios, N.Papadopoulos, K.Farmakis  
pp. 49
6. A stand-alone photovoltaic system for domestic electrification in the area of Attiki  
Ph.Tsalidis, A.Balouktsis, A.Thanailakis  
pp. 50

## 9. APPLICATION OF SOLAR ENERGY IN AGRICULTURE

1. Active solar systems for drying agricultural products  
C.Kyranoudis, Z.Maroulis, D.Marinos-Kouris  
pp. 51
2. Performance of solar greenhouse heating systems with heat pump  
P.Axaopoulos, S.Kyritsis  
pp. 52
3. The potential of heat pump applications for energy conservation in an olive press  
G.Vourdoumbas  
pp. 53
4. Spray type desalination assisted by heat pump  
D.Tsitsis  
pp. 54
5. Hybrid solar drying for agricultural crops  
M.Tsabralis, M.Marousis  
pp. 55
6. Greenhouse heat transfer dynamics. A computer application program  
D.Kritharidis, E.Kayafas, G.Cambouridis  
pp. 56

## 10. WIND ENERGY

1. Installation of wind turbines in the "OTE" stations of islands Kea, Paros and Syros.  
P.Dokopoulos, I.Pinatsis, Ch.Dimoulis  
pp. 57
2. Experimental study of the pressure distribution on the blades of a horizontal axis wind turbine  
A.Papaconstantinou, G.Bergeles, N.Athanasiadis  
pp. 58
3. Data acquisition systems for photovoltaic and wind power generating stations  
P.Pligopoulos, A.Androutsos  
pp. 59
4. A methodology for site selection of wind turbines over complex terrain  
D.Trifonopoulos, G.Bergeles, N.Athanasiadis  
pp. 60

5. Regulations, licence procedures and non-technical issues related to private wind turbine plants.  
I. Pinatsis, P.Dokopoulos  
pp. 61
6. Pilot study for the installation of a wind park at Ano Moulia, Crete Island  
A.Zervos, G.Ayerides, Y.Glekas, Th.Papaconstantinou  
pp. 62
7. Monthly wind power assessment of the Pogonitsa region, Greece  
A.Antoniou, H.Stapountzis, G.Tsilingiridis  
pp. 63
8. A Greek wind turbine 220/50Hz with advanced technology  
Ch.Vouros  
pp. 64
9. Site selection for windfarms in Greek Islands  
A.Androustos, E.Bakis  
pp. 65
10. Installation of a 250KW wind turbine interconnected to a heat pump-heat storage system  
D.Papastefanakis, M.Karagiorgas  
pp. 66
11. Study for a 150KW wind turbine application for irrigation in Anogia, Greece  
A.Zervos, S.Garyfalakis, D.Papastefanakis, Ch.Chaldoupis  
pp. 67
12. Stochastic modelling of the electric output of wind turbines  
Th.Karakatsanis, N.Chatjiargyriou  
pp. 68
13. An evaluation of some methods for estimating the two parameters of the Weibull distribution  
Th.Karakostas, E.Flocas, K.Kakaliagou  
pp. 69
14. Studies on the load flow and the output loss in large wind parks  
S.Garyfalakis, K.Vournas  
pp. 70
15. Energy effectiveness and optimal design of arrays of wind turbines  
S.Voutsinas, A.Zervos  
pp. 71
16. Energy calculation for the wind farms on Limnos  
D.Kanellopoulos, F.Zachos  
pp. 72
17. Self-excitation of wind driven generators, following a grid interruption  
Ch.Dimoulas, P.Dokopoulos  
pp. 73
18. Voltage and frequency fluctuations caused by wind generators in small grids  
Ch.Dimoulas, P.Dokopoulos, A.Laskareli  
pp. 74
19. Feasibility analysis of private wind turbine parks  
E.Gavanidou, M.Ketselidis, T.Bakirtzis, P.Dokopoulos  
pp. 75

20. Results of the cost effectiveness analysis for private wind energy parks  
E.Gavanidou, M.Ketselidis, T.Bakirtzis, P.Dokopoulos  
pp. 76

## 11. HYDRAULIC ENERGY

1. Selection of a centrifugal pump to stock and generate the energy produced by a windmill  
D.Papantonis  
pp. 77
2. Design of a "Cross Flow" water turbine  
M.Panagiotopoulos, D.Papantonis  
pp. 78
3. Small hydroelectric plans in Greece: energy and economic considerations  
G.Douzinas  
pp. 79

## 12. GEOTHERMAL ENERGY

1. Design and construction of two simple systems for distribution of geothermal energy in greenhouses  
M.Grafiadellis, G.Spanomitsios, I.Asimakopoulos  
pp. 80
2. Factors influencing scaling due to high enthalpy geothermal fluids  
A.Karabelas, N.Andritsos, A.Mouza  
pp. 81
3. Parameters for a rational development of geothermal resources  
G.Koutinas  
pp. 82
4. Opportunities for the development of technology for the exploitation of geothermal energy in Greece  
M.Goumas, Y.Kalogirou, L.Papayannakis  
pp. 83
5. The use of geothermal energy for industrial cooling  
D.Kouremenos, S.Chatzidakis  
pp. 84
6. The significance of zero dimensional models in geothermal reservoir simulation. A case study  
J.Gelegenis, N.Koumoutsos  
pp. 85
7. The thermal status in the sedimentary basin of Thessaloniki  
N.Kollios, Th.Kavouridis  
pp. 86
8. A model for low-medium enthalpy geothermal energy development: Implementation on Polichnitos area  
T.Goumas, M.Christou  
pp. 87

## XIV

9. Development possibilities of medium and low enthalpy geothermal energy-ETBA A.E. programme  
I.Argyropoulos  
pp. 88
10. Use of multicriteria decision making methods for optimum utilization of geothermal energy. Application to the geothermal field of the Nea Kessani-Thrace  
D.Psychogios, M.Goumas, V.Lygerou  
pp. 89
11. Setting of priorities for the development of the geothermal energy in Greece. Multiple criteria analysis of the problem and first results  
M.Goumas, V.Lygerou  
pp. 90
12. A method for determining flow rate and quality of two phase geothermal fluids  
M.Samolada, S.Paras, A.Karabelas  
pp. 91

## 13. BIOMASS

1. Energy sources management in Apiranthos, Naxos: the case of biomass  
Th.Tsoustos, L.Pyrgiotis, V.Mauvatjas, E.Koukios  
pp. 92
2. Integrated energy utilization of swine wasters in Naxos Island  
A.Tsvdaris, D.Georgakakis, P.Axaopoulos  
pp. 93
3. Contribution to the study of solar radiation effect on Biomass production in an optimized HRAP system  
F.Batzias, S.Arnoutis  
pp. 94
4. Biomass production with plantations of fast growing species  
K.Panetsos  
pp. 95
5. Thermochemical densification of biomass-process investigation for production application  
D.Koullas, N.Ambatzoglou, E.Koukios  
pp. 96
6. Direct microbic conversion of pre-treated straw to ethanol  
P.Chrystacopoulos, D.Koullas, D.Kekkos, E.Koukios, V.Makris  
pp. 97
7. Economical evaluation of anaerobic digestion as an energy production process; the case study of Vinassa treatment  
A.Vlissidis, A.Zoumboulis, A.Hatzifotiou  
pp. 98
8. The use of linear and non-linear mathematic models for the simulation of biomass systems: Principles-methodology, limitations, applications  
K.Chatjigiannakis, E.Koukios  
pp. 99

**14. SOLID WASTE EXPLOITATION**

1. The energy criterion in the evaluation of packaging materials recycling  
D.Diakoulaki, N.Koumoutsos  
pp. 100
2. Wastes and their evaluation  
I.Frantzis  
pp. 101

**15. TECHNOLOGIES OF PHYSIOCHEMICAL CONVERSION**

1. Odor emission in the sugar industry; measures and control  
I.Velentza  
pp. 102

**16. LAW AND FINANCIAL PROBLEMS OF RENEWABLE ENERGY SOURCES**

1. Oil substitution by renewable sources and development  
C.Stelakatos  
pp. 103

**17. RENEWABLE ENERGY SOURCES AND THEIR IMPACT ON THE ENVIRONMENT**

1. District heating: the solution for a clean and hygienic environment  
O.Planakis  
pp. 104
2. District heating by biomass and solid waste combustion  
O.Planakis  
pp. 105
3. On the employment energy sources in the power system of Crete  
T.Papazoglou  
pp. 106

**18. ENERGY CONSERVATION IN INDUSTRY**

1. Steam electricity co-operation proposal in the industrial area of Thessaloniki  
P.Christodoulou  
pp. 107
2. Energy conservation by electricity and heat co-generation in the industrial area of Thessaloniki  
G.Alivizatos, A.Vacalis  
pp. 108





# NOCTURAL THERMAL SKY RADIATION IN THE SUMMERTIME IN ATHENS. INFLUENCES OF THE ATMOSPHERIC POLLUTANTS

G.PAPADAKIS, G.VOULGARIS, S.KYRITSIS

Laboratory of Agricultural Structures, Agricultural University of Athens

A.FRANGOUDAKIS

Faculty of Architecture, School of Engineering, A.U.T

Measurements of the noctural thermal radiation in Athens have been made during June 1987. The measured values were correlated to the usual relations giving the thermal sky radiation. It was found that the equation of Brunt, Brutsaert and Idso fit the measured data. Taking as criterion the value given by the intersection of the radiation axis, an equation relating the ambient temperature (exponent six) and the partial pressure of water (exponent two) has been derived. The atmospheric pollutants have real influence on the sky radiation. The proposed equation, fitting best the measured values, involves the sum of the partial pressure of the five pollutants, NO, NO<sub>2</sub>, SO<sub>2</sub>, CO, and O<sub>3</sub> with the exponent two as well as the ambient temperature and the partial pressure of water.

**KEY WORDS:** Nocture atmospheric radiation, temperature, humidity and pollutants of the atmosphere.

\* \* \*

## COMPARISON OF MODELS OF SOLAR RADIATION-SUNSHINE DURATION

F.A.BATZIAS, S.G.ARNAOUTIS

Research Group of Systems Analysis, The Piraeus Institute of Technology

This work deals with the comparison of the main competitive models of the relation solar radiation-sunshine duration. It is proved that linear and multi-linear as well as exponential models are statistically adequate and reliable. Linear models predominate in simplicity and diffusion among users, while exponential models are most likely to be combined with other "explanatory" functions. It is proved that the weighting of linear and non-linear regression do not differentiate substantially the parameter estimators produced by the usual methods of regression without weights and with simple linear regression (by the use of the corresponding linearized model) respectively. Moreover, it is proved that the superiority, quoted in literature, of the Angstrom-Black equation against its rival exponential models is due to the erroneous use of solar radiation  $Q$  as dependent variable in the place of the correct reduced form  $Q/Q_0,i$ .

**KEY WORDS:** Angstrom-Black Equation, Model Validation, Parameter Estimation, Regression, Solar Radiation, Sunshine Duration

\* \* \*

## A STUDY ON THE RESIDUALS OF SOLAR RADIATION- SUNSHINE DURATION CORRELATION

F.A.BATZIAS, S.G.ARNAUTIS

Research Group of Systems Analysis, The Piraeus Institute of Technology

This paper deals with the investigation of statistical adequacy of the linear relation between relative solar radiation  $Q/Q_0$  and sunshine duration  $n/N$ . It is proved that this model is generally adequate but the residuals (RES) of regression show systematic deviation leading to underestimation of solar radiation  $Q$  during the spring and corresponding overestimation during the winter. In the case of Athens basin it is proved that we may distinguish three 4month periods: March-June with high relative frequency (RF) of underestimation of  $Q$ , July-October with very low RF of underestimation and November-February with high RF of overestimation of  $Q$ . These deviations may lead to considerable errors when the  $Q$ -value of a certain month is used for the design of an installation. For the correction of the  $Q$ -estimations, we suggest the introduction of a coefficient which can be easily estimated with reliability as we have also proved that  $Q$ ,  $n$  and the RES follow the normal distribution.

KEY WORDS: Analysis of Residuals, Angstrom-Black Equation, Estimation of Parameters, Solar Radiation, Sunshine Duration, Normal Distribution, Overestimation, Underestimation

\* \* \*

## CORRELATION BETWEEN SUNSHINE DURATION AND TOTAL SOLAR RADIATION FOR THESSALONIKI

CH.SACHSAMANOGLOU, T.MAKROGIANNIS  
Laboratory of Meteorology-Climatology, Dep. of Geology, A.U.T.

Solar radiation measurement for Thessaloniki cover a rather small period. An assessment of its monthly values is, thus, presented, according to the Angstrom correlation. In particular, the constants a and b were calculated, based on sunshine duration data for the periods 1931-40 and 1946-87. The solar energy availability in Thessaloniki is rather low, in comparison to the extraterrestrial radiation. Furthermore, a reduction in its values may be manifested over the last 50 years. This reduction is believed to be the result of atmospheric pollutants, (mainly solid particles) rather than attributed to the presence of heavy clouds over the period considered.

KEY WORDS: Solar radiation, sunshine duration

\* \* \*

## RELATION BETWEEN CLOUD COVER AND SUNSHINE DURATION IN THESSALONIKI

CH.SACHSAMANOGLOU, D.CHATZIOAKIM

Lab. of Meteorology-Climatology, Dep. of Geology, A.U.T

The cloud cover in Thessaloniki over the year presents typically a simple fluctuation with a maximum in December and a minimum in August. For a Fourier analysis of its variations, the first three harmonic coefficients describe it by 100%. No significant variations of the cloud cover were observed over the past 50 years, although, some months (July) show a tendency for increase and some others (November) a tendency for decrease. The analysis of the cloud cover data has not revealed any significant periodicity of 3 years. For the Thessaloniki area a simple linear correlation exists between the cloudiness and the sunshine duration.

KEY WORDS: Cloud cover, sunshine duration

\* \* \*

## ON THE ESTIMATION OF MONTHLY AVERAGE HOURLY VALUES OF GLOBAL IRRADIATION OVER GREECE

A.A.FLOCAS, A.A.BLOUTSOS, P.J.PENNAS

Department of Meteorology and Climatology, University of Thessaloniki, Greece

The hourly solar radiation data for six stations over Greece are analyzed. Monthly average values of the ratio  $r_t$  ( $r_t$ =hourly/daily of global irradiation on a horizontal plane) are plotted against the solar time, for each of the 12 months. The normal distribution curve:  $p(t)=(1/\sigma\sqrt{2\pi})\exp(-(t-12)^2/2\sigma^2)$  is found to fit the data closely. The  $\sigma$  values are found to be related to the monthly average daily maximum possible sunshine duration ( $s_0$ ) by the linear equation  $\sigma=as_0+b$ . The values of the correlation coefficient of the six obtained equations range from 0.983 to 0.994. The used technique is simple, fairly accurate and enables the estimation of the hourly values of global irradiation at a place where such measurements are not available.

KEY WORDS: Radiation, Sunshine duration

\* \* \*

MEASUREMENTS AND COMPUTATION METHOD FOR TOTAL  
SOLAR IRRADIANCE FLUX THROUGH INCLINED SURFACES  
WITH ARBITRARY ORIENTATION

H.KAMBETZIDIS, N.PAPANIKOLAOU

Institute of solar meteorology and Physics of the Atmospheric Environment,  
National Observatory of Athens, P.O. Box 20048,  
11810 Athens, Greece

This paper presents the first experimental measurements of hourly total solar radiation fluxes on any day of the year through inclined surfaces of arbitrary azimuthal orientation in Greece. The application of a clear-day model developed by the authors shows good approximation to the measurements (Figs 3,4,5b). Fig.5a shows the calculation of the total solar radiation flux at tilt angles in the range  $0^{\circ}$ - $90^{\circ}$  at 1300 LST on 4/8/1987. Also shown are measurements of the same quantity at selected tilt angles ( $8^{\circ}$ - $88^{\circ}$  with a step of  $10^{\circ}$ ) made in the period 25/7 to 12/8/1987 at the National Observatory of Athens. Despite the time difference the approximation is quite good.

\* \* \*

**TECHNIQUES OF PASSIVE COOLING OF BUILDINGS****A.DIMOUDI**

Civil Engineer, 4 Esopou st. Serres

**P.LIVERIS**Civil Engineer-Solar Village's Measurement and Evaluation Team,  
71 Erithrou Stavrou st., 186 48 Drapetsona, Piraeus

The main techniques of Passive Cooling of Buildings are presented in this paper, classified according to the natural processes of heat transfer: Convection, radiation, conductance, evaporation. Each of them is briefly described and their characteristic parameters underlying their performance and efficiency are mentioned.

**KEY WORDS:** Passive systems, passive cooling of buildings, natural ventilation, solar chimney, wind-tower, roof-pond, water-film, roof-spray, underground building, air-pipes

\* \* \*



4 EXAMPLES OF PATHETIC SOLAR PLANNING-MODERN-  
POSTMODERN AND CONTEMPORARY ENVIROMENTAL LOCO-  
CENTRIC PLANNING

M.SOUVATZIDIS

Architect

The 4 examples contain the methodology of pathetic solar planning, the results of calculated with an electronic computer (method BALCOMB) and an electronic device constructed for the measurement of temperature around.

**KEY WORDS:** Ecology, participation, enviromental planning, loco-centric planning, pathetic planning, sun protection, multiplicity, collective memory, mild technologies, decentralisation consciousness, modern, postmodern

\* \* \*

## THE SOLAR TOWN HALL OF PALEO PHALIRO

G.KONTOROUPIIS, T.BIRIS, G.CHRISTOFILIS, P.KOKORIS  
National Technical University of Athens

TH.VOUDIKLARIS  
Civil Engineer

In the Hellenic Architecture Competition for the study of the Town Hall-Cultural Center of Paleo Phaliro, a condition of incorporating passive solar heating systems was included. According to this condition, the ambition of our team to design a novel solar building for both space heating and hot water production has been materialized. Simple technology, construction techniques and materials were adopted for harmonic overall design. The final product conveys a clear message for the vast potential of solar energy utilization in space heating.

**KEY WORDS:** Town Hall, Paleo Phaliro, solar systems, greenhouse, atrium, shading, movable insulation

\* \* \*

## ENERGY EFFICIENCY OF PERIPHERAL UNITS IN MODERN POULTRY PROCESSING PLANTS

M.J.KONSTANTINOY  
El. Eng. IPB

J.L.SOUFLIS  
El. Eng. N.T.U

A.V.MACHIAS  
Ass. Profesor N.T.U

This paper is studying the energy efficiency of a specific peripheral poultry processing plant. The study includes the analysis of the energy requirements of that specific unit as well as the factors influencing the energy consumption. This unit is interesting since its thermal requirements are satisfied through the burn of olive kernel. There are suggesting methods and procedures which can apply with the intent of saving energy. Finally, the possibility of technological advancement with import of new technology is also studied. (Optimization of energy efficiency with usage of solar energy-Biogás, as well as the set up of new departments or automation of existing departments in production procedures). The total energy requirements are calculated in  $3,2 \cdot 10^6$  MJ per year, i.e. the consumption per Kg. ready to cook weight is 1.4 MJ. As a result the percentage of electrical energy is 64% and that of the heat energy is 36%. From the recommended program regarding the reduction of energy consumption the following energy saving percentages are deduced:

- a) 26% for electrical energy
- b) 39% for heat energy

\* \* \*

## EFFECTS OF BUILDING CONSTRUCTION ON THE PRIMARY ENERGY CONSERVATION IN GREECE

V.SOTIROPOULOS, K.PAPAKOSTAS

Lab. of Process Equipment Design, A.U.T.

The effects of the geometry of a building on its heating requirements is investigated. Consequently, the impact of the various modes adopted in the construction of buildings on the energy consumption is assessed. Finally specific solutions are recommended for energy conservation

KEY WORDS: Building, heat losses, energy conservation

\* \* \*

## THE REVIVAL OF STONE ARCHTECTURE

G.BATJILIS

The tradition of the stone architecture has survived thanks to the painting and both oral and written inheritance to the new generations. Monuments and houses built in Greece in the 50's are giving examples of the stone architecture. The international trends seem to encourage such a revival. However, due care is needed because of the particular features of this architecture in Greece. The most critical point for its success is the choice of the suitable technology among those already mastered, which will closely relate with the tradition.

**KEY WORDS:** Stone architecture, modern technology

\* \* \*

## ENERGY CONSERVATION IN BUILDINGS WITH PLANTS AND GREEN AT THEIR ROOFS AND FACADES

K.EVMORFOPOULOU

Architect, Assistant

Division of Science and Technology of Constructions,

Department of Civil Engineering, Aristotle University of Thessaloniki

Green is necessary in cities for various reasons. One important reason is its positive influence in the climate-formation of cities. With the increasing reconstruction, green areas are constantly decreasing. One type of replacement for the disappearing green, is its transfer at the openspaces, the facades and the roofs of the buildings. At the above mentioned surfaces, beside the other function-aesthetics, psycology, health, ecology-green can cover necessities of constructive physics (indoorclimate) and climate. It controls the temperature and the humidity of the buildings' enviroment, acts as heatj-insulating, offering codness during summer, warmth during winter, and protects them from the influence of winds.

KEY WORDS: Vegetation, Facade, Roof, Wind, Heat-insulation, Humidity

\* \* \*

**APPLICATION OF PASSIVE SOLAR SYSTEMS IN TWO  
SCHOOLS IN CRETE AND CALCULATION OF THEIR  
PERFORMANCE**

**Y.KALLIGERIS**

Architect, M. Koundourou 22, 731 00 Chania, Greece

**Dr.M.SANTAMOURIS**

Phisicist, Energy Consultant,  
4 Bikou st. 163 42 Ilioupolis, Greece

The buidings are located in Rethymnon, Crete. Each building is used as a kindergarten for 60 children and a primary school for 180 children. For the heating and cooling of the buildings direct gain systems, greenhouses, cross ventilation and earth-contact are used. Notably the buildings do not have any additional heating sources.

**KEY WORDS:** Earth-contact; direct communication with courtgard-level, shell protection direct gain, greenhouse, natural lighting, sunprotection, thermal selfsufficiency, calculations

\* \* \*

**A DEMONSTRATION PROJECT IN PASSIVE SOLAR  
ARCHITECTURE OF THE COMMISSION OF THE EUROPEAN  
COMMUNITIES**

**G.BERNDT**  
Dipl. Engineer

**M.PAPADOPOULOS**  
Civil Engineer

Over 42% of the total energy consumption in W.Germany takes place in the space heating in the transportation sectors. Each one of the 25 millions families consumes more than 2000lt of oil, thus being a significant source of environment pollution. Since burning of fossil fuels is inexorably combined with the pollution of the environment, any effort towards the reduction of fossil fuel needs should be supported. Solar energy utilization for space heating consists a very sound step towards this direction

**KEY WORDS:** Passive solar systems, Houses, Glass, Greenhouse

\* \* \*



DETERMINATION OF POPULATION DENSITY AND BUILDING  
REGULATIONS WITH GEOMETRICAL METHODS. HOUSE  
ORIENTATION

A.ANASTASIADIS

Ass.Professor, Architectural Engineer Dep., A.U.T

The orientation of a building is addressed in a general form in the present study. Useful results have resulted for Greece; in particular, various correlations have been established between the building regulations in large urban centers and the building orientation. The population density, the number of floors and the overall building regulations at different latitudes have been considered. A coefficient of "hygienic living" has been introduced. A geometrical interpretation of differences encountered in various buildings is provided, based on their orientation. Thus, an answer has been given to the question of whether it is possible to conserve energy in urban sites by solar energy utilization.

KEY WORDS: Building orientation, population density, hyperbolic paraboloid, building regulations, environment quality

\* \* \*

## SOLAR HOT WATER CENTRAL SYSTEMS OF AN OPEN LOOP/SINGLE PASS TYPE

**G.KOSTOYLAS**

Mechanical-Electrical Engineer, NTU

**A.EFTHIMIADIS**

Mech.-Elec. Engr. NTU, PhD MIT, EL.KE.PA

**V.BELESSIOTIS**

Research Scientist, Democritus Lab.

In this paper the solar hot water central systems of an open loop/single pass type are analysed, both from a thermal and economic point of view. A methodology is developed which performs optimal sizing of the main parameters of a single-pass system: the collectors' area, the heat exchanger area, the ratio of the flow rates at each side of the heat exchanger and the volume of the storage tank. It is found that large scale optimal single-pass systems exhibit very good economic performance in comparison to the classical multi-pass systems and that economic optimization is required in order to achieve this performance.

**KEY WORDS:** Active Solar System, Solar Hot-Water Systems, Design and Optimization

\* \* \*

## THERMO-HYDRAULIC SIMULATION OF A SOLAR DOMESTIC HOT WATER SYSTEM UNDER PSEUDO STEADY-STATE CONDITIONS

V.BELESSIOTIS

Physicist, Research Scientist, "Democritos" N.R.C.P.S.

A.EFTHIMIADIS

Mech. Engr. PhD MIT, ELKEPA

P.ANDRONIKOS

Elec. Engr., Research Scientist, "Democritos" N.R.C.P.S.

In this paper we present the experimental results of the thermal behaviour of a closed loop thermosyphonic unit. We also analyze its basic characteristics. During a 12 hours working period the operation of the thermosyphon unit is distinguished by three characteristic phases:

- I. Starting Phase
- II. Quasistable Phase
- III. Saturation Phase

Analytical equations for the instantaneous simulation of the thermosyphon unit, 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. Finally it was followed that the heat transfer coefficient of the storage tank  $U_e$ , remains constant.

\* \* \*

## PERFORMANCE MONITORING OF A THERMOSYPHONIC UNIT INSTALLED AT A CUSTOMER'S HOUSE AND DAILY WATER CONSUMPTION PROFILES

T.A.PAFELIAS

Dr. Mechanical & Electrical Engineer, Consultant CALPAC BP

A specially designed monitoring system has been used to monitor (printing every hour) the performance of a thermosyphon (160 liters, 4m<sup>2</sup>) installed at a customer's house. Monitoring took place under real conditions of operation of the thermosyphon. Measurements were conducted for a period of eight-months. Performance data have been "extended" for the remaining four months so that a whole year could be covered. Furthermore, there was a correction for some "abnormal" use of the electric energy. Under these assumptions it was found that the sun covered 59% of energy needs for hot water, while electric energy was used for the remaining 41%. The system efficiency was 29.3% and the solar energy obtained was 456 Kwh/m<sup>2</sup>. Finally hot water consumption profiles have been created.

KEY WORDS: Thermosyphon, Measurements, Performance, Solar Fraction, Water Consumption Profiles

\*\*\*

## USE OF HOT WATER IN SOLAR DHW IN GREECE

T.A.PAFELIAS

Dr. Mechanical & Electrical Engineer, Consultant CALPAC BP

Simple flow meters have been installed at thirteen users of solar domestic hot water (DHW) Systems in Greece ( ten in Athens, three in Corinth), in order to gain information about the hot water consumption. The measured (15 months) consumption is 34 liters per day and per person. Data are included (four users) about the monthly average hot water consumption during a year. There was parallel monitoring of the electric energy used in the case of nine users. It was found that each person was using 139 Kwh per heating season ( November to April).

**KEY WORDS:** Solar Domestic Hot Water Systems, Water Consumption, Electric Energy Consumption, Measurements

\* \* \*

## TESTING METHODOLOGIES FOR THE DETERMINATION OF THE THERMAL PERFORMANCE OF SOLAR DOMESTIC HOT WATER SYSTEMS

D.GILLIAERT, P.TEBALDI

Joint Research Centre, 21020, Ispra (Varese), Italy

Solar domestic hot water systems are one of the applications of the solar energy technology which has reached the level of a breakthrough in various regions in Europe, especially where industrialists succeeded combining the requirements of thermal performance, system reliability and durability, price and comfort. The commercialized systems cover different system types, which can be grouped as forced circulation systems, thermosiphon systems, systems with a two phase heat transfer fluid and integrated collector systems. Even within each group, a wide range of sizes is available. Although all systems have a common goal of heating water, one can distinguish a large variety in designs. This makes even more difficult the choice of the user, as he is missing information on the system performance, durability and reliability, in relation to its location.

The development of standard procedures for the determination of the thermal performance of a system will contribute to the further development of the solar market where there will be space for only high quality products. Such standard testing procedures should not only take into account the specific demands for the manufacturers and users, but should also consider the testing effort, time and costs.

Important theoretical and experimental research activities were carried out at the Joint Research Centre (JRC), which is part of the Commission of the European Communities (CEC), and in various national laboratories of the 12 member countries. These various efforts were fully integrated and were a substantial part of the workprogramme of the "Collector and System Testing Group" (CSTG), which was a concerted action, directed by the CEC-JRC and involved the active collaboration of 22 national laboratories.

\* \* \*

## EUROPEAN RESEARCH ACTIVITIES ON TEST METHODS FOR SOLAR COLLECTORS AND SOLAR WATER HEATING SYSTEMS

W.B.GILLETT, J.E.BATES

Sir William Halcrow & Partners Ltd, Burderop Park, Swindon, UK

E.AРАНOVITCH, D.GILLIAERT

CEC Joint Reasearch Centre, Ispra 21020, Italy

M.ANTINUCCI

Conphoebus s.c.r.l, Via G Leopardi 148, 951217 Catania, Italy

The European Research programme on test methods for solar collectors and solar water heating systems has been carried out since 1975 with the participation of more than 20 European laboratories engaged in standards activities. The main aim of this programme is to support the European solar industry by raising confidence through the development of experimentally based standards, and by encouraging collaboration between specialists from research centres and industry within the European Community. The work has led to the development of performance test procedures for collectors which have been widely used as a basis for National and International Standards, including those published by the International Standards Organisation (ISO) and the European Union of Agreement (UEAtc). Recent work has been focussed mainly on the development of qualification tests to determine the durability of collectors, and performance test procedures for solar water heating systems, air collectors, and unglazed collectors. A new approach has been developed for determining the long term performance of all types of family sized solar water heating systems.

**KEY WORDS:** Solar heating systems, solar collectors, durability, performance, test procedures, Standards

\* \* \*

## COLLECTOR COMBINING SOLAR HEATING AND RADIATIVE COOLING

A.FRAGOUDAKIS

Faculty of Architecture, School of Engineering, A. U. T.

G.PAPADAKIS, S.KYRITSIS

Lab. of Agricultural Structures, Agricultural Univ. of Athens

In this work a numerical simulation method that considers the radiation exchange in a flat plate collector covered with a Polyethylene film is described. The authors have tried to introduce a number of parameters as functions of the temperature (i.e. convection in the air layer between radiating surface and cover) and further, diffuse geometrical configuration factors as functions of the real geometry, the position and the horizon of the collector. After a short presentation of the models used, results from applying the simulation method to a real collector will be compared with those obtained experimentally. A fair agreement between numerical and experimental results will be achieved.

**KEY WORDS:** Solar Collectors, Thermal Radiation, Radiative Cooling, Night Sky-Radiation

\* \* \*



THEORETICAL AND EXPERIMENTAL DETERMINATION OF THE  
DHWS PARAMETERS. LONG TERM THERMAL PERFORMANCE  
OF DHWS

V.BELLESOTIS, P.ANDRONIKOS,  
N.R.C.P.S "Democritos", Aghia Paraskevi 15310 Attiki

K.PAPATHANASOPOYLOS  
University of Patras, Dpt of Physics 26000 Patras

In this paper we present the theoretical derivation of the equation (1) which was experimentally used by Dr. D. Gilliaert [1] for the evaluation of the Thermal Performance of DHWS. i.e

$$Q_{out} = a_1 H + a_2 (T_a(av) - T_c) \quad (1)$$

$Q_{out}$  = Useful energy extracted from the system 6 hours after solar noon

$H$  = Daily irradiance

$T_a(av)$  = Average ambient temperature

$T_c$  = Cold water inlet temperature

$a_1, a_2$  = coefficients of the systems

We also describe the method for calculating these coefficients, and the necessary measurements for calculating the long term performance of the domestic Thermosyphon units. Finally we present our experimental results for long term prediction of DHWS using the results of the short term system test.

\* \* \*

## EFFECTS OF THE EXTERNAL SURFACE CONVECTION COEFFICIENT ON THE THERMAL PERFORMANCE OF A BUILDING

D.BOZIS, V.SOTIROPOULOS  
Lab. of Process Equipment Design, A.U.T.

The effects of the convection heat transfer coefficient of the external surfaces of a building on its thermal performance are investigated. This has been analysed under various climatic conditions for different values of the convection coefficient, by using the finite differences method. The results show that for an external wall with good thermal insulation the effects of the external surface convection heat losses are small or minimal, at least for surfaces shaded from the sun.

**KEY WORDS:** External heat losses, convection, building, thermal performance

\* \* \*

## A MODEL FOR THE DETERMINATION OF 2-DIMENSIONAL TEMPERATURE DISTRIBUTION IN RECTANGULAR BUILDING ELEMENTS

K.DIMOULAS, N.PAPADOPOULOS, D.BOZIS, V.SOTIROPOULOS

Lab. of Process Equipment Design, A.U.T.

The mathematical model employed for the analysis of the temperature distribution in rectangular building elements is presented. The differential equations describing the heat flow are modified to a system of algebraic equations by using the finite differences method. The features of the computer programmes developed are also presented. The results derived are compared to those from other workers. Finally, some representative examples for geometries not accounted in previous studies are given.

**KEY WORDS:** Rectangular building elements, finite differences, temperature distribution, thermal insulation

\* \* \*

ENERGY CONSERVATION IN THE DOMESTIC -  
(APPLICATION IN THE DEPARTMENT OF LESVOS)

T.GOUMAS, M.CHRISTOU  
Energy Policy Unit, NTUA

The region-faced energy conservation gives more opportunities for detailed analyses and for evaluation of certain interventions at a financial, technological and informational level. In this study the methodology developed for facing the problem is presented, in combination with the real case of the Department of Lesvos. First, through an on-site survey, the energy consumption by use, fuel and appliance was estimated. After the analysis of the qualitative and quantitative characteristics of the consumption and the study of the energy technologies' market, we concluded in certain proposals which constitute the intervention and concern: central (or intergrated) woodstoves, electric night storage heaters, heat pumps, fluorescent lamps and solar collectors. For these technologies, a central (Nomarchia) intervention is proposed, through information campaign and subsidies, aiming at the penetration of these technologies in the region's households. In addition, by using the simulation model RUEB, we estimated the financial and energy dimensions of the intervention as well as microeconomic information for potential investors.

KEY WORDS: Energy Conservation, Domestic Sector, New Energy Technologies, Central Woodstove, Regional Economy, Lesvos Department, Simulation Model, Microeconomic Evaluation.

\* \* \*

## A COMPARISON OF SOLAR DRIVEN $\text{NH}_3/\text{H}_2\text{O}$ AND $\text{H}_2\text{O}/\text{LiBr}$ ABSORPTION REFRIGERATORS

D.A.KOUREMENOS

Profesor

K.A.ANTONOPOYLOS

Ass. Profesor

E.ROGDAKIS

Research Assistant

National Technical University of Athens,  
Mechanical Engineering Department,  
42 Patission St. Athens 106 82 Greece

A solar driven absorption refrigeration unit operating with  $\text{NH}_3/\text{H}_2\text{O}$  mixture is compared to the corresponding  $\text{H}_2\text{O}/\text{LiBr}$  absorption unit. The comparison is based on hour by hour calculation of the performance of both units during the typical year in the Athens area. The hourly local values of solar radiation and ambient temperature have been determined in previous publications by a numerical processing of related data corresponding to many years. A method is developed for simulating the operation of the absorption unit, which is based on functions describing the thermodynamic properties of the  $\text{NH}_3/\text{H}_2\text{O}/\text{LiBr}$  absorption refrigerator provides higher values of theoretical cooling power with theoretical coefficient of performance ranging from 86% to 96% along the typical year. In the case of the  $\text{NH}_3/\text{H}_2\text{O}$  absorption refrigerator the calculated theoretical coefficient of performance is lower, i.e. from 72% to 75%, but the temperatures obtained are lower than those of the  $\text{H}_2\text{O}/\text{LiBr}$  unit.

**KEY WORDS:** Refrigeration unit, Solar Energy, Absorption, Ammonia, Lithium Bromide, Athens

\* \* \*

## CONSTANT HEAT STORAGE AND PUMPING BASED ON THE ZEOLITE-WATER ADSORPTION INTERMITTENT CYCLE

M.KARAGIORGAS

PhD. Mechanical Engineering, Spec. Collab. GSRT, Tel. 7711519

F.MEUNIER

Maitre de Recherches CNRS, Laboratory of Fluid Thermodynamics,  
LIMSI, Orsay, FRANCE

The present work explains the adaptation of an adsorption Zeolite-water heat pump on a given house thermal supply and how the heat pump answers to the load profile. The heat pump stores heat during the night (until 309 Kwh/m<sup>3</sup>) and rejects it back to the house during the day, multiplied by its performance ratio, called COA (coefficient of amplification of the heat) The COA is between 1.30 and 1.37, depending on cycle working way and temperatures.

**KEY WORDS:** Heat pump, Energy economy, Adsorption, House heating, Heat storage, Zeolites

\* \* \*

**RELIABILITY ANALYSIS OF DOMESTIC HOT WATER SOLAR  
COLLECTORS INSTALLED IN GREECE**

**S.PANTELIOU, G.BOUZIOTIS, T.CHONDROS, A.DIMAROGONAS**

University of Patras, Depr. of mechanical engineering, Machine Desing Lab.

Reliability data concerning the functioning conditions of Solar DHW systems in operation in Greece were collected. A computerized data base system was established and a statistical analysis was performed to yield reliability figures for the systems, frequencies of failures, etc. Different graphs and general conclusions describing the situation are presented.

**KEY WORDS:** Reliability of DHW Solar Collectors

\* \* \*

## NUMERICAL SIMULATION OF HEAT TRANSFER TO A WATER JET FROM A FLAT SOLAR COLLECTOR

A.BAGTZOGLU

Computational Hydrology Laboratory, Civil Engineering Dept.,  
University of California, Irvine, Ca 92717, U.S.A

A numerical simulation, based on the Simple algorithm, is performed in this study to investigate the heat transfer phenomenon taking place between a flat solar collector and an impinging water jet. It was found that in order to maximize the amount of heat transported, the flow must be laminar and characterized by a Reynolds number of the order of 100. It was also found that the maximum efficiency is achieved when the dimensionless distances between the entrance nozzles are of the order of 10.

**KEY WORDS:** Numerical Model, Flat Collector, Simple Algorithm, Laminar Flow, Sherwood Number, Dimensionless Temperature, Entrance Nozzle.

\* \* \*



**NON TRACKING CONCERNING SOLAR COLLECTORS WITH  
IMPROVED EFFICIENCY**

**J.TRYPANAGNOSTOPOULOS**

Assistant, Dept. of Physics University of Patras

**P.YIANOULIS**

Assoc. Prof., Dept. of Physics University of Patras

Novel designs of non-tracking, concentrating, solar collectors were studied, constructed, and tested. Proper design for the reduction of the thermal losses, mainly by thermal convection from the absorber to the ambient, was applied. The experimental models were tested for working temperatures up to 100 C and the results show that the collection efficiency of these models is considerably improved, compared to models which are not using this mode of suppression of thermal losses.

**KEY WORDS:** Non-tracking solar collectors, concentrating solar collectors, passive or integrated solar collectors, efficiency of solar collectors, thermal energy storage

\* \* \*

## QUALIFICATION TESTS FOR SOLAR COLLECTORS

B.BELESIOTIS, P.ANDRONIKOS, A.SPYRIDONOS,  
N.R.C "Democritos", Institute of Materials Science,  
153 10 Aghia Paraskevi, Attiki

K.PAPATHANASOPOYLOS  
University of Patras, Department of Physics, 260 00 Patras

In this paper we describe the necessary tests, carried out in our laboratory, on Solar Collectors as well as the way of performing these tests. We also present several tests methods performed on Solar Flat Plate Collectors. These tests are performed on Solar Flat Plate Collectors with or without glazing, with metallic or organic absorbers and with water or air as heat transfer medium.

The tests are the following:

- 1) Internal pressure of absorber fluid passage ways
- 2) Stagnation temperature
- 3) Internal thermal shock
- 4) External thermal shock
- 5) Short term ageing test
- 6) Rain penetration test
- 7) Mechanical tests on Collectors supports
- 8) Mechanical tests on the Cover of the Collector
- 9) Mechanical tests under dynamic charge

**KEY WORDS:** Qualification tests on Solar Collectors, Mechanical behavior of Solar Collector, Thermal behavior of Solar Collectors

\* \* \*

**ANALYSIS OF PERFORMANCE OF SOLAR SYSTEM DHW  
SYSTEMS AND PORTABLE INSTRUMENTATION FOR  
CHECKING IT**

**T.A.PAFELIAS**

Dr. Mechanical & Electrical Engineer, Consultant CALPAC BP

**E.VASEOS**

Mechanical & Electrical Engineer, BP of GREECE

The input/output Diagram (Fig. 1) of a solar DHW system and the fact that the draw off profile (Fig. 2) keeps its shape, have been used to present in a diagram the temperature difference  $T_{max}-T_c$  as a function of the daily solar irradiation for various values of  $T_a(av)-T_c$ . This diagram is considered important for manufacturers and users and is the basis for a technique which allows the checking of the performance of a DHW system at a user's house. Portable instrumentation, which can be easily attached to a DHW system, has been developed and can provide all necessary information for the checking process.

**KEY WORDS:** Solar Domestic Hot Water System, Performance, Portable Field, Measurement System.

\* \* \*

## ECONOMO-TECHNICAL OPTIMIZATION OF SOLAR ENERGY UTILIZATION IN A DESALINATION PLANT

F.A.BATZIAS, J.S.SIGALAS  
Research Group of Systems Analysis  
The Piraeus Institute of Technology

This paper is a contribution to the techno-economical optimization of solar energy utilization in a desalination plant based on the Vacuum-Freezing Ejector Absorption (VFEA) process. Optimization includes: collector area (32,500 m<sup>2</sup> for a 330,000 m<sup>3</sup>/yr plant), starting delay (0-6 yrs) and government subsidy (36-47%) for maximum energy savings.

**KEY WORDS:** Desalination, Economo-technical Optimization, Solar assisted Heating, Solar Energy, Vacuum-Freezing Absorption

\* \* \*

## IMPROVED CYCLE OF NH<sub>3</sub>/H<sub>2</sub>O HIGH PRESSURE SOLAR AIDED ABSORPTION HEAT PUMP

S.K.CHATZIDAKIS

Ass. Profesor, Nat. Techn. Univ., Athens

Mechanical Engineering Dpt.

42 Patission Street, Athens 106 82, Greece

Heat driven ammonia-water absorption systems are used either for refrigeration purposes or as heat pumps. Raising substantially the low and high pressure values the ammonia water absorption heat pump works with, and using solar energy of low temperature level, it is possible to deliver heat of high temperature level to the absorber and the condenser. Using a heat exchanger between the condenser and the evaporator the efficiency of the system will be considerably improved especially in periods when solar radiation is insufficient. After performing the thermodynamic analysis and calculating the high pressure absorption cycles the heat input and output rates and the relevant heat gain coefficients HGC of the system are given in the form of diagrams for various operation conditions.

**KEY WORDS:** Solar Energy, Absorption Heat Pump, Heat Transformer, Absorption, Ammonia

\* \* \*

## CONCENTRATION OF HYGROSCOPIC SOLUTIONS WITH SOLAR ENERGY

**S.YANNIOTIS**

PhD., Ass. Professor of Food Engineering

**E.FOUDOUKIDIS**

PhD., Chem. Engineer-Economist

In the present report the concentration of calcium chloride solutions was studied with two methods: a) by exposing the solution directly to the sun and b) by blowing warm air through the solution. The rate of concentration was measured as a function of the solution concentration, the air temperature and the depth of the solution. The percentage of solar insolation that was used for evaporation was also measured.

**KEY WORDS:** Calcium chloride, hygroscopic solutions, solar energy, regeneration, concentration

\* \* \*

## UNIVERSAL OPTIMAL CONTROL OF A SOLAR HOT WATER SYSTEM OF A SINGLE PASS TYPE UNDER CONSTRAIN

P.MANTZARI

ChE NTU, PhD Candidate at NTU

A.EFTHIMIADIS

Mech. Eng. NTU, PhD MIT, ELKEPA

D.MARINOS-KOURIS

Ass. Profesor, NTU

In this paper, mathematical closed form solutions are developed for the optimal control of the heated water flow rate in a single-pass solar system, with the objective to maximize daily solar gain. The constrain imposed is that the integral of the water flow rate passing through the collector filed during the day is fixed. Variational methods are employed for the solution of this problem. The Euler equation is formulated. The solution of the equation leads to the development of a universal optimal controler. A map is constructed which compares the solar gain improvements using the optimal versus the non-optimal control systems,

**KEY WORDS:** Solar Energy, Active Solar Systems, optimal control

\* \* \*

## PERFORMANCE OF SOLAR DRIVEN $\text{NH}_3/\text{H}_2\text{O}$ AND $\text{H}_2\text{O}/\text{LiBr}$ ABSORPTION HEAT TRANSFORMERS

D.A.KOUREMENOS, E.RODGAKIS, K.A.ANTONOPOYLOS  
Professor, Research Professor, Ass. Professor

National Technical University of Athens,  
Mechanical Engineering Department,  
42 Patission Street, Athens 106 82, Greece.

A comparison of heat transformers operating with the reversed absorption  $\text{NH}_3/\text{H}_2\text{O}$  and  $\text{H}_2\text{O}/\text{LiBr}$  regrideration cycles is made. The heat transformers receive heat by use of solar collectors under an intermediate temperature level; they reject a part of it in the ambient under a lower temperature level and deliver the remaining useful heat at a high temperature level and deliver the remaining useful heat at a high temperature level. The comparison of the heat transformers is made for operation in the Athens area, for which hourly values of solar radiation and ambient temperature are available. A method for simulation the operation of the heat transformers is developed, which is based on analytical functions describing the thermodynamic properties of the  $\text{NH}_3/\text{H}_2\text{O}$  and the  $\text{H}_2\text{O}/\text{LiBr}$  mixtures. Under the conditions examined the  $\text{H}_2\text{O}/\text{LiBr}$  heat transformer obtains a higher and more constant theoretical heat gain factor (i.e. 50.5% - 50.7%) than the  $\text{NH}_3/\text{H}_2\text{O}$  unit (44.3% - 48.3%). The theoretical useful thermal power of the  $\text{H}_2\text{O}/\text{LiBr}$  heat transformer is considerably higher than that of the  $\text{NH}_3/\text{H}_2\text{O}$  but it is delivered under lower temperature levels during the whole year.

**KEY WORDS:** Heat Transformer, Absorption, Solar Energy, Ammonia, Lithium Bromide, Athens

\* \* \*



## HONEYCOMB SOLAR POND

C.D.RAKOPOYLOS

Prof. Assoc., Mech. Eng. Dpt. Nat. Techn. Univ., Athens

E.VAZEOS, D.N.GABRIIL

Dipl. Ing., Nat. Techn. Univ., Athens

The present work gives an application of solar energy which belongs to the solar ponds class. It concerns a combination of solar collector-storage tank, which is called "Honeycomb solar pond". The pond surface is covered with floating metallic panels which are equipped with a honeycomb placed on a black selective surface in order to limit the thermal losses. The efficiency of the system is examined, via a computer program implementing the analysis, for various operation temperatures. Possible practical applications are discussed.

**KEY WORDS:** Solar Pond, Honeycomb, Thermal Storage

\* \* \*

## SOLAR DRIVEN ICE MACHINE WITH ADSORPTION OF ETHANOL ON ACTIVE CARBON

M.KARAGIORGAS

PhD Mechanical Engineering, Spec. Collab. GSRT, Tel 7711519

A.BOUBAKRI

Ph. GRENIER, M. PONS, PhD Mechanical Engineering,

Laboratory of Fluid Thermodynamics

LIMSI, Orsay, FRANCE

The solar cooling and the production of ice by solid adsorption uses the phenomenon of the adsorption of steams on the pores of a porous solid with high porosity. The solids studied for this purpose are the zeolites and the active carbons. In the present work are presented the results of a solar cooling system working on active carbon higher performance than the zeolites that are better applied for heat storage purposes (12).

**KEY WORDS:** Solar Energy, Adsorption, Porous media, Active carbon

\* \* \*

## DYNAMIC THERMAL BEHAVIOUR OF A ROCK BED HEAT STORAGE

K.DIMITRIADIS, N.PAPAGEORGIU, A.CHRISTOFORIDIS,  
V.SOTIROPOULOS

Lab of Process Equipment Design

A simulation model for the dynamic thermal behaviour of a rock bed heat storage is proposed in the present work. The storage consists effectively of a tank filled with rocks and shells. Two differential equations, one of the solid and another for the gaseous phase, are employed; these are solved by using the finite differences method. The results derived from the computer programme developed compare well to those reported by previous workers.

**KEY WORDS:** Sensible heat storage, thermal conduction, heat diffusion, temperature distribution, finite differences

\* \* \*

## ON THE THERMAL BEHAVIOR OF A SALTLESS POND

A.V.SPYRIDONOS

N.R.C.P.S "DEMOCRITOS", Aghia Paraskevi 153 10, Greece

A laboratory scale saltless solar pond (SSP) covered with paraffin oil is studied. Every thermal cycle of the SSP is composed from the period of heating and the period of cooling. A study is made based on the average initial and final temperature of each period. The efficiency of heat storage on the SSP depends linearly on the differences of the initial and the final average temperature of every cycle. The envelopes of the heating of the SSP and of the heat storage, which describe the macroscopic behavior of the SSP, are drawn. Knowing the heat transfer coefficients, a model of the energy balance, during the heating and cooling period, is proposed. In the same way the envelopes are also drawn. From the experimental and theoretical results, a satisfactory estimation of the maximum attainable temperature of the SSP, of the heat storage capacity and of the time of heat saturation can result.

**KEY WORDS:** Solar Energy, Solar Pond, Saltless Solar Pond, Heat Storage, Heat Saturation Time.

\* \* \*

## USE OF PHOTOVOLTAIC CELLS FOR THE CATHODIC PROTECTION OF STEEL PIPING FOR NATURAL GAS DISTRIBUTION

G.BATIS, N.KOULOUMBI

Ass. Prof. of National Technical University of Athens

D.DIMITROPOULOS

Mechanical and Electrical Engineer

This work concerns the applied study and the technological evaluation of the use of solar energy for cathodic protection. The study was applied on a steel piping (pilot) for the natural gas distribution. Based on laboratory and in site measurements the application study of cathodic protection was done, the type of cells and batteries was chosen, their number was calculated and the lay-out of the system was studied and structured. The first three months measurements of the output characteristics of the photovoltaic system and of the input and output ones of the cathodic protection show the efficiency and the stability of the studied system. The economical consideration indicates that the application of this system is advantageous when the distance of electric energy is more than 2 km.

**KEY WORDS:** Photovoltaics, Corrosion, Cathodic protection of steel pipelines

\* \* \*

## STUDY OF ELECTRICAL AND OPTICAL PROPERTIES OF a-SiC:H FOR PHOTOVOLTAIC CONVERSION

L.MAGAFAS, N.GEORGOULAS, D.GIRGINOUDI, A.THANAILAKIS

Laboratory of Electrical and Electronic Materials Technology,

Department of Electrical Engineering

Democritus University of Thrace, 67100 Xanthi, Greece

In this work the dependence of optical and electrical properties of a-SiC:H films on substrate temperature is studied for the first time. a-SiC:H thin films were rf sputtered on corning glass, using a 99.8% purity SiC target of constant composition (66wt% Si and 34 wt% C) and 81cm<sup>2</sup> in area. The deposition was carried out in an argon-hydrogen atmosphere and for different substrate temperatures, from room temperature up to 330 C. The rf power was 250 watts and the argon flow rate 20 scc in all cases, whereas the hydrogen flow rate was either 9 scc or 20 scc. The experimental results show a variation of electrical and optical properties of a-SiC:H films with the substrate temperature and the hydrogen partial pressure., which may be exploited in photovoltaic applications. The optical energy band gap increases, by about 0.25 eV, with the increase in substrate temperature, whereas the room temperature electrical dark conductivity varies by about two and a half orders of magnitude for the same range of substrate temperatures. Increasing the hydrogen flow rate from 9scc to 20scc causes a band gap increase by up to 0.4 eV. Depending on deposition conditions, it is possible to observe either a localized state hopping transport mechanism or an extended state carrier transport mechanism.

**KEY WORDS:** thin films, rf sputtering, electrical properties, optical properties

\* \* \*

## GROWTH AND CHARACTERISATION OF $a\text{-Si}_{1-x}\text{Sn}_x$ THIN FILMS AS PHOTOVOLTAIC MATERIALS

A.MITTAS, N.GEORGOULAS, D.GIRGINOUDI, A.THANAILAKIS

Laboratory of Electrical and Electronic Materials Technology,

Department of Electrical Engineering

Democritus University of Thrace, 67100 Xanthi Greece.

In this work  $a\text{-Si}_{1-x}\text{Sn}_x$  thin films have been grown on room temperature glass substrates using the techniques of simultaneous electron beam deposition of Si and Knudsen cell evaporation of Sn, under high vacuum conditions ( $5 \times 10^{-6}$  Torr). The characterisation of these films has been done with room temperature optical absorption measurements, to determine the optical band gap, and electrical dark conductivity measurements as a function of temperature, in the range from room temperature up to 200 C. The optical and electronic properties of  $a\text{-Si}_{1-x}\text{Sn}_x$  films have been studied systematically, for various values of x from x=0 (a-Si), down to 0.35 eV, for x=0.20. For the same range of values of x, the room temperature dark conductivity was found to increase from  $10^{-9}$  ( $\Omega\text{cm}$ )<sup>-1</sup> up to  $10^{-2}$  ( $\Omega\text{cm}$ )<sup>-1</sup>. Extended state carrier transport mechanism has been observed for low concentrations of Sn, and localized state hopping for high Sn concentrations. The systematic control of energy band gap and electrical conductivity of  $a\text{-Si}_{1-x}\text{Sn}_x$  alloys by varying the alloy composition, combined with the relatively simple and cheap technique for growing such films, make these materials very interesting in optoelectronic applications, e.g. solar cells, detectors etc.

**KEY WORDS:** thin films,  $a\text{-Si}_{1-x}\text{Sn}_x$ , growth, electronic properties

\* \* \*

## COST CONSIDERATIONS OF PHOTOVOLTAIC ELECTRICITY GENERATION STATIONS

P.KOUTRAS, G.TSILINGIRIDIS

Dep. of Mechanical Engineering, A.U.T.

Large P/V stations with power rate of 1MW, connected to a central electricity grid are examined in this study. Simulation calculations have been performed for the intensity of solar radiation, the mean monthly efficiency of the P/V and the efficiency of the overall system. The yearly fraction of the load has been calculated for stations with an average rated power. The cost of the power installed as well as the cost of the electricity produced is then determined. The analysis shows that these costs are heavily depended on the cost of the P/V panels and their efficiency. The fraction of the load that is yearly met by the P/V station is mainly depended on the area of the P/V, the capacity of the batteries not having a significant effect.

KEY WORDS: P/V Panels, P/V stations, solar energy, costs

\* \* \*



## PHOTOELECTROCHEMICAL BEHAVIOUR OF n-InSe SINGLE CRYSTALS

I.POULIOS, N.PAPADOPOYLOS

Lab. of Phys. Chemistry,  
Aristotelian University of Thessaloniki, Greece

K.FARMAKIS

Lab. of Physics, Technological Educational Institute,  
Thessaloniki, Greece

The photoelectrochemical behaviour of n-InSe single crystals was studied in the presence and in the absence of various redox systems. Among the latter,  $Ce^{3+}/Ce^{4+}$  and  $KJ/J_2$  have given the best results for photocurrent, photovoltage and photostability. Using the Mott-Schottky theory and measurements of differentials capacitance we have also estimated the donor concentration and the Fermi level of the semiconductor.

**KEY WORDS:** Semiconductor, Photoelectrochemistry, Photoelectrodes, Photoelectrochemical cells, InSe, Photovoltaic, Semiconductor/ Electrolyte Contacts.

\* \* \*

## A STAND-ALONE PHOTOVOLTAIC SYSTEM FOR DOMESTIC ELECTRIFICATION IN THE AREA OF ATTIKI

PH.TSALIDIS, A.BALOUKTSIS, A.THANAILAKIS

Dpt. of Electrical Engineering, School of Engineering,  
Democritus University of Thrace, 67100 Xanthi, Greece

This paper presents the design of a stand-alone photovoltaic (PV) system for domestic electrification in the area of Attiki. An optimum design technique of stand-alone PV systems based on daily simulation is used. The collection and analysis of the data related to the behaviour of the various subsystems (PV) panels, batteries and inverter) operated under real climatological conditions in Greece, are of particular interest of this paper.

**KEY WORDS:** Photovoltaics, Stand-alone, Design, Electric load, Domestic, Batteries, Solar Energy, Sensors

\* \* \*

## ACTIVE SOLAR SYSTEMS FOR DRYING AGRICULTURAL PRODUCTS

C.KYRANOUDIS, Z.MAROULIS, D.MARINOS-KOURIS

Department of Chemical Engineering, NTU, GR 106 82, Athens, Greece

The purpose of this paper is to develop and evaluate a mathematical model that would describe the dynamic performance of a solar-based tobacco-drying system and analyse its operation using a computer simulating method. On these grounds, the simulation of the aforesaid system was carried out for the period that would match the actual process (typical July). As a result of this, useful remarks were made on its dynamic response, consistency with specifications and thermal efficiency. The system proved out to be efficient during the first two days of drying, covering in this way a big percentage of the dryer's thermal duties.

**KEY WORDS:** Simulation, Active Solar System, Flat-plate solar collector, Thermal storage bed, Dryer, Plate heat Exchanger

\* \* \*

## PERFORMANCE OF SOLAR GREENHOUSE HEATING SYSTEMS WITH HEAT PUMP

P.AXAOPOULOS, S.KYRITSIS

Two different heating systems with heat pump are used for two similar greenhouses. Each greenhouse has an area of 1000 m<sup>2</sup> and has been monitored during the heating period of the first year of operation. The data obtained are analysed in order to determine and to compare the performance of systems. The results has shown that each of the systems has operated satisfactory.

**KEY WORDS:** Heat pump, greenhouse, unglazed solar collector, storage tank, average daily temperature, average night temperature, acquisition data, wind speed, solar radiation

\* \* \*

## THE POTENTIAL OF HEAT PUMP APPLICATIONS FOR ENERGY CONSERVATION IN AN OLIVE PRESS

G.VOURDOUMBAS

Chemical Engineer

Heat pumps are largely used abroad in various sectors, whereas in Greece their use is limited almost exclusively in space heating applications. The potential of a heat pump application (water to water) in an agricultural process is examined in the present work. In a previous work we addressed the potential of energy conservation in the same process, by applying waste heat recovery from its drying and fuel burning facility.

**KEY WORDS:** Energy conservation, heat pumps

\* \* \*

## SPRAY TYPE DESALINATION ASSISTED BY HEAT PUMP

**D.TSITSIS**

Former Instructor in National University of Athens,  
Member of I.S.E.S and Solar Technique Institute

A hybrid system of solar desalination assisted by water to air heat pump is presented. Spray systems are designed for both, evaporation and condensation. A description of the proposed system is provided. The operation is examined psychrometrically and also an estimate of initial and operational cost are provided.

**KEY WORDS:** Solar Desalination, Spray Evaporation and Condensation, Heat Pump Applications

\* \* \*

## HYBRID SOLAR DRYING FOR AGRICULTURAL CROPS

M.TSABARLIS, M.MAROUSIS  
Dep. of Physics, University of Athens

An hybrid solar dryer with a capacity of 1000Kg approximately has been constructed and tested. The solar section of the dryer consists of 5.65m<sup>2</sup> of flat plate air collectors and 20 vacuum tubes with an air to air heat exchanger. Various crop such as raisin, sultana, apricot, and prunes were used. The experimental results of these tests are presented.

**KEY WORDS:** Solar dryer, Agriculture, raisin, crop

\* \* \*

**GREENHOUSE HEAT TRANSFER DYNAMICS  
A COMPUTER APPLICATION PROGRAM**

**D.KRITHARIDIS, E.KAYAFAS, G.CAMBOURAKIS**

National Technical University of Athens

Computer Science Division

Zografou 15773, Athens

In this work, a computer program is presented, which simulates the operation of a Greenhouse. It takes into account the exact meteorological data of the particular place, the specific agricultural demands, the required microclimatic conditions and determines the heat transfer between Greenhouse and enviromental space. Energy resources and costs are also determined from the program, which is written in Turbo Pascal language and can be run in a common PC.

\* \* \*



## INSTALLATION OF WIND TURBINES IN THE "OTE" STATIONS OF ISLANDS KEA, PAROS AND SYROS

P.DOKOPOULOS, I.PINATSI, CH.DIMOULIAS  
Dep. of Electrical Engineering, A.U.T.

The technical aspects, the regulations and the limitations involved in the installation of wind turbines in the islands of Kea, Paros, and Syros are addressed. The fluctuations in the voltage and the frequency are considered resulting from the variations of the wind speed during operation, as well as during cut-in and cut-out periods. The specifications of the wind turbines and the power network are given. Finally a cost analysis of the overall system is provided.

**KEY WORDS:** wind turbines, installation, network specifications

\* \* \*

## EXPERIMENTAL STUDY OF THE PRESSURE DISTRIBUTION ON THE BLADES OF A HORIZONTAL AXIS WIND TURBINE

A.PAPACONSTANTINOU, G.BERGELES, N.ATHANASIADIS  
Lab. of Aerodynamics, Fluids section, Mechanical Eng. Dept., NTUA

Measurements are presented of the static pressure distribution on the blades of a horizontal axis wind turbine in the 4.5 x 3.6 m<sup>2</sup> test section of the wind tunnel of the Laboratory of Aerodynamics, NTUA. Measurements were obtained at 5 wind velocities with the wind turbine connected to the utility grid. The results show the variation of the non-dimensional loading of the blade and the lift coefficient along the blade, whilst the influence of wind velocity on lift and pressure coefficients is also evident. Conclusions are drawn about the blade loading for various tip speed ratios; a data bank is created for numerical studies of the flowfield around wind turbine rotors.

**KEY WORDS:** Horizontal axis wind turbine, blade loading, pressure distribution, lift coefficient, wind tunnel

\* \* \*

## DATA ACQUISITION SYSTEMS FOR PHOTOVOLTAIC AND WIND POWER GENERATING STATIONS

A.KORONIDIS  
PhD., SSD/PPC

P.PLIGOPOYLOS, A.ANDROUTSOS  
Eng. AED/PPC

Data acquisition systems have been installed in PV and wind energy stations of PPC in Greece. These systems monitor and record operational data. The basic design and software development was done in house. In the case of Karpathos wind gen. station the system was designed to provide remote monitoring and control of the wind-generator from the Diesel power station of the Island. The systems have been working satisfactorily and without interruption since December 1987 ( first installation).

**KEY WORDS:** Photovoltaic, Wind Energy, Data, Acquisition, Recording

\* \* \*

## A METHODOLOGY FOR SITE SELECTION OF WIND TURBINES OVER COMPLEX TERRAIN

D.TRIFONOPOYLOS, G.BERGELES, N.ATHANASIADIS  
Lab. of Aerodynamics, Fluids section, Mechanical Eng., NTUA, Athens

The existing anemological data may imply that the wind energy potential of Greece is excellent. In the special case of an island, where the production of electric energy is quite expensive, the interest for wind energy applications becomes even greater. In this paper a methodology for estimating the wind energy potential over complex terrain in the islands of Skiathos and Skopelos. The results show that the available wind energy potential could cover the current electric needs of the islands.

**KEY WORDS:** Wind energy potential, complex terrain, site selection

\* \* \*

**REGULATIONS, LICENCE PROCEDURES AND NON-  
TECHNICAL ISSUES RELATED TO PRIVATE WIND TURBINE  
PLANS**

**I.PINATSIS**

Mechanical-Electrical Engineer

**P.DOKOPOULOS**

Prof. of Electrical Energy

Dep. of Electrical Engineering, A.U.T

The application of the pertinent regulations and the procedures to be followed for a private wind turbine plant are examined in this work. The terms set by the Ministry of Industry, Research and Technology (YBET), the public Power Corporation (ΔΕΗ), and the Ministry of the Environment (ΥΠΕΧΩΔΕ) are analysed. The proper procedures to be followed by entrepreneurs are presented. Practical experience on the above issues has been gained from the installation of wind turbines in the islands of Paros, Syros and Kea.

**KEY WORDS:** Regulations, wind energy plans, non-technical issues

\* \* \*

## PILOT STUDY FOR THE INSTALLATION OF A WIND PARK AT ANO MOULIA, CRETE ISLAND

A.ZERVOS, G.AYERIDES, Y.GLEKAS, TH.PAPACONSTANTINO  
NTUA, Fluids Dept., Lab. of Aerodynamics, 106 82, Athens, Greece

D.PAPASTEFANAKIS  
Dr. Mechanical Eng., E.E.T.A.A., 19 Omirou st., 106 72 Athens, Greece

The present summary study presents the methodology applied for the elaboration of a pilot study for the installation of a 30 MW wind park at the region of Ano Moulia, Heraclion, where the wind potential is more than satisfactory. At first, the appropriate region for the installation of a wind park is selected and validation and selection of wind generators to be used is done based on the region's wind data. Then the analysis of the connection of the wind park to the utility grid is elaborated. During the last part of the study, the optimum siting of wind generators of various sizes in the selected area is examined and the process for the selection of size and number of wind generators is defined, based on technical and economical criteria.

**KEY WORDS:** Wind generator, wind park, optimum wind generator siting, wind penetration

\* \* \*

## MONTHLY WIND POWER ASSESSMENT OF THE POGONITSA REGION, GREECE

A.ANTONIOU, H.STAPOYNTZIS, G.TSILINGIRIDIS

Aristotle University of Thessaloniki, Mech. Eng. Dept.,

Thessaloniki 54006, Greece

The possibility of wind power exploitation for partially covering the energy requirements of a fish breeding plant located at Preveza in north-western Greece, is examined in this work. Wind power potential was estimated from meteorological data at a nearby airport and were supplied by the Greek Meteorological Office. These data consisted of air speed and direction records, on a monthly basis, covering a period of 13 years from 1971 to 1983. The terrain around the plant and the airport is almost flat over a radius of at least 20 km, with the exception of a rather round smooth hill near the plant, 150m high and about 1200m in diameter. The top of the hill is considered to be the most appropriate location for installing the wind turbines, therefore the wind power potential results given refer to that point. They consist of wind roses, Weibull distributions and wind speed duration curves based on each month and on the whole year. Following the methodology described in the "Wind Atlas for Denmark" corrections were applied to the Weibull distribution parameters of the airport due to the changes in the surface roughness, height and shape of the hill. The yearly average wind power flux was found to be  $197\text{W/m}^2$ . The average monthly maximum flux was  $407\text{W/m}^2$  during January while the minimum was  $78\text{W/m}^2$  during July. This potential would be sufficient for covering some energy needs of the plant like water pumping and heating totaling to about 100 MWhrs/year. A preliminary study with the power curves of two commercially available wind turbines with nominal power 15 and 75 KW showed corresponding load coefficients 45% and 25%.

\* \* \*

## A GREEK WIND TURBINE 220/50 Hz WITH ADVANCED TECHNOLOGY

CH.VOUROS  
WINDSOL Ltd.

The autonomous advanced technology wind turbine of the WINDSOL company has been designed with particular scope to the electricity needs of remote areas. Apart from the wind turbine, the overall system exhibits a battery storage and a power converter. Thus, a current of 220/50Hz is within  $\pm 1\%$  available to the user, irrespectively of the wind velocity fluctuations, even during calms. This design is available in the range of 0.5-10KW, thus suited for several applications, such as houses, camping cites, etc.

**KEY WORDS:** Autonomous wind turbine, Output converter

\* \* \*



## SITE SELECTION FOR WINDFARMS IN GREEK ISLANDS

A.ANDROUTSOS, E.BAKIS

Public Power Corporation, Direction of Alternative Energy Forms,  
Section of Solar Energy Forms

PPC, in the framework of the HORS QUOTA program intends to install windfarms on a number of islands in the Aegean Sea. This work presents the methodology that was followed at the selection of the windfarms sites and an analysis of the main parameters involved in the proper site selection procedure is performed. Also, the site selection in the island of Limnos is included as a case of study.

**KEY WORDS:** Site selection, wind energy, windfarms, wind generators, wind resource

\* \* \*

INSTALLATION OF A 220KW WIND TURBINE  
INTERCONNECTED TO A HEAT PUMP-  
HEAT STORAGE SYSTEM

D.PAPASTEFANAKIS, M.KARAGIORGAS  
Dr.Mechanical Engineer Dr.Mechanical Engineer

A tourist sport center is constructed in the area of Epos at Vrondades, Chios. The high cost involved in the air conditioning needs justified the use of a wind turbine, since the measurements of the wind speed indicated that a potential for such an application existed. The system consists of a wind turbine, a heat pump and a storage for heating and cooling. This configuration will meet most of the energy requirements, while the local electricity grid is used as back up. The maximum of autonomous operation will be persued via an intelligent usage of the energy available, by employing a microprocessor. The latter gives a high priority to the cooling and heating loads, and a lower one to the other consumptions and the surplus fed to the public grid.

KEY WORDS: Wind energy, Air conditioning, wind turbine, Heat Pump, Heat Storage, control

\* \* \*

## STUDY FOR A 150KW WIND TURBINE APPLICATION FOR IRRIGATION IN ANOGIA, CRETE

A.ZERVOS, S.GARYFALAKIS, D.PAPASTEFANAKIS, CH.CHALDOUPIS  
Ass. Prof, N.T.U, Electrical Eng., Dr.Mechanical Eng., Ass.Prof.,Univ. of Crete

High cost of irrigation is the main drawback for its application in some municipalities. This is the case of the municipality of Anogia, where four pumping substations are employed. A system combining a 150KW wind turbine connected to two of the pumping substations has been designed. The optimum usage of the wind energy is envisaged by means of a complex strategy controlled by a microprocessor. Funding of this program is provided through the demonstration programmes of EEC.

KEY WORDS: Wind turbine, irrigation

\* \* \*

## STOCHASTIC MODELLING OF THE ELECTRIC OUTPUT OF WIND TURBINES

TH.KARAKATSANIS, N.CHATJIARGYRIOU

Lab. of Electric Power, Dep. of Electrical Engineering N.T.U., Athens

In renewable energy sources applications a stochastic analysis of the load sequences is needed, because of the stochastic nature of the energy availability. A deterministic analysis in the design of such systems may lead to erroneous conclusions with regard to the maximum exploitation of the energy available. The function of the possibility density for the wind turbine output is incorporated in the pertinent equations. An algorithm accounting for the load sequences observed has been developed, enabling useful results to be extracted for a system combining both renewable and conventional energy sources.

**KEY WORDS:** Wind turbines, Stochastic load demand

\* \* \*

## AN EVALUATION OF SOME METHODS FOR ESTIMATING THE TWO PARAMETERS OF THE WEIBULL DISTRIBUTION

TH.KARAKOSTAS, E.FLOCAS, K.KAKALIAGOU

Dept. of Meteorology and Climatology  
University of Thessaloniki, Greece

The knowledge of an analytical expression of the wind speed frequency distribution is a very important tool, mainly due to its applicability on the calculations of the available wind energy. The two-parameter Weibull distribution model has been successfully used for the estimation of the available wind energy, because it usually gives an approximate and generally good fit to the observed wind speed distribution and its ease of use with the necessity to estimate only two parameters. The present paper highlights five different methods of calculating the scale factor  $C$  and shape factor  $K$  of the Weibull distribution. The data used for these calculations are hourly values of the wind speed of one of the most representative Greek stations. The comparison of the methods is based upon statistical tests and graphical depictions.

**KEY WORDS:** Wind energy, wind speed, frequency distribution, two-parameter Weibull distribution, scale factor, calculation of the two Weibull parameters

\* \* \*

## STUDIES ON THE LOAD FLOW AND THE OUTPUT LOSS IN LARGE WIND PARKS

S.GARYFALAKIS

Electrical Engineer

K.VOURNAS

Lecturer, Dep. of Electrical Engineer, N.T.U

Among the problems encountered in wind turbine installations, particularly in small scale applications, is that of output loss when the wind speed exceeds the accepted limit. Under such conditions, severe disturbances may also result in the system performance. The incorporation of a wind turbine in an existing electricity grid also alters the loads on the transportation lines. Thus, a comprehensive study of the interconnection configuration is needed.

**KEY WORDS:** Wind turbines, Wind Park, electricity grid, output loss, control

\* \* \*

## ENERGY EFFECTIVENESS AND OPTIMAL DESIGN OF ARRAYS OF WIND TURBINES

SP.VOUTSINAS, A.ZERVOS

NTUA, Dept. of Mechanical Eng., Fluids Section,

Lab. of Aerodynamics, Athens, Greece

The prediction of the annual energy production of a wind park as well as its optimal model designed to calculate the energy effectiveness is proposed. The model is based on the analysis of Abramovich [3]. Using this model two algorithms are proposed for the optimal design of a wind farm based on given data. Results are presented for the site at Ano Moulia of Crete.

**KEY WORDS:** wind energy, wind park

\* \* \*

## ENERGY CALCULATION FOR THE WIND FARMS ON LIMNOS

D.KANELLOPOYLOS

Aeronautical Eng., Fluid Mechanics

F.ZACHOS

Nuclear Eng.

PPC/ Alternative Energy Forms,

10 Navarinou st., 106 80 Athens, Greece

The work presents an energy calculation for an area, where there are monthly anemometer readings. This is possible by correlating hourly data recorded on another location on the island. The method is based on calculating the Weibull parameters  $k$  and  $c$  from experimental data.

**KEY WORDS:** Wind potential, wind duration curves, anemographic stations, energy calculations

\* \* \*



## SELF-EXCITATION OF WIND DRIVEN GENERATORS, FOLLOWING A GRID INTERRUPTION

CH.DIMOULIAS, P.DOKOPOULOS

Lab. of Electric Energy Systems, A.U.T.

In a grid with wind driven generators and capacity loads, a considerable voltage may be inducted to the grid after an abrupt reduction of shut-down of the conventional sources, namely the synchronous generators. This high voltage is attributed to the wind turbines and under some combinations of load and capacity values may even exceed the nominal voltage of the grid, with severe risks for the grid and the operation staff. In the present work a theoretical analysis of the above phenomenon is given, along with experimental data derived from a set of asynchronous generators and a representative grid. A means of avoiding the development of high voltages is to disconnect the wind generator from the grid, when a set limit of voltage is exceeded.

**KEY WORDS:** wind generators, self-excitation, voltage, grid

\* \* \*

## VOLTAGE AND FREQUENCY FLUCTUATIONS CAUSED BY WIND GENERATORS IN SMALL GRIDS

CH.DIMOULIAS, P.DOKOPOULOS, A.LASKARELI  
Lab. of Electric Energy Systems, A.U.T.

In small electricity grids, e.g., in islands, there is a limit of the maximum power that can be supplied by a wind generator, because of:  
a) fluctuations caused by stochastic variations of the wind speed, and  
b) problems that may arise in case of an abrupt cut-out of the wind generator. The above two characteristics are analysed in the present work, by examining the effects of the following parameters: power, fluctuation percentage, moment of inertia and control of the Diesel engines. The variations of the voltage and the frequency are investigated by using a computer programme, under various conditions of abrupt interruptions in the overall grid. The results derived are mostly useful for selecting the suitable wind turbine in a particular application.

**KEY WORDS:** Voltage and frequency fluctuations, wind generators, small grids

\* \* \*

## FEASIBILITY ANALYSIS OF PRIVATE WIND TURBINE PARKS

E.GAVANIDOU, M.KETSILIDIS, T.BAKIRTZIS, P.DOKOPOULOS

Lab. of Electric Energy Systems, A.U.T.

The scope of the present study is to set a basis for a comprehensive feasibility analysis of private aiolic parks. The energy fluxes and the cost of the energy produced are calculated in order to assess its cost effectiveness. The main data required are the hourly variations of the wind speed and the load, the power-wind speeds curves of the wind generators, the cut-out periods of the wind turbine, the cost of the wind turbine, the cost of the electricity and the internal rate value. A computer program based on the statistics theory and incorporated cost analysis techniques has been developed. The results of this study are presented in a companion work.

**KEY WORDS:** Wind generators, feasibility study, cost effectiveness, private sector

\* \* \*

## RESULTS OF THE COST EFFECTIVENESS ANALYSIS FOR PRIVATE WIND ENERGY PARKS

E.GAVANIDOU, M.KETSILIDIS, T.BAKIRTZIS, P.DOKOPOULOS  
Lab. of Electric Energy Systems, A.U.T.

The result of a cost analysis of the installation of a private wind station for electricity generation are presented in this study. The fraction of the electric demand met by the wind generator is calculated, together with the net present value of the entire investment and the rate, depending on a number of various parameters, such as: the rated power of the station, the average wind speed, the cost of electric energy, the cost of the wind generator and state policy (e.g.subsidies e.t.c.). Low voltage private stations are considered. In case of absence of any form of subsidy, the wind station play may be not cost effective, even if the values of buying and selling electric energy are equal. This is true for wind speed values up to 6m/s. However, in case of 55% subsidy, the plant becomes cost effective with wind generators around 30KW, even for average wind velocities of 5m/s.

**KEY WORDS:** wind generator, private sector, cost effectiveness, subsidy

\* \* \*

## SELECTION OF A CENTRIFUGAL PUMP TO STOCK AND GENERATE THE ENERGY PRODUCED BY A WINDMILL

D.PAPANTONIS

Ass. Prof., NTUA, Dept. of Mechanical Eng.,  
Lab. of Hydraulic turbomachines, 106 82 Athens

In this work the necessary data are given and a method is proposed for the selection of the proper centrifugal pump, the role of which is to stock the energy produced by a windmill by pumping water from a lower to a higher reservoir and then to produce electric energy running in the inverse mode as turbine, in order increased power needs of the electrical grid or periods without wind. For the selection of the pump the difference of the characteristic curves between operation as pump and as turbine is taken into account. The selection is the result of an optimization in order to obtain the minimum sum of the energy losses for the operation of the system for pumping and for turbinig. Finally the result of the selection of a centrifugal pump is given concerning a small autonomous electrical grid.

**KEY WORDS:** Hydraulic Turbomachines, Hydraulic Energy, Pumps, Turbines

\* \* \*

**DESIGN OF A "CROSS FLOW" WATER TURBINE****M.PANAGIOTOPOYLOS**

Mechanical Eng., NTUA

**D.PAPANTONIS**

Ass. Professor, NTUA

National Technical University of Athens,

Dept of Mechanical Eng., Fluid Section, Lab. of Hydraulic Turbomachines

42, Patission st., 106 82 Athens, Greece

The present paper deals with the study and desing of an experimental Cross Flow (Banki) water turbines, which could be useful as a model for the fabrication of turbines of the same type with nominal output between 100 and 1000KW. The Banki turbine is a simple, low cost, radial, impulse-type turbine with two velocity stages and a very flat topped efficiency curve. So it is especially suitable for exploitation of water flows varying between wide limits. Because of its design this turbine is suitable for experimental study and visualisation of the flow, as much along the nozzle - by measuring the velocity field in chosen points and the pressure distribution along the walls - as through the runner blades - by measuring the velocity field upstream and downstream - for different operation points.

**KEY WORDS:** Hydraulic machine, Water Turbine, Mini water turbine

\* \* \*

## SMALL HYDROELECTRIC PLANS IN GREECE: ENERGY AND ECONOMIC CONSIDERATIONS

G.DOUZINAS

Economist, Lecturer of Military Geography

The energy issue, with its global dimensions, is regarded as a critical and acute parameter for the development of our country. Despite the over 160 years of independant existance of Greece, the various resources, among which the energy sources, have not been adequatly exploited (except for the lignite). Solar, wind, hydraulic and geothermal energy, although being cheap resources and free of enviromental pollution, have not been harnessed up to a satisfactory level. The aim of the present work is to underline the importance of small hydroelectric plants for the electricity production. Additional benefits that may result from a further usage of the water downstream the hydroelecric plant, are also addressed.

KEY WORDS: Hydropower, small plants, energy, economy

\* \* \*

## DESIGN AND CONSTRUCTION OF TWO SIMPLE SYSTEMS FOR DISTRIBUTION OF GEOTHERMAL ENERGY IN GREENHOUSES

M.GRAFIADELLIS, G.SPANOMITSIOS, I.ASIMAKOPOULOS  
Agricultural Research Center of Northern Greece, Thessaloniki

To overcome the various problems, which are faced in the use of geothermal water for heating greenhouses, two simple systems for the distribution of geothermal energy were constructed in Agricultural Research Center of Northern Greece. In the first system the thermal water flows into transparent polyethylenetubes of 50-60 cm perimeter. This system has very low cost and it is very simple and effective on the function of distributing the geothermal energy inside greenhouses. The second system is a water-air exchanger. It consists of a polyethylene tube, 160 cm perimeter, and two interior polyethylene tubes significantly smaller: 50-60 cm in diameter. The water pump and the fan are activated during the cold part of the day. When warm water flows inside the small tubes air blows from the outside environment, absorbs heat from the water tubes and releases all this sensible heat into the greenhouse. The main role of this exchanger is to reduce the high values of relative humidity. Some results during the three years function of the two systems in Eleochoia setting are also reported.

**KEY WORDS:** Geothermal energy, heat exchanger, greenhouse, water drill, erosion, air heater, vegetative heating, transparent PE tubes, polyethylene film.

\* \* \*



## FACTORS INFLUENCING SCALING DUE TO HIGH ENTHALPY GEOTHERMAL FLUIDS

A.KARABELAS, N.ANDRITSOS, A.MOUZA

Chemical Process Engineering Research Institute, P.O. Box 19517 and

Chemical Engineering Dept.,

Aristotle University of Thessaloniki,

GR 54 006 Thessaloniki, Greece

The cause of sulfide and silica scale formation are summarized as well as the ensuing problems in geothermal installations. The study of brine physicochemical characteristics shows that scale formation, for both sulfide and silica compounds, is significantly affected by PH. The temperature seems to play a significant role only for reducing scaling of high temperature brines. Scale control can also be achieved with the appropriate design and operation of geothermal plants.

**KEY WORDS:** Scaling, geothermal energy, high enthalpy fluids, physicochemical characteristics, sulfides, silica, scale control methods

\* \* \*

## PARAMETERS FOR A RATIONAL DEVELOPMENT OF GEOTHERMAL RESOURCES

G.KOUTINAS

Mining Engineer & Eng. of ENSPM/IFP

Geothermal Energy as alternative-renewable energy source is characterised by several peculiarities. Moreover, a geothermal project from stage of initial reconnaissance study up to the final development stage, is associated with important high risks of an economic nature. Therefor, for a rational utilization of the existing Geothermal Potential in a certain area, the application of the existing relelvant international technology and practice is necessary in respect to the methodology, the technical specifications and procedures for every stage of a geothermal project. In this report an emphasis is placed on the case of high enthalpy geothermal potential. The several peculiarities and inherent risks are mentioned, together with the most basic and critical parameters of a geothermal project, during the stages of exploration, source appraisal, field development and exploitation of the existing recoverable geothermal energy potential, in a certain area.

**KEY WORDS:** Geothermal Energy, High Enthalpy, Geothermal Project, Geothermal Research and Development.

\* \* \*

**OPPORTUNITIES FOR THE DEVELOPMENT OF TECHNOLOGY  
FOR THE EXPLOITATION OF GEOTHERMAL ENERGY IN  
GREECE.**

**M.GOUMAS**

Mining Engineer

**Y.KALOGHIROU**

Chemical Engineer, Economist, M.Sc.

**L.PAPAYANNAKIS**

Ass. Professor, Dept. of Chemical Eng., NTUA

In this paper the different stages of a geothermal programme are presented. Then the issue of maximization of domestic participation in the projects concerning exploration, development and exploitation of the geothermal field is examined.

**KEY WORDS:** Geothermal energy, Transfer of technology, Technological policy

\* \* \*

## THE USE OF GEOTHERMAL ENERGY FOR INDUSTRIAL COOLING

D.KOUREMENOS, S.CHATZIDAKIS

National Technical University of Athens, Mechanical Eng. Dept.,  
42 Patission st., Athens 106 82, Greece

Geothermal energy appears - especially in some islands of the Aegean Sea- at quite high temperatures. Using this energy to drive ammonia-water absorption refrigeration systems for industrial cooling, it is possible to realize considerable electric savings. The produced cooling can be used for the storage of fresh perishable agricultural products, while the condensation and absorption heat can be used for heating purposes. The present paper investigates the feasibility of such an ammonia-water absorption system driven by geothermal energy as primary energy input. After performing the thermodynamic analysis and calculating the relevant cooling absorption cycles, the cooling efficiency, the heat input and output rates, the coefficient of performance COP and the heat gain coefficient HGC are given in the form of diagrams for various operation conditions. The results show that ammonia-water absorption systems driven by geothermal energy can achieve considerable electric energy savings.

**KEY WORDS:** Geothermal energy, Industrial Cooling, Absorption Refrigeration Unit, Absorption, Ammonia

\* \* \*

## THE SIGNIFICANCE OF ZERO DIMENSIONAL MODELS IN GEOTHERMAL RESERVOIR SIMULATION. A CASE STUDY.

J.GELEGENIS, N.KOUMOYTSOS  
Chemical Engineering Department, NTUA.

In this study a methodology, dealing with geothermal reservoir simulation by zero dimensional models, is developed. The method is applied to Wairakei, New Zealand, geothermal field, resulting satisfactory predictions in reservoir pressure and fluids' enthalpy. The usefulness of zero dimensional models is also analyzed and their potential when applied in relevant problems is underlined.

KEY WORDS: Aquifer, cold intrusion, efficiency, enthalpy,  
geothermy,model, parameter identification, recharge,  
recovery, reservoir, simulation, Wairakei.

\* \* \*

## THE THERMAL STATUS IN THE SEDIMENTARY BASSIN OF THESSALONIKI

N.KOLLIOS, TH.KAVOURDIS  
Institute of Geothermal and Fossil Research  
Geothermal Energy Department

The Thessaloniki bassin is located to the east of mountains Vermion, Pieria and Olympos, as far as mountain Chortiatis. It is a tectonic product of the tertiary period with a maximum thickness of residuary materials of 4000m. In the eastern section, the sub-bassins of Mygdonia and Anthemounta are observed, both of pleiotetartary age, where considerable thermal anomalies have been located. The drilling activities in research of oil have provided significant information on the thermal status, the tectonic formations and the lithology of the sediments. Moreover, some areas with considerable geothermal potential have been observed.

**KEY WORDS:** Geothermal energy, isothermal, heat flow, tectonic

\* \* \*

## A MODEL FOR LOW-MEDIUM ENTHALPY GEOTHERMAL ENERGY DEVELOPMENT: IMPLEMENTATION ON POLICHNITOS AREA

T.GOUMAS, M.CHRISTOU

Energy Policy Unit, National University of Athens

Although low-medium enthalpy geothermal energy is available at many places in Greece, the broad exploitation has not been achieved at present. This delay is surely attributed to the specific technical and investment problems, but equally it is attributed to the absence of an efficient operational model for geothermal energy utilization. The designation of an institution (company) with appropriate legal and economic structure, that should undertake the transfer of geothermal energy to interested investors, is the major objective of this study. Specifically, based upon the real data of the Polichnitos area, a microeconomic evaluation on the viability of the proposed geothermal company is carried. By the use of a simulation model, it is possible to investigate the expected financial efficiency of private investors, mainly on greenhouse and fish-farming units, in correlation with the financial operation of the geothermal company. The resulting outcome is very encouraging, concerning either individuals or the local economy and the energy consumption.

**KEY WORDS:** Geothermal energy, Development, Local Economy, Geothermal Company, Polichnitos, Simulation Model, Microeconomic Evaluation

\* \* \*

DEVELOPMENT POSSIBILITIES OF MEDIUM AND LOW  
ENTHALPY  
GEOTHERMAL ENERGY-ETBA A.E. PROGRAMME

I. ARGYROPOULOS  
Ass. Director of ETBA A.E.

Geothermal energy consists a significant renewable energy source in Greece, which provides a central point for the technological and economic development of the pertinent areas. If exploitation may be pursued via a gradual installation of greenhouses, while some other activities (e.g. crop drying, fisheries) may also benefit, thus resulting considerable fossil fuel conservation. The ETBA programme for the development of geothermal energy aims at: a) development of a technology adapted to the particular features of the pertinent fluids, b) integrated development of geothermal fields (research, investments, etc), c) installation of pilot plans under the supervision of OTA, and d) obtaining EEC funding.

KEY WORDS: Geothermal fields, Nea Kessani Xanthi, Polichnitos Lesvos, greenhouse, crop drying, fisheries

\* \* \*



USE OF MULTICRITERIA DECISION MAKING METHODS FOR  
OPTIMUM UTILIZATION OF GEOTHERMAL ENERGY.  
APPLICATION TO THE GEOTHERMAL FIELD OF THE  
NEA KESSANI-THRACE

D.PSYCHOGIOS, M.GOUMAS, V.LYGEROY

Dept. of Chemical Eng., NTUA

A systematic procedure to develop and evaluate alternative scenaria for optimum exploitation of a geothermal field is proposed. The appropriate criteria and available multicriteria technics for decision making are presented. The multicriteria evaluation method PROMETHEE is applied to alternative scenaria proposed for the exploitation of teh low enthalpy geothermal field of N. Kessani-Xanthi. The advantages and limitation of the method are discussed.

**KEY WORDS:** Geothermal energy, Multiple criteria analysis

\* \* \*

SETTING OF PRIORITIES FOR THE DEVELOPMENT OF THE  
GEOTHERMAL ENERGY IN GREECE.  
MULTIPLE CRITERIA ANALYSIS OF THE PROBLEM AND  
FIRST RESULTS

M.GOUMAS

Mining and Metallurgical Engineer

V.LYGEROY

Ass. Professor, Dept. of Chemical Eng., NTUA

The necessity for setting priorities for the development and full exploitation of the geothermal fields of Greece is pointed out. A multiple criteria approach to the problem is attempted where both the physical characteristics of the field and the social and economic development of the region are taken into consideration. The method PROMETHEE is applied for decision making and the results are discussed.

**KEY WORDS:** Geothermal Energy, Energy policy, Multiple criteria analysis

\* \* \*

## A METHOD FOR DETERMINING FLOW RATE AND QUALITY OF TWO PHASE GEOTHERMAL FLUIDS

M.SAMOLADA, S.PARAS, A.KARABELAS

Chemical Process Engineering Research Institute, P.O. 19517 and

Chemical Engineering Department, Aristotle University,

Thessaloniki, GR 540 06, Greece.

The proposed method is particularly useful in the exploration phase of a geothermal field, during surface facilities are limited. The method combines easily acquired data, such as pressure drop in a straight pipe section and across an orifice, with models and correlation for two-phase flow characteristics. A special algorithm allows the determination of flow rate and quality by "trial-and-error". Thermodynamic data used in the computer program cover the case of water, over a wide range of pressures and temperatures and various degrees of salinity. Comparisons of experimental data from the literature with predictions based on the new method are quite satisfactory. However, additional data are required, especially from geothermal fields, to check the accuracy of this method.

**KEY WORDS:** Two phase geothermal fluids, geothermal fieldd exploration, new wells, prediction of flow rate and quality, computer code.

\* \* \*

## ENERGY SOURCES MANAGEMENT IN APIRANTHOS, NAXOS: THE CASE OF BIOMASS

TH.TSOUSOS, L.PYRGIOTIS, V.MAURATJAS, E.KOUKIOS  
Chemical Engineering Dept., N.T.U., Athens

The results of an in situ study on the energy demands and the activities of the inhabitants of the Apiranthos village in Naxos, are presented in this work. The present way of the existing energy resources is investigated based on the available data. Particular emphasis is given to biomass, which is regarded as the most promising renewable energy source, being already exploited in the system considered. The overall potential of biomass is investigated, based on its availability and the present energy demands.

**KEY WORDS:** Energy, community development, biomass, combustion, survey, Apiranthos

\* \* \*

## INTEGRATED ENERGY UTILISATION OF SWINE WASTERS IN NAXOS ISLAND

**A.TSAVDARIS**

Agriculturist, Member of the Scientific Group of the  
Integrated Energy System- Naxos

**Dr.D.GEORGAKAKIS**

Ass. Prof., Agric. Univ. Athens

**Dr.P.AXAPOYLOS**

Ass. Prof. Technol. Inst. Athens

The combined utilisation of a small swine unit wastes on Naxos island, has a very small cost of operation and a limited use of the produced biogas. The full utilisation of the biogas and its higher production per unit volume of the digester, make the digester economically acceptable. Fertilizers production seems to be more economical under the assumption of full production use. The environment is fully protected due to the treatment and utilisation of the wastes.

**KEY WORDS:** Biogas, Fertilizer, Energy Utilisation, Environmental Protection, Wastes Utilisation, Wastes Treatment, Swine Unit, Energy Production, Solar Energy, Solar Collector

\* \* \*

**CONTRIBUTION TO THE STUDY OF SOLAR RADIATION  
EFFECT ON BIOMASS PRODUCTION IN AN OPTIMIZED HRAP  
SYSTEM**

**F.BATZIAS, S.ARNAOUTIS**  
Research Group of Systems Analysis  
The Piræus Institute of Technology

In this work, we present a single-function generalized model of biomass production in a High Rate Aerobic or Algal Pond (HRAP). This model is heavily based on the simulation of the HRAP to a continuous-flow stirred tank bioreactor. It is proved that the optimal design of HRAP leads to considerable saving of surface area of the pond. Moreover, the sensitivity of the relative frequency of the expected daily biomass production is presented, in relation to changes of (a) the incident solar radiation and (b) the residence time of wastewater in the HRAP.

**KEY WORDS:** Aerobic Pond, Algae, Bioreactor, Biomass, Photosynthesis, Simulation, Solar Radiation, System Analysis, Wastewater Treatment

\* \* \*

## BIOMASS PRODUCTION WITH PLANTATIONS OF FAST GROWING SPECIES

K.PANETSOS

Prof. of A.U.T.

Greece, as most of the EEC countries, exhibits a deficit in the primary energy sector, in timber and its products. At the same time, an over-production of agricultural products is present, the increase of which causes serious storage, subsidy and consumption problems. Thus, a policy promoting the switching over from agricultural to foresting activities of fast growing plants is gaining ground. The prospects of the potential of the latter is addressed in the present work.

**KEY WORDS:** Biomass, fast growing species, poplar tree, plane tree, eucalyptus tree, coniferous, genetic improvement

\* \* \*

## THERMOCHEMICAL DENSIFICATION OF BIOMASS: PROCESS INVESTIGATION FOR PRODUCTION APPLICATION

D.KOULLAS, N.AMBATJOGLOU, E.KOUKIOS

Chemical Engineering Dept., N.T.U., Athens

The thermochemical densification by briquetting of lignocellulose material (small particles of coniferous biomass) has been investigated, at temperatures of 80-215 C and pressures of 100-400 bar for time periods of 0.5-5h. The following characteristics of the resulted briquettes were determined: weight loss, apparent density, equilibrium humidity and heat content. The experimental data show that optimum quality of the briquettes results at temperatures of 130-170 C and pressure of 200 bar approximately. Under the above conditions, the energy content of the product is approximately four times that at the initial material. It has also been verified that the pressure level significantly affects the physical, chemical and energy properties of the overall process.

**KEY WORDS:** Thermochemical energy densification, briquetting of lignocellulose, process

\* \* \*



## DIRECT MICROBIC CONVERSION OF PRE-TREATED STRAW TO ETHANOLE

P.CHRYSTAKOPOULOS, D.KOULLAS, D.KEKKOS, E.KOUKIOS V.MAKRIS  
Chemical Engineering Dept., N.T.U., Athens

The effects of several parameters on the direct microbic conversion of pre-treated straw to ethanole by the fungus *Fusarium oxysporum* have been investigated. In particular, the influence of the type and the crystalline formation of the cellulose, along with the activity of B-glycozidase, on the conversion rate have been analysed. Theoretical values of the conversion efficiency higher than 60% have been obtained, at satisfactory fermentation times.

KEY WORDS: Microbic conversion, straw, ethanole, crystallography, alkaline pre-treatment, *Fusarium oxysporum*

\* \* \*

## ECONOMICAL EVALUATION OF ANAEROBIC DIGESTION AS AN ENERGY PRODUCTION PROCESS; THE CASE STUDY OF VINASSA TREATMENT

**A.VLISSIDIS**

Dr. Chemical Engineer, Laboratory of Organic Chemical Technology  
in National Technical University of Athens

**A.ZOUMBOULIS**

Dr. Chemist, Laboratory of General and Inorganic Chemical Technology in  
University of Athens

**A.HATZIFOTIOU**

Industry Chemist

The anaerobic digestion at 50 C - 53 C is recommended for saving energy and purification of waste waters for distilleries processing beet molasses, figs, raisins and winew. A new process is applied consisting of two stages, in order to overcome the high sulfate conc., the high organic strength and high nitrogen conc. of the effluent. The best results that will be obtained with full strength (100.000mg COD/l) waste feed and stable operation are: volumetric loading  $B_{v,COD}$ : 8 kg/m<sup>3</sup>-d, gas production  $\gamma'_{v,gas}$ : 2.52m<sup>3</sup>/m<sup>3</sup>-d methane production:  $Y_{CH_4/COD_r}$ : 0.42m<sup>3</sup>/kg COD<sub>r</sub>, efficiently in converting organic solids to CH<sub>4</sub>: 70% and CO<sub>2</sub> content in biogas 18%. The mean net energy production is 96.744 BTU/d-m<sup>3</sup> of bioreactor. Also an economical evaluation is presented that is based on the above method and results.

**KEY WORDS:** Anaerobic digestion, thermophilic, vinassa, distillery slops, economical evaluation, biogas

\* \* \*

**THE USE OF LINEAR AND NON-LINEAR MATHEMATICAL  
MODELS FOR THE SIMULATION OF BIOMASS SYSTEMS:  
PRINCIPLES-METHODOLOGY, LIMITATIONS, APPLICATIONS**

**K.CHATJIGIANNAKIS, E.KOUKIOS**  
Chemical Engineering Dept., N.T.U., Athens.

Biosystems, as integrated living and abiotic subsystems among which biomass is exchanged in various forms, may be simulated with mathematical models. In order to gain reliability, the inherent non-linearities of the living sub-systems (eg. dependance on density, time retardation, diffusion, age stratification) can be removed by employing linear terms, as long as the overall behaviour of the system is not seriously affected. In effect, linearising is proven to be an intrinsic trend of living systems, being a result of the symbiotic, collaborating and recycling patterns developed in order to maintain stability. The development of mathematical models is assisted by resorting to mechanic and economic analogies. The use of simplified linearized models is justified by numerous previous studies on these systems.

**KEY WORDS:** Biomass, biosystem, system theory, linear and non-linear simulation, models

\* \* \*

## THE ENERGY CRITERION IN THE EVALUATION OF PACKAGING MATERIALS RECYCLING

D.DIAKOULAKI

Scientific collaborator

N.KOUMOUTSOS

Professor

Dept. of Chemical Engineering, NTUA

The subject of this paper is the comparative evaluation of the influence of recycling, in respect with the impacts from the production and usage of packaging materials. Two approaches are examined: First, energy analysis of energy savings caused by recycling. Second, important impacts establishing the social cost of packaging materials. The results obtained reveal that, from an energy or multicriteria point of view, recycling of aluminum cans incures more benefits, when compared to other packaging materials.

**KEY WORDS:** Energy analysis, Energy conservation, Energy cost, Multicriteria analysis, Packaging, Recycling

\* \* \*

## WASTES AND THEIR EVALUATION

I.FRANTZIS

Assosiation of Communities and Municipalities in the Attica Region.

Head of Research and Programming Department

In our times, wastes are not treated as materials from which we must get rid of, but also, as materials that must be evaluated. Most widely implemented methods for that purpose is incineration, by which the produced energy is used for hot water, electricity e.t.e., recycling where by mechanical means metals, as well as glass, paper, compost and R.D.F., are recoverd, and Sorting at source by which useful materials are recovered within the source of consumption. Furthermore, even when wastes are controlled dumped, biogas, that is produced due to their decomposition, can be used as a supplementary fuel. Therefore, we may say that wastes are not only an enviromental problem but also a stock of energy.

**KEY WORDS:** Wastes-Pollution-Energy-Incineration-Recycling-Biogas-Biological treatment

\* \* \*

## ODOR EMISSION IN THE SUGAR INDUSTRY; MEASURES AND CONTROL

I. VELENTZA

Chemical Engineer, Section of Technologies,

Dept. of Chemical Engineering

Aristotle Polytechnic School of Thessaloniki

The odor problem is perhaps the most difficult to deal with, because odors offend the senses and often cause emotional reactions rather than being health hazards. Many states are approaching odor as a nuisance and several others have enacted emission limits and regulations to deal with odor. Odor control is very important. In this paper a survey is given of the applied odor measurement technics, the odor control and the odor evaluation from various sources in the Sugar Industry, as well as the odor problems related to waste water systems and the possible odor reducing measures. The aim of a research program about odors is to identify the odor sources, to calculate their effects on the surrounding area and to investigate abatement technics for the odor sources.

**KEY WORDS:** Odors, sugar industry, problem, measures, control measurement technics, odor evaluation, research programs

\* \* \*

## OIL SUBSTITUTION BY RENEWABLE SOURCES AND DEVELOPMENT

C.STELAKATOS

Advisor of the Ministry of Industry Energy and Technology  
Director to the Directorate General of Public Power Corporation (DEH)

The need to change our Energy Planning breaking away from oil is established, which on the same time shall boost economic development. Strategy and policy measures to this effect are proposed. The basic principle is : Invest and operate Renewable Energy Sources (RES) instead of consuming considerable portion of our income in the purchase of oil. To achieve energy price stability and uniformity and to promote RES development a tax on energy is proposed. Rapid expansion of energy systems using RES can be achieved if such systems are enowed at the beginning and all income is subsequently re-invested to finance their expansion. Other measures proposed are: Groups of Energy Producers, an Energy Bank, an Energy Trading Agency. Central and Regional Energy Planning is required.

**KEY WORDS:** Energy Planning, Development, Renewable Sources, Oil Substitution, Energy Pricing, Energy Cost.

\* \* \*

## **DISTRICT HEATING: THE SOLUTION FOR A CLEAN AND HYGIENIC ENVIRONMENT**

**O.PLANAKIS**

Civil Engineer-Hygiologist

A concise description of electric energy production with a co-generation system is presented. This system is well known globally (although not quite so in Greece) and consists of combined production of electricity for space heating and hot water. The background of district heating and its importance for the protection of environment are discussed.

**KEY WORDS:** District heating, co-generation, energy, pollution, boiler, solid waste

\* \* \*



**DISTRICT HEATING BY BIOMASS AND SOLID WASTE  
COMBUSTION**

**O.PLANAKIS**

Civil Engineer-Hygiologist

A description of biomass utilization for heat production is given. The potential of biomass exploitation in Greece and its impact on the economy are addressed. The need for such an utilization by a district heating system is explained

**KEY WORDS:** District heating, biomass, solid waste, wood charcoal, pulping

\* \* \*

## ON THE EMPLOYMENT ENERGY SOURCES IN THE POWER SYSTEM OF CRETE

T.PAPAZOGLOU  
Professor TEI, Iraklion

The case for the utilization of the renewable energy sources in the electric power system of Crete, is examined. The direction of development of the island as well as the environmental conditions are conducive to the use of RES. The existing potential of RES as well as the characteristics of the electric power system, are reviewed. Conditions are determined for the employment of RES in the electric systems. Comparative reference is made to characteristics of other electric systems.

KEY WORDS: Electric power system of Crete, renewable energy sources

\* \* \*

## STEAM-ELECTRICITY CO-OPERATION PROPOSAL IN THE INDUSTRIAL AREA OF THESSALONIKI

P.CHRISTODOULOU

Dr. Chemical Engineer

Hellenic Sugar Industry S.A., Thessaloniki

The research made by a study group of the Technical Chamber in Thessaloniki resulted in the gathering of the needs in steam and electricity of industrial units in the industrial area of Thessaloniki. The needs in electricity from the national grid are covered by means of transformers, while the needs of steam (approximately 100T/H) are covered by boilers of 10 Bar pressure 230 C. The exergy efficiency of such a low pressure and temperature steam production is low (18%), while by steam electricity co-generation a better exergy efficiency of 28,5% is achieved. By using the same quantity of fuel, 7.9 T/H the need in electrical power of the Thessaloniki industrial area can be covered and the amount of 1.700.000.000 drachmas per year can be gained from the electricity own production. The investment cost of the proposed station (2 boilers of 50T/H, 2 Turbogenerators of counter pression 8 MW each together with the necessary net of steam distribution ) is estimated that will not overrun the annual gain.

**KEY WORDS:** Energy conservation in the Industry, steam-electricity co-generation, KWH cost in the case of own production, vacuum and counter pressure turbines, Industrial Area, energy and exergy efficiency.

\* \* \*

## ENERGY CONSERVATION BY ELECTRICITY AND HEAT CO-GENERATION IN THE INDUSTRIAL AREA OF THESSALONIKI

G.ALIBIZATOS, A.VACALIS

Dr.Mechanical Engineers

The potential of a co-generation application in the industrial area of Thessaloniki for meeting the electric and thermal requirements of the relevant industries is investigated. The choice of the best suited co-generation technology is made. Finally the effects of several parameters (eg. energy cost, fossil fuel cost, investment features) on the cost effectiveness of the overall system is analysed.

\* \* \*







