The Higher Technical Institute Review 2002-2003

Review 2002/2003

No 32, November 2003, Nicosia Cyprus

The Higher Technical Institute (HTI) was established in 1968 as a Government of Cyprus project with assistance by the United Nations Special Fund (UNDP), the United Nations-Education-Scientific and Cultural Organisation (UNESCO) and the International Labour Office (ILO). Cyprus Government Executing Agency: The Ministry of Labour and Social Insurance.

Ag Director:
C. Loizou BSc CEng. MIEE

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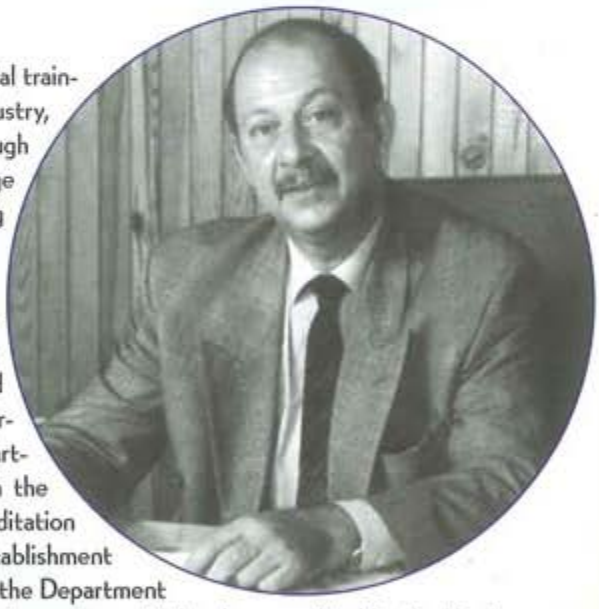
Forward by the Ag Director Mr Constantinos Loizou (BSc CEng MIEE)

Each year, in this publication we highlight a selection of the activities and achievements that have taken place at HTI over the last academic year.

At the Higher Technical Institute (HTI) we are committed to applied higher education that supports the economic developments, technological advancement, cultural enrichment and personal fulfillment. It provides a wide range of challenging learning experiences, in an English speaking environment, and its courses are designed to meet the needs of today's industry.

Special emphasis is placed in the area of research. Various projects are running in the fields of solar energy, computer assisted applications, solutions to engineering problems, desalination of water, e-manufacturing, rapid prototyping, 3D-reconstruction and reproduction, robotics and aseismic repairs due to earthquakes, optical fibre sensing and telecommunications, just to name a few. Since 1992, HTI has participated in the European Programmes Leonardo and Socrates/Erasmus, which include activities like student and staff exchanges in Tertiary Education and intensive courses between Institutions.



A key strength is the emphasis we place on industrial training, close co-operation with employers and industry, summer industrial training, summer training through IAESTE and ensuring that the skills and knowledge acquired by our students are geared up to meeting the demanding requirements of today's workplace.

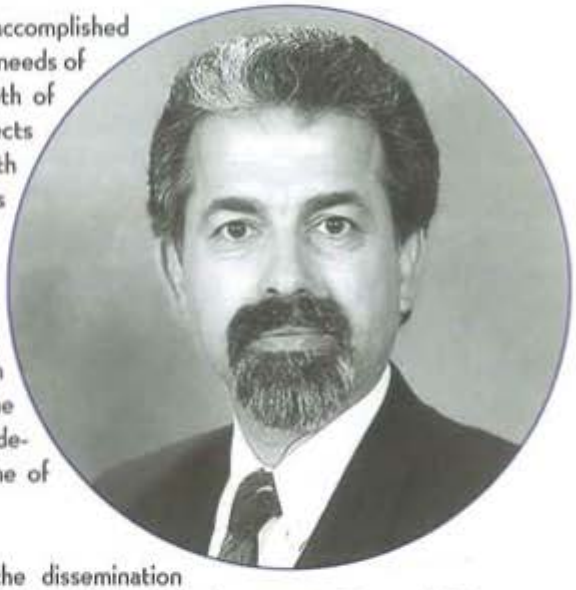
The quality and high standard of HTI graduates are widely recognised to such a degree that they are highly preferred in the labour market and offered excellent terms of employment. Furthermore, graduates of the Electrical Engineering Department can register as Incorporated Engineers with the Engineering Council of UK based on an accreditation which made HTI the first overseas educational establishment to achieve such recognition outside UK. Currently the Department of Mechanical Engineering and Marine Engineering have also applied to be accredited by the Engineering Council.

A great number of the Institute's graduates are pursuing distinguished careers in Universities and Research Centres abroad, offering HTI international recognition and reputation.

Constantinos Loizou
Acting Director of HTI

Message from the Chairman of the Central Academic Council

The core mission of an Academic Institution is the creation, application, dissemination and integration of knowledge. The Higher Technical Institute, for 35 years has consistently and constantly epitomized the aforementioned principles in the field of Engineering.



The creation of knowledge has been intrinsically accomplished through research in areas that predominantly reflect the needs of the local industry and the economy at large. The depth of involvement and level of complexity of research projects range from industrial to academic in nature. Our in-depth commitment to innovative research inherently assures teaching excellence.

The application and dissemination aspects have been exemplified in the framework of departmental teaching activities and short training courses, as well as through consultancy services offered to the local industry. The curricula are designed to provide a good balance of academic and work-related skills through a controlled scheme of industrial training in the local industry and abroad.

The HTI Review has substantially contributed to the dissemination aspect. Since its inception in 1971, when publications of its caliber were at least rare in Cyprus, HTI Review hosted in its pages a great number of contributions from staff and students as well as authors from industry. Most of the contributions covered a wide range of topics that closely pertain to the local industry and the Cyprus economy in general.

Nowadays, the Institute is facing a new challenge; in recognition to its widely acclaimed achievements and contribution to the local economy, it is destined to form the nucleus of the "Technological University of Cyprus" that is due to commence its operations shortly. Such a key development will undoubtedly not only enhance the Institute's role as a local and regional engineering training and research Institution but also will facilitate further links with Academic and research establishments in the European Union, which Cyprus is to join in May 2004.

Dr Ioannis Michaelides
Chairman, Central Academic Council

General Background: The Higher Technical Institute

The Higher Technical Institute (HTI) was established in 1968 initially as a 5-year joint project between UNDP, UNESCO, and ILO and the Government of Cyprus. In 1973 it became the sole responsibility of the Government of Cyprus and operates under the Ministry of Labour and Social Insuarance. Its main purpose is to train high-level Technician Engineers in order to satisfy the needs of a developing industry in suitably trained personnel capable of taking middle management technical positions.

By 2001 there were over 4249 HTI graduates, including overseas students, all of whom have secured appropriate employment locally and abroad.

Throughout the years of its operation the international status of the HTI has been enhanced with an ever-increasing number of foreign students mainly from Commonwealth and from countries of the region.

Programmes of Study

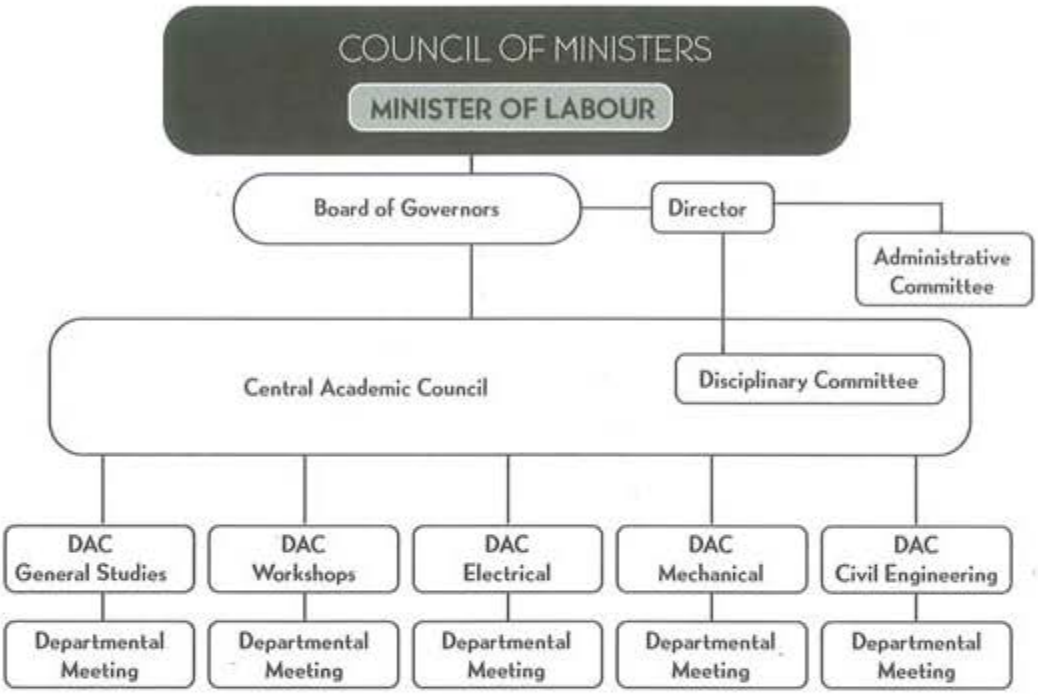
The Institute offers three-year, full-time courses for the Diploma of Tecnhnician Engineer in the following fields:

Civil Engineering
Electrical/Electronic Engineering
Mechanical Engineering
Marine Engineering*
Computer Studies

Other Courses:
- Evening preparatory courses for the Engineering Council Examinations of UK
- Short Courses to professionals from local industry and abroad offered in collaboration with the Professional Institutions and the Human Resourse Development Authority.

*Graduates also qualify for the award of the Certificate of Competency as Cadet Officers in Engineering issued by the Cyprus Merchant Shipping Department in compliance with IMO/STCW 78 Convention as amended in 1995.

HTI ACADEMIC STRUCTURE



The Board of Governors

Chairman:	
Mrs L Samuel	Permanent Secretary Ministry of Labour and Social Insurance
Secretary:	
Mr C Loizou	Ag Director Higher Technical Institute
Members:	
Mr Ch Adamou	Representative Ministry of Education and Culture
Mrs I Petrocosta	Representative Ministry of Finance
Mrs O Stylianou	Representative Ministry of Commerce, Industry and Tourism
Mr Ch Theopemptou	Elected Member Permanent Academic Staff
Mr S Savvides	Elected Member Permanent Academic Staff
Mr C Anastasiades	Elected Member Permanent Academic Staff
Mr Ch Pissarides	Elected Representative Students Union
Mr C Zymaras	Elected Representative Students Union

The Central Academic Council

Chairman:	
Dr I Michaelides	Chairman Departmental Academic Council Mechanical & Marine Engineering Department
Executive Secretary:	
Mr C Loizou	Ag Director HigherTechnical Institute
Members:	
Dr H Stavrides	Head Civil Engineering Department
Mr G Iordanou	Head Mechanical Engineering Department
Dr A Stathopoulos	Head Computer Studies Department
Mr N Mantis	Head General Studies Department
Mr M Poullaides	Chairman Departmental Academic Council Civil Engineering Department
Mr Ch Chrysafiades	Chairman Departmental Academic Council Electrical Engineering Department
Mrs Zena Schiza	Chairman Departmental Academic Council General Studies Department
Mr P Masouras	Chairman Departmental Academic Council Computer Studies Department
Dr G Florides	Chairman Departmental Academic Council Engineering Practice Department
Mr C Papaleontiou	Representative of the Academic Staff Civil Engineering Department
Dr M Kassinopoulos	Representative of the Academic Staff Electrical Engineering Department
Dr N Angastiniotis	Representative of the Academic Staff Mechanical Engineering Department
Mrs M Theodorou	Representative of the Academic Staff Computer Studies Department
Mrs M Neophytou	Representative of the Academic Staff General Studies Department
Dr S Kalogerou	Representative of the Academic Staff Engineering Practice Department
Mr V Savvides	Representative of the Students Union
Miss N Barri	Representative of the Students Union
Mr L Demetriades	Representative of the Students Union

Civil Engineering Department

Academic Staff

Head of Department:
H Stavrides BEng MEng PhD

Senior Lecturers:
M Poullaides BSc ACGI MSc DIC
D Serghides AADipl AAGRAD RIBAII PhD

Lecturers:
K Anastasiades BSc
D Andreou BSc MSc DIC
C Chrysostomou BSc MEng PhD
I Economides BSc MSc
N Kathijotes BSc MSc PhD
A Kkolos BSc MSc DIC
C Papaleontiou BS MS PhD

Senior Laboratory Assistant:
M Agathocleous Diploma HTI

Laboratory Assistants:
N Hadjigeorgiou BSc MPhil
P Pelecanos BSc (Hons)

Electrical Engineering Dpartment

Academic Staff

Head of Department:
C Loizou BSc CEng MIEE

Senior Lecturers:
C Chrysafiades BSc CEng MIEE
S P Spyrou BSc MIEE

Lecturers:
J Demetriou BSc (Hons)
A Georgiou BSc (Hons) MSc
S Hadjioannou CEI (II) MSc
M Kassinopoullos MSc PhD
G Kourtellis BSc
D Lambrianides BSc MSc Ceng MIEE
C C Marouchos MSc PhD
Ch Theopemptou BSc (Hons)
S Voskarides BSc (Hons)

Senior Laboratory Assistant:
M Michaelides HND

Laboratory Assistants:
J Pampouris OND HNC
C Ioannou Diploma HTI

Mechanical Engineering Department

Academic Staff

Head of Department:
G Iordanou BSc MSc

Senior Lecturers:
I Michaelides BSc(Hons) Dipl Sol Energy PhD
C Neocleous BE(Mech)MSc(Naval Arch)PhD

Lecturers:
N Angastiniotis BS MS PhD
P Demetriou BSc(Hons) ACGI
P Eleftheriou BSME, MSME, PhD
G Katodrytis BSc(Hons)
L Lazaris BSc(Hons)PhD MIExE
A Loizides Chief Eng MSc
V Messaritis BSc(Hons) PhD
N Papanastasiou BSc(Hons)
A Stassis BSc(Hons)PhD Ceng
Th Symeou HTI Dipl. BSc(Hons)
P Tramountanellis BSc(Hons)

Senior Laboratory Assistant:
Ch Kaloyirou Diploma HTI

Laboratory Assistants:
I I Angeli Diploma HTI BEng MPhil (TQM) PhD CEng MIMechE Senior MASQ
C Christodoulou Diploma HTI ECE Part II
H Haridemou Diploma HTI

Computer Studies Department

Academic Staff:

Head of Department:
A. Stathopoulos BA DPhil CPhys MInstP FRMS MEPS

Senior Lecturer:
P Masouras BSc MSc MCCS

Lecturers:
E Angelidou-Loizou BSc MSc
M Ioannides Dr BSc MSc SMACS MCCS
P Katsouri BSc MCCS
C Makarounas BSc
M Theodorou BSc MBA(IS) MACM MIEEE MCCS
M Tsindas-Hadjiyiannakou BSc MSc MBCS MCCS
C Panayiotou BSc(Hons) MSc(Adv) MPhil MCCS

Laboratory Assistants:
D Kkalli-Christodoulou Diploma HTI
E Papa-Shiakidou Diploma HTI
P Tsikkou-Christoforidou Diploma HTI

General Studies Department

Academic Staff:

Head of Department:

N Mantis Degree in Political Science
Diploma in Industrial Management

Science

Senior Lecturer:

C Demetriades BSc PhD
Z Schiza Degree in Maths

Lecturers:

P Christodoulides BSc (Hons) MSc PhD
K Kalli BSc (Hons) PhD Cphys,
MinstP, MIEEE, MOSA
P Kronis BSc
A Mouskou-Peck GDES, BEd (Hons), Camb.Dipl.
M Neophytou BA Diploma TEFL MA
P Zarpetea-Loizidou BA MA

Sports Masters:

Z Papacostas Degree in PEd
Ph Sofocleous Degree in PEd

Engineering Practice Department

Academic Staff:

Workshops Superintendent:
S.Savvides Diploma HTI MBA IEng FIIE Techn. Eng VDI (Electrical Engineering)

Senior Instructors

Ch Antoniou Diploma HTI MPhil (Civil Engineering)
P Chrysostomou Instructors Certificate (Mechanical/Marine Eng.)
G Florides Diploma HTI MPhil PhD VDI (Mechanical/Marine Eng.)
C Georghiades Diploma HTI IEng MIIE (Electrical Engineering)
A Shammas Instructors Certificate (Mechanical/ Marine Eng.)

Instructors:

G Alexandrou Diploma HTI (Civil Engineering)
I Antoniou Diploma HTI BEng (Mechanical/Marine Eng.)
S Avgousti Diploma HTI MSc IEng MIIE (Electrical Eng.)
C Christofi Diploma HTI (Mechanical/Marine Engineering)
E Evangelou Diploma HTI IEng MIIE (Mechanical/Marine Eng.)
P Hadjimichael Diploma HTI IEng MIIE (Electrical Engineering)
S Kyzas Diploma HTI (Civil Engineering)
M Shiammas Diploma HTI (Mechanical/Marine Engineering)
Ch Tsioutis Diploma HTI IEng MIIE (Mechanical/Marine Eng.)
S Kalogirou Diploma HTI MPhil PhD EurIng CEng MCIBSE MASHRAE MISES VDI (Mechanical/Marine Eng.)

Graduation Lists

Civil Engineering Course

- Elina Achillidou
- Panayiotis Andreou
- Stelios Charalambous
- Polycarpos Chrysanthou
- Anna Dionysiou
- Andreas Eleftheriou
- Katia Iacovou
- Socrates Ioannou
- Kyprianos Ioannou
- Maria Isaia
- Ioannis Kramvis
- Stavros Makris
- Maria Mavroudi
- Panayiota Neophytou
- Kyriaki Paphiou
- Lefteris Papalefteri
- Panayiotis Patatakos
- Marios Polycarpou
- Andreas Poupas
- Christina Spanou
- Marios Tzionis
- Stefanos Assos

Electrical Engineering Course

- Christos Constantinides N.
- Spyros Efthymiou E.
- Michael Hadjiroussos G.
- Kypros Hadjistyllis S.
- Neophytos Iosif
- Michalis Kyriacou L.
- Evagoras Mama H.
- Demetris Nathanael Ch.
- Constantinos Savva G.
- Marios Savva P.
- Anastasis Shiamishis Ch.
- Kypros Tziakouris A.
- Ioannis Tziortzis A.
- Philippos Adamou S.
- Demosthenis Chiletis C.
- Michalis Hadjiefthymiou Th.
- Michalina Kouspou
- Theodoros Papazacharia A.
- Omiros Psaltas
- Stylianos Serghiou S.
- Andreas Tsioutis C.

Marine Engineering Course

- Andreas Ch. Charalambides
- Marinos O. Glykeriou
- Charalambos S. Seftalis
- Christopher Edem Kwaku Tumfo
- Marios A. Agathocleous

Mechanical Engineering Course

- Shadi M.K. Agha
- Shadi M.A. Al Halabi
- Christoforos M. Attas
- Constantinos A. Charalambous
- Demetris K. Demetriou
- Pantelakis C. Demetriou
- Andreas N. Harka
- Yiannakis S. Houtris
- Angelos G. Karamouzis
- Alexis G. Kourtellas
- Lambros V. Kyrlitsias
- Christoforos K. Loizides
- Costas K. Petrides
- Michalis A. Spyrou
- Stylianos M. Stylianou
- Andreas Y. Symeou
- Demetrios Th. Vasiliou
- Omiros S. Yerolemou
- Charalambos A. Zenios
- Costas P. Zymaras
- Panayiotis S. Toumbas

Computer Studies Course

- Michalis Chaili
- Andreas Charalambous
- Panayiota Chimonidou
- Christos Christodoulou
- Christos Christodoulou
- Christos Constantinou
- Emilia Kasinou
- Andreas Kirtou
- Achilleas Koutsou
- Demetra Michael
- Alexis Papageorgiou
- Katerina Paphite
- Charalambos Photiou
- Christophoros Pissarides
- Androula Rikkou
- Efthymia Savva
- George Savva
- Andreas Siekkeris
- Phanos Socratous
- Georgoula Symeou
- Theodosis Theodosiou
- Michail Tochnitis
- Aliki Vasiliou
- Christoforos Zorlis

Graduation Prizes

Prizes awarded to students of the full-time Diploma Courses in Civil, Electrical, Mechanical & Marine Engineering and Computer Studies.

Presidential Prize for the Highest Overall Performance

A prize of £5000 sponsored by H.E. the President of the Republic Mr Tassos Papadopoulos for the Highest Overall Performance is awarded to:
Christopher Edem Kwaku Tumfo - Marine Engineering

Prizes for the Best Overall Performance in each specialisation

A prize of £500 sponsored by Ioannou and Paraskevaides Ltd for Best Overall Performance in Civil Engineering is awarded to: Maria Isaia

A prize of £500 sponsored by The Institution of Electrical Engineers Cyprus (IEE - Cyprus) (in memory of Dinos N. Ioannou) for Best Overall Performance in Electrical Engineering is awarded to: Marios Savva P.
(Honorary Mention: Michalis Hadjiefthymiou Th.)

A prize of £500 sponsored byThe Electricity Authority of Cyprus (EAC) for Best Overall Performance in Mechanical Engineering is awarded to: Michalis A. Spyrou

A prize of £500 sponsored by The Cyprus Popular Bank Ltd for Best Overall Performance in Marine Engineering is awarded to: Christopher Edem Kwaku Tumfo

A prize of £500 sponsored by The Bank of Cyprus Ltd for Best Overall Performance in Computer Studies is awarded to:

Christopher Edem Kwaku Tumfo - Presidential Prize

Maria Isaia. - Civil Engineering

Christopher Edem Kwaku Tumfo - Marine Engineering

Marios Savva P. - Electrical Engineering

Prize for Ethos and Social Contribution
(Ήθους και Κοινωνικής Προσφοράς)

A prize of £500 sponsored by PASYDY-HTI Staff Association (in memory of Andreas Tamanas and Andreas Achillides) for Ethos and Social Contribution is awarded to:
Michalina Kouspou

Michalina Kouspou - Ethos and Social Contribution

Prizes awarded to Civil Engineering Graduates

Best Project in Building Construction Works
A prize of £200 sponsored by Messrs Andreas Constantinou & Associates Architects - Engineers for the Best Project in Building Construction Works is awarded to:
Maria Isaia

Best Project in Civil Engineering Works
A prize of £200 sponsored by The National Guard for the Best Project in Civil Engineering Works is awarded to:
Ioannis Kramvis

Best Performance in Building Construction Subjects
A prize of £200 sponsored by The Building Contractors Association for the Best Performance in Building Construction Subjects is awarded to:
Maria Isaia

Best Performance in Civil Engineering Subjects
A prize of £200 sponsored by The Civil Engineers and Architects Association for the Best Performance in Civil Engineering Subjects is awarded to:
Maria Isaia

Charalambos Photiou - Computer Studies

Prizes awarded to Electrical Enginnering Graduates

Best Project in Electrical Power
A prize of £100 sponsored by The Cyprus Professional Engineers Association (in memory of Soteris Anastasiades) for the Best Project in Electrical Power is awarded to :
Ioannis Tziortzis A.

Best Project in Electronics
A prize of £200 sponsored by The Cyprus Workers Confederation (ΣΕΚ) for the Best Project in Electronics
is awarded to:Stylianos Serghiou S.

Michalis Spyrou - Mechanical Engineering

Best Performance in Electrical Power Subjects

A prize of £200 sponsored by The EAC Professional Employees Union (ΣΕΠΑΗΚ) (in memory of Andreas Hadjipaschalis) for the Best Performance in Electrical Power Subjects is awarded to: Michalis Hadjiefthymiou Th.

Best Performance in Electronics Subjects

A prize of £200 sponsored by The Free Pancyprian Organisation of Telecommunication Employees (ΕΠΟΕΤ) for the Best Performance in Electronics Subjects is awarded to: Marios Savva P.

Prizes awarded to Mechanical Engineering Graduates

Best Project in Plant Engineering

A prize of £200 sponsored by E&C&C Paraskevaides (Steel Works) Ltd for the Best Project in Plant Engineering is awarded to: Angelos G. Karamouzis

Best Project in Production Engineering

A prize of £200 sponsored by ExxonMobil Cyprus Inc for the Best Project in Production Engineering is awarded to: Yiannakis S. Houtris

Best Performance in Plant Engineering Subjects

A prize of £200 sponsored by Lanitis Bros Ltd for the Best Performance in Plant Engineering Subjects is awarded to: Michalis A. Spyrou

Best Performance in Production Engineering Subjects

A prize of £200 sponsored by S & T Plasticon Ltd for the Best Performance in Production Engineering Subjects is awarded to : Yiannakis S. Houtris

Prizes awarded to Marine Engineering Graduates

Best Performance in Marine Engineering Subjects

A prize of £200 sponsored by The Greek Ship-owner Mr Panayiotis Tsakos for the Best Performance in Marine Engineering Subjects is awarded to:
Christopher Edem Kwaku Tumfo

Best Performance in the Subject of Marine Power Plant

A prize of £500 sponsored by Hanseatic Shipping Co Ltd for the Best Performance in the Subject of Marine Power Plant is awarded to: Christopher Edem Kwaku Tumfo

Best Performance in the Subject of Ships Construction and Naval Architecture

A prize of £250 sponsored by Intership Navigation Co Ltd for the Best Performance in the Subject of Ships Construction and Naval Architecture is awarded to:
Christopher Edem Kwaku Tumfo

Best Performance in the Sea Service and Engineering Practice

A prize of £200 sponsored by Marlow Navigation Co Ltd for the Best Performance in Sea Service and Engineering Practice is awarded to: Christopher Edem Kwaku Tumfo

Prizes awarded to Computer Studies Graduates

Best Commercial Project A prize of £200 sponsored by The Cyprus Computer Society for the Best Commercial Project is awarded to:
Panayiota Chimonidou & Eftymia Savva
(Honorary Mention: Michail Tochnitis)

Best Web Based Technology Project

A prize of £200 sponsored by PriceWaterHouseCoopers for the Best Web Based Technology Project is awarded to:
Christos Constantinou & Phanos Socratous
(Honorary Mention: Andreas Siekkeris & George Savva)

Best Performance in Programming Languages Subjects

A prize of £200 sponsored by The Cyprus Information Technology Enterprises Association (CITEA) for the Best Performance in Programming Languages Subjects is awarded to: Charalambos Photiou & Christos Constantinou

Best Performance in Software Engineering Subjects

A prize of £200 sponsored by The Semi Government, Municipal and Local Authority Workers and Employees Trade Union Cyprus (ΠΕΟ) for the Best Performance in Software Engineering Subjects is awarded to:
Charalambos Photiou

Scholarships

Goverment Scholarships

Overseas students, scholars of the Cyprus Government (Board and Lodging, Travel, Books Allowance, Tuition Fees)

	£
One scholar from Greece	
Two scholars from Palestine	£9,480

Other Scholarships (in alphabetical order)

APOP Palechoriou	
(in memory of Panicos Louca)	£50
BAT (Cyprus) Ltd	£250
CTC Ltd	£250
Cybarco Ltd	
(in memory of Sophoclis Kyriacou)	£200
Cyprus Petroleum Refinery Ltd	£1200
EAC Professional Employees Union of the Electricity Authority of Cyprus	
(In memory of G Kontopoulos)	£200
ExxonMobil Cyprus Inc	£100
Geo Pavlides & Araouzos Ltd	
(in memory of Byron Pavlides)	£300
Hellenic Bank Ltd	£100
Hellenic Petroleum Cyprus Ltd	£800
Hellenic Technical Enterprises Ltd (Y Fund)	£50
HTI Graduates Association	£50
I Ioannou Family	
(in memory of George Ioannou)	£50
Jet G Kallis (Manufacturers) Ltd	£100
Lanitis Bros Ltd	£107
Metalco (Heaters) Ltd	£100
NCR (Middle East) Ltd	£100
New Co-Operative Society of Aglantzia	£150
People's Coffee Grinding Co Ltd	£100
The Semi-Government Municipal & Local Authority Workers & Employees	
Trade Union Cyprus (PEO)	£50

Subscriptions & Donations

Cyprus Forest Industries
Cyprus Hotel Association
Cyprus Telecommunications Authority
Electricity Authority of Cyprus
Hellenic Mining Co. Ltd
Ioannou & Paraskevaides Ltd

Donations to the IAESTE Fund

The Cyprus Youth Organisation
Ioannou & Paraskevaides Ltd

Other Donations

Cyprus Assoc. of Medical Physics & Biomedical Engineering
Cyprus Computer Society
Cyprus Group of Civil and Mechanical Professional Engineers
Cyprus Telecommunications Authority
The Institution of Electrical Engineers - IEE Cyprus
The Institution of Incorporated Engineers – IIE Cyprus Centre

Industrial Training Sponsorship

Sea Training
The following shipping companies offered sea training vacancies to 2nd year Marine Technician Engineering students during 2002 (in alphabetical order):

Columbia Shipmanagement Ltd
Hanseatic Shipping Co Ltd
Interorient Navigation Co Ltd
Intership Navigation Co Ltd
Lefkaritis Bros Marine Ltd
Louis Cruise Lines
Marlow Navigation Co Ltd
Navigo Shipmanagement Co Ltd
Reederei "NORD" Klaus E Oldendorff Ltd

Human resourse development authority of Cyprus

92 3rd-year students participated in structured industrial training sponsored by the Human Resource Development Authority Of Cyprus.
Participating firms (In alphabetical order):
"O LOGOS" TV and RADIO STATION
A & C Nexus Engineering Ltd
A & P Andreou Ltd
A & P Paraskevaides Ltd
A Eracleous Electrical Installations Ltd
A F Modinos & S A Vrahimis
A Iasonos
A Mavrokefalos Ltd
A Panayides Contracting Ltd
A S Air Control Ltd
A S L Air Mec Ltd
A Th Loizou & Son Ltd (Bull)
AKI Constructions Ltd
Akis Charalambous Partnership
Akritas Consultants Eng Ltd
ALCO Filters
Alexandros Stephanis Ltd
Alpha Bank
Amathus Beach Hotel
Amazon Ltd
Antonis Askanis Ltd
Atlantis Engineering Co Ltd
Atlas Copco
Avacom Computer Services
Bank of Cyprus Ltd
BAT (Cyprus) Ltd
C.M.P.
Ch Apostolides Ltd
Chapomed Ltd
Charalambous & Stylianou Dev Ltd
Charalco Ltd
Chrysilios Agapiou
Chrysostomou Bros Ltd
CLR Financial Services Ltd
Confort Reliance Eng Co Ltd
Cybarco Ltd
CyBC
Cylift & Equipment Ltd
Cynex Computer Solutions (Compusource)
Cyprus Airways
Cyprus Imports Corporation Ltd
Cyprus Land Development Corporation
Cyprus Popular Bank Ltd
Cyprus Ports Authority
Cyprus Telecommunications Authority
Cyprus Tourism Organisation
D Couvas Ltd
D I Demades Ltd
D P Vision Net Ltd
D. Stylianou Enterprises
Defrodom Domestic Appliances Ltd

DEKSA Ltd
Doros Neophytou
E & S Electric Services Ltd
EKA Ltd
El & D Christou Ltd
Electricity Authority of Cyprus - EAC
Electromatic Ltd
Eliofotou & Zinieris Co Ltd
Ewald & Makis Ltd
G Roditis
G.A. Christoforou & Associates
G.S.H Electrical Contractors Ltd
Galatariotis Telecommunications Ltd
Geo Pavlides & Araouzos Ltd
I.T.S Computer Ltd
IKA Computer Systems
Ilias & Kapsos
Ioannou & Paraskevaides Ltd
J Theophilou & Associates
K Ellinas Investments Ltd
KANIKA Construction Ltd
KEMOS Computers
Kermia Ltd
Kyriacos Loizides Garage
L Josephides & Associates
Lakis Stylianou
Larnaka Sewerage & Drainage Board
LINDE-Hadjikyriakos Gas Ltd
Loel Ltd
Lois Builders Ltd
M Apostraros - M Frangos
M C Michael & Associates
MDA (Cyprus) Ltd
Medcon Construction Ltd
Medisell Co Ltd
Metalco Heaters
Metalco Ltd
Metaxas CompuPlanet
Millenium Media Centre
Miltos Papadopoulos
Municipality of Aglantzia
Municipality of Aradippou
Municipality of Ayios Dometios
Municipality of Larnaka
Municipality of Nicosia
Municipality of Strovolos
N Afaniotis & I Pavlides Ltd
N Kourtellas Ltd
NETINFO Group of Companies Ltd
Nicolaou & Konnides
Nicolas Demetriou
P Vassiliou & Son (Cont) Ltd
PAG Architects & Engineers
Pampos Nicolaou & Son Ltd
Pandora Investments Ltd
Petrolina (Holdings) Ltd
Polycarpou Garage
Powersoft Computer Solutions Ltd
S & P Computers Ltd
S Houtris & Sons Ltd
S Ioannides & Associates
S Kyriacou Ltd
S Stylianou Ltd
Santamas Bros
Sapeco Ltd
Sewerage Board of Nicosia
Soteris Kyriakides
SP Sun Power Ltd
Spidernet Services Ltd
Spyros Stavrinides & Sons Ltd
Stavros Koumbaros & Associates
Synchrotech Ltd
SYNOVATE (MEMBR CRW)
Tecon Ltd
Telmen Ltd
Thermofast Ltd
TIHACO Business Solutions Ltd
Tofarco Ltd
Tsangaris & Sons Ltd
Tsircon Co Ltd
Unicars Ltd
Universal Bank
UTL
Valiantis Microoptics Ltd
Varnava Varnavas
Water Board of Limassol
Water Board of Nicosia

2003 HTI Graduation Ceremony

The Higher Technical Institute held its 33rd Graduation Ceremony on Friday, 27 June 2003 at the Cyprus International Conference in Nicosia. The President of the Republic Mr Tassos Papadopoulos, attended the ceremony and awarded the Presidential prize of £5000 to Mr Christopher Edem Kwaku Tumfo, from Ghana, the graduate with the highest overall performance.

The Minister of Labour and Social Insurance Mr Iacovos Keravnos who also attended the ceremony proceeded with the award of the diplomas to the ninety two graduates while the Chairman of the HTI Board of Governors Mrs Lenia Samuel awarded the prizes for the best overall performance, and the HTI Acting Director awarded the prizes sponsored by organizations and Professional bodies, to the graduates who excelled in their academic studies. The Chairman of the HTI Central Academic Council Dr Ioannis Michaelides also congratulated students awarded with prizes.

Members of the Parliament, government officials, representatives of the political parties, trade unions and professional bodies attended the ceremony.

The President of the Student Union, Mr Michalis Hadjiroussos addressed the gathering and highlighted the students efforts and demands for the professional recognition and restructuring of the Higher Technical Institute.

The main speaker was the HTI Acting Director Mr C. Loizou who thanked the dignitaries and all those who attended the Ceremony. An abridged translation of his graduation speech is given below:

On behalf of the Ministry of Labour and Social Insurance, the Higher Technical Institute and the Graduating Students, I would like to thank you for honouring us with your presence at the thirty third Graduation Ceremony of the Higher Technical Institute.

We consider your presence at our Ceremony as a proof of your interest in the work carried out at the Higher Technical Institute.

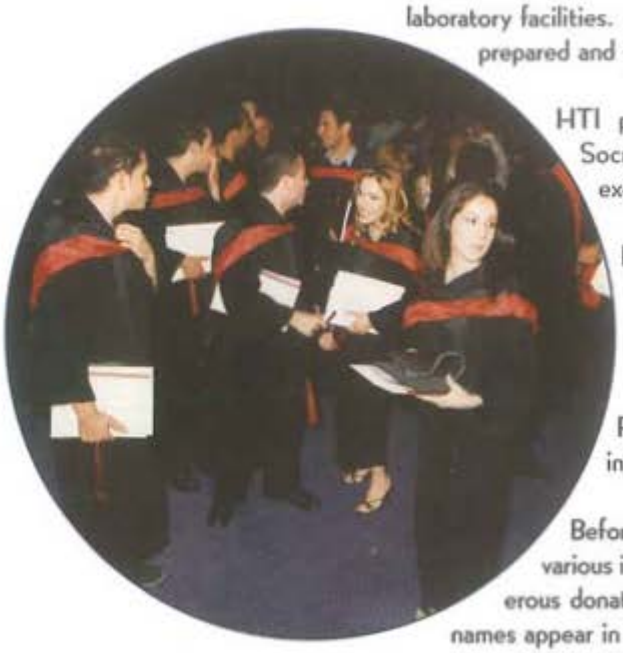
This year 92 students graduate from the three-year full-time courses namely, 21 in Electrical Engineering, 21 in Mechanical Engineering, 5 in Marine Engineering, 22 in Civil Engineering and 23 in Computer Studies.

Apart from the full-time courses, the HTI has also organized, 12 short courses with a total of 190 participants from industry in the framework of Continuous Professional Development.

It is well known that the HTI was established in 1968 on the basis of a 5-year Program of the Government of Cyprus with the assistance of the United Nations Development Program (UNDP), UNESCO and the International Labour Office (ILO).

We have given a total of 4440 Graduates to the Cyprus Industry and elsewhere from Technical Engineers to University Professors both in Cyprus as well as in numerous Universities abroad.

As far as the HTI infrastructure is concerned, we continue our efforts for the improvement of our computer and



laboratory facilities. Draft regulations for the Credit Point System have been prepared and forwarded to the Board of Governors for approval.

HTI participates actively in the European Union Program Socrates/Erasmus and Leonardo for staff and student exchanges.

In the meantime, the HTI continues to offer excellent training to its students both locally and abroad and, in addition, it is participating in research programs financed by the European Union as well as by the Government.

Furthermore, the HTI continues to offer its services to industry through consultancy work and materials testing.

Before ending my Graduation speech I would like to thank the various industries, organizations as well as individuals, for their generous donations, scholarships and prizes given to us this year. Their names appear in the Graduation Ceremony Booklet.

I would also like to express our thanks to his Excellency the President of the Republic for the Presidential Prize valued CY £5000 which is awarded to the best graduating student.

Concluding my speech, on behalf of the Ministry of Labour and Social Insurance as well as the Government, I would like to wish today's graduating students progress in life and a successful career.

IAESTE Programme

IAESTE stands for "International Association for the Exchange of Students for Technical Experience", and is a confederation of National Committees representing academic, industrial and student interests. Each National Committee is responsible for the administration of the exchange in its own country. The international body of IAESTE is a non political, independent, non-governmental organisation, in operational relationship with the United Nations Educational, Scientific and Cultural Organisation (UNESCO) and maintaining consultative relationships with the UN Economic and Social Council (ECOSOC), the United Nations Industrial Development Organisation (UNIDO) and the International Labour Office (ILO).

IAESTE is also in contact with the United Nations Economic Council for Africa (ECA), the Food and Agriculture Organisation (FAO), the Organisation of American States (OAS) and the European Union (EU), as well as with other educational non-governmental organisations.

The Aim of IAESTE

The Association is an organisation for the exchange of students at institutions of higher education wishing to obtain technical experience abroad relative to their studies in the broadest sense.

It shall promote international understanding and good will amongst the students of all nations irrespective of race, colour, sex or creed.

The association operates an exchange programme for the benefit of students, academic institutions, industrial and other organisations offering traineeships.

"I.A.E.S.T.E. (Cyprus)" stands for the International Association for the Exchange of Students for Technical Experience, and is the name of the Cyprus National Committee. The National Committees of all member countries form the International Organization named I.A.E.S.T.E.

The National Secretariat of I.A.E.S.T.E. (Cyprus) is located at the Higher Technical Institute, Nicosia.

The Cyprus National Committee members are:

Chairman: Constantinos Loizou, Acting Director, H.T.I.
National Secretary: Charalambos Chrysafiades, (until January, 2003)
Theodoros Symeou, (since February, 2003)

Members:
Director of Labour, Ministry of Labour & Social Insurance
Mikis Theodosiou, Representative of J & P Ltd
Stefos K. Loizides, Representative of Hellenic Mining Co.
Personnel Manager, Electricity Authority of Cyprus
Petros A. Vrahimis, General Manager, Representative of Cyprus Forest Industries
Zacharias Ioannides, Director-General, Representative of Cyprus Hotel Association
Nitsa Kambanella, Representative of Higher Hotel Institute of Cyprus
Head of Human Resource and Development, Cyprus Telecommunications Authority
HTI Students' Union

Mary Zenonos-Manison, Secretary IAESTE Cyprus

IAESTE Cyprus - Activity Report for the yeas 2002 - 2003

A total number of 11 Cypriot students received their training overseas and 22 overseas students obtained their training in Cyprus in the year 2003.

Our annual "Welcome to Cyprus Programme" consisted of a Formal Dinner with folk dancing, where all the students and most employers participated. The Chairman, National Secretary, IAESTE staff, as well as members of the National Committee were also present.

Also, a full day's excursion around the island was organised by IAESTE Cyprus, accompanied by a tour guide provided by the Cyprus Tourism Organisation, to historical sites, which included the Kolossi Castle, Aphrodite's Rock, and the beautiful mosaics of the House of Dionysos (God of Wine). A lunch was offered, and all students enjoyed the history, nature and hospitality of Cyprus. IAESTE staff also participated.

IAESTE Cyprus would like to express its gratitude to IAESTE Committee members, all employers, and financial supporters, for the valuable support and economic assistance.

The Chairman, HTI Ag. Director, Mr Constantinos Loizou and the National Secretary of IAESTE Cyprus, Mr Charalambos Chrysafiades, participated in the 55th Annual Conference, held in Bangkok,, Thailand between 18 - 25 January 2003.

Participating Employers

British American Tobacco (Cyprus) Ltd

Cyprus Forest Industries

Cyprus Land Development Corporation

Cyprus Petroleum Refinery Ltd

Cyprus Telecommunications Authority

Electricity Authority of Cyprus

Forest Park Hotel

Hellenic Copper Mines Ltd

Joannou & Paraskevaides Ltd

Municipality of Nicosia

Sewerage Board of Nicosia

Water Board of Nicosia

Footwear Thechnology Centre

The Centre was established at the HTI in 1975 with the aid of the UNDP with the aim of assisting the footwear and leather industries. It has a well equipped laboratory capable of carrying out laboratory tests on a wide range of materials used in the footwear and leather industries as well as finished products.

The Centre has recently purchased the Soling abrasion machine, adding to its range of equipment, details of which are listed below.

During the last year, the Centre has carried out 600 tests on materials and finished products in its related fields.

The Centre also carries out technical consultancy work to Government departments, manufacturers and importers in its field of expertise.

The drawing up of technical specifications and offering quality control services are also carried out by the Centre. Over the last year, technical specifications were drawn up for Nurses shoes and for Specialized leather bags for medical equipment, used by paramedical staff of the Ministry of health.

The Centre also holds the post of Chairman of the Footwear Technical Committee of the Governments' Central Tender Board.

Revised List of tests

TEST NO.	TESTING EQUIPMENT	TEST METHOD	PROPERTY TO BE MEASURED
1	Lastometer STD 104 Instant lastometer STD 190	BS 3144/8	a) Ball distention at grain crack (mm) b) Load at grain crack (Kg)
2	Monsanto tensometer Type W	BS 5131/5.4	Peel strength of adhesive joints at room temperature (N/mm)
2a	Monsanto tensometer Type W	BS 3424 part 5 method 7C	Tongue tear strength (N)
2b	Monsanto tensometer Type W	BS 5131/2.6	Split tear strength (N/mm)
2c	Monsanto tensometer Type W	BS 3144/5, IUP/6	a) Tensile stength (N/mmÇ) b) Elongation at break (%)
2d	Monsanto tensometer Type W	BS 3144/6, IUP 8	Slit tear strength (N)
2e	Monsanto tensometer Type W	CYS EN ISO 13934-1:99	a) Breaking load (N/50mm width) b) Elongation at break (%)
2f	Monsanto tensometer Type W	BS EN ISO 2062:1995	Breaking load of threads (N)
2g	Monsanto tensometer Type W	BS 5131 sec.3.7:91	Breaking load of laces (N)
3	Cantilever tensiometer STM 163 (Heated chamber)	SATRA AM 1	Peel strength of adhesive joints at elevated temperatures (N/mm)
4	Sole adhesion tester STD 185 Preset adhesion tester STD192	BS 5131/5.1	Sole bond strength (Kg)
5	Vacuum forming m/c STM 329	----------	Plastic forms (each)

Revised List of tests

TEST NO.	TESTING EQUIPMENT	TEST METHOD	PROPERTY TO BE MEASURED
6	Finish heat resistance tester STD 111	BS 3662/5	Resistance to heat (ÆC)
7	Dead load hardness tester Wallace H1	BS 903/ A26:95 method N, ISO:48	Hardness of soling material (IRHD)
	Pocket hardness tester Wallace H2	BS 903/ A57:89 ISO 7619	Hardness of soling material (IRHD)
8	Finish rub fastness tester STM 102/103	BS 3662/8&9, BS 1006 UK-LC	Resistance to rubbing, dry & wet (Grey scale)
9	Insole backpart stiffness tester STD 177M1	SATRA PM 59	Longitudinal stiffness of back part of insole
9a	Insole back part stiffness tester STD 177M2	SATRA PM 88	Torsional stiffness of back part of insole
10	Dome plasticity apparatus STD 110M	BS 3144/10	Shape retention or set (%)
11	Finish adhesion tester STD 112M	SLF 11	Adhesion of finish, dry & wet (g/cm)
12	Wrinkleometer STD 119M	BS 5131/3.4	Resistance to wrinkling after shortening of material (%)
13	Upper material flexing m/c STM 101	BS 3424 Part 9/11C	Resistance to flexing, dry & wet
14	Shoe flexing m/c STM 184M	SATRA PM 92	Resistance of complete shoe to flexing
15	Ross flexing m/c STM 141M	BS 5131/2.1	Resistance of sole to flexing (strip)
15a	Ross flexing m/c STM 141M	BS 5131/2.1	Resistance of sole to flexing (whole sole forepart)

Revised List of tests

TEST NO.	TESTING EQUIPMENT	TEST METHOD	PROPERTY TO BE MEASURED
16	Heel fatigue tester STM 156	BS 5131/4.9	Resistance of lady's heels to impact
17	The bottom leather grain crack tester STD 132	BS 3144/7	Resistance of soling leather to cracking (crack index)
18	Compression set apparatus STD 401	BS 903 part A6	Compression set of soling material (%)
19	Soling leather abrasion m/c STM 140M	SATRA PM 84	Abrasion resistance of leather soling (mm/1000 throws)
19a	Soling abrasion m/c	ISO 4649, CYSEN 12770:00	Abrasion resistance of soling (relative volume loss in mmN)
20	Satrafoil	----------	Sole pressure distribution (each foil)
21	Thickness gauge	BS 3144/3 EN 344 4.5.1	Thickness measurement of leather (mm) Thickness measurement of coated fabric and textile (mm)
22	Electronic weighing balance and measuring cylinder	----------	Density/Specific gravity (g/cmN)
23	Electronic balance	----------	Weight (g)
24	Bally penetrometer	BS 3144/21, IUP 10	a) Penetration time (minutes) b) Water absorption (%) c) Water penetration (g/h)
25	Impact tester	EN 344 5.3	Impact resistance of safety footwear (mm clearance after impact)
26	Gloss determination tester	ISO 2813	Gloss determination
27	Textile water penetration apparatus(Hydrostatic tester)	CYSEN 20811:92	Resistance of fabrics to water penetration (cmH2O)

1 July, 2003
AV/AV Revised list of tests

Research at the Higher Technical Institute

One of the basic objectives of HTI has always been the promotion and development of research. Research is coordinated by the "HTI Research Committee" which ensures an effective utilisation of the infrastructure and the available funds. Over the last years there has been an extensive activity on applied research, both at National and European levels. The main areas in which research is currently being done are:

Civil Engineering Department

› Measures of optimal RES (renewable energy resources). Integration design in architecture and urban planning

› Proposal for possible amendments of the Cyprus seismic code.

› Stability and stress analysis of the Tan Miller dam in Austin, Texas, USA.

› Flexural strengthening with carbon fiber-reinforced polymer composites of beams.

› Use of sludge as a soil conditioner: environmental effects on soils in terms of macro and microelements concentration.

Computer Studies Department

› Computer integrated network for manufacturing applications (CINEMA)

› E-Manufacturing/Rapid Prototyping

› Qualitative reasoning and modelling of reasoning techniques for a single and multiple agents (self-directed autonomous programs that are influenced by the environment in which they reside and revise their targets/goals appropriately)

Electrical Engineering Department

› Digital signal processing

› Bispectral analysis: Processing of the interference pattern of electromyographic signals

› Installation and testing of an experimental computer network

› Switching function algebra: Analysis of power electronic circuits.

› Mobile transmission for intelligent telecardiology management system.

General Studies Department

> The pedal curve and surface (Classical Differential Geometry).

> The Introduction of Project Work in Secondary Education.

> Kinetic parameters estimation in non-linear adsorption systems.

> Repatriated Cypriots and Bilingualism.

> Using technology in the teaching of English

> Fluid Mechanics - Interfacial Waves - Dynamical Systems - Mathematical Modeling

Engineering Practice Department

> Low energy air-conditioning of buildings.

> Hydrogen fuelled internal combustion engines.

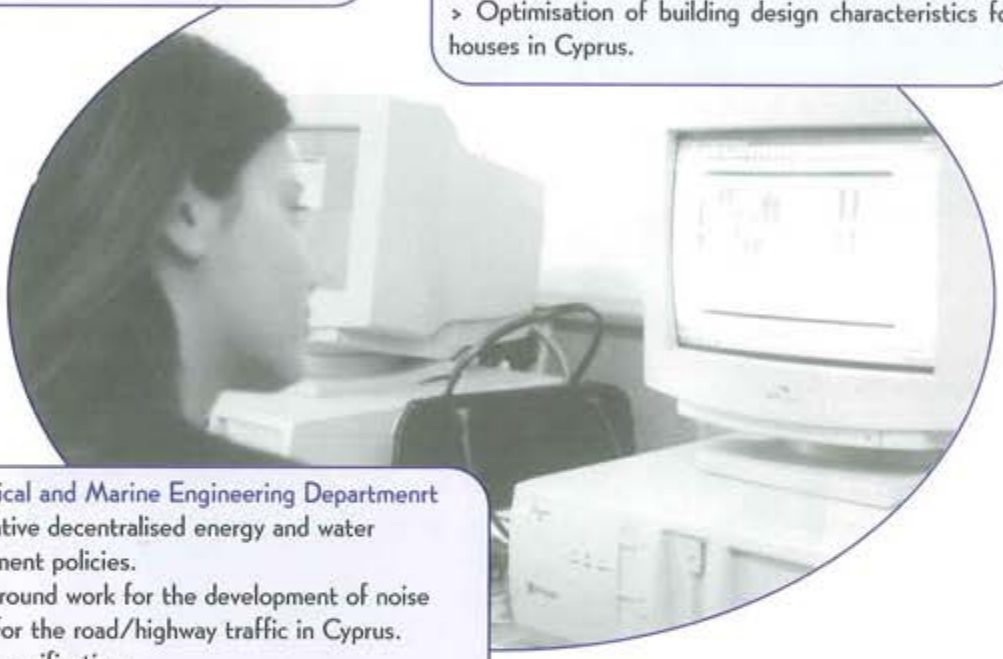
> Design and construction of a spray evaporator for sea-water desalination.

> Building construction: traditional practices and memories of the past.

> Optimisation of the surface finish produced by various tools available in the local market under various cutting conditions for turning operation using the CNC lathe.

> Design, construction and performance evaluation of a solar air-collector for domestic applications in Cyprus.

> Optimisation of building design characteristics for houses in Cyprus.



Mechanical and Marine Engineering Departmenrt

> Innovative decentralised energy and water management policies.

> Background work for the development of noise models for the road/highway traffic in Cyprus.

> Water purification.

> Thermochemical processing for the synthesis of nanostructured composite powders and the consolidation into net-shaped parts and thermal deposition

> Fault diagnosis in gas cylinders using computational intelligence techniques

> Intelligent robotic control.

> Predict future failure of a plant by condition monitoring.

> Development of mathematical models, software and hardware for improving the dynamic characteristics of structures and machine tools

> Mechanical rubbish collector from the embankments of highways.

> Optimisation of thermal insulation thickness in air-conditioned buildings in Cyprus.

European Programmes

Since 1994 the HTI has been participating in various European Programmes as follows:

> "MED-CAMPUS Training Course on Renewable Energy Sources and their Practical Applications in the Mediterranean Region", sponsored by the European Union (Malta, 29 August - 9 September 1994).

> SAVE Programme: Creation of a Third Countries Educational Network for Energy Efficiency Purposes (1994 - 1996)

> INCO Programme, Concerted Action ERB3514PL972951: "MED-POL" Innovative Decentralised Energy and Water Management Policies can encourage the creation of a market and help rural development (1998 - 2002).

> LEONARDO DA VINCI Programme, Project No. D/02/B/F/PP-112615: "MARVEL" Virtual Laboratory in Mechatronics, Access to Remote and Virtual e-Learning (October 2002 - to-date).

> EU–KIT–204 Surfmod: 3D Scanning, Reconstruction & Reproduction in Mechanical Engineering, Architectury, Archaeology

> EU–Jewelmed: JCA3-1999-10005 dentification, Analysis, Preservation & Disemination of manufacturing technologies in goldsmithing & silversmithing from the 7th to 1st century BC int he mediterranean area.

> EU–Leonardo: Software Quality Evaluator. (SQE)

> 5th Framework Programme (SPEAR) . Seismic Performance Assessment and Repairs. (2000- to-date).

In 1998 the HTI was the contractor and coordinator of the project C.E.M.E.N.T. Centre and the contractor of the project HERMES within Leonardo da Vinci Programme.

Since 1998 the HTI has been participating in the Socrates/Erasmus Programme which involves Institutions of Tertiary Education. The most significant of its activities include:

(i) student/staff exchanges between European Institutions

(ii) joint educational programmes (curricula) and Intensive Programmes (I.P.) within groups of staff and students of the various Institutions.

The HTI participated initially with Preparatory Visits and student/staff exchanges, but for the last couple of years it is being involved in other activities as well.

Each year nearly 4% of the students and 5% of the entire staff of the Institute participate in the programme.

Ten European Universities have already cooperated with the HTI through the Socrates/Erasmus Programme, mainly from Germany, Greece, Finland and the United Kingdom.

In the coming years the participation of the HTI is expected to rise significantly as a result of the following:

(i) the accession of Cyprus to the European Union.

(ii) the introduction of the Credit Point System in the HTI which enables students to transfer credits (ECTS) between Institutions and facilitates their exchange and recognition of studies.

(iii) the upgrading of the HTI under the umbrella of the proposed University of Applied Sciences and Arts.

Sports Activities

October
All first and second year students participated in an intramural volleyball championship.

November
The HTI Basketball team participated in a Basketball tournament, which was held in Nicosia between 27 and 28 of November.

All first and second year students participated in an intramural Futsal championship.

All first and second year students participated in an intramural Basketball championship.

The HTI team ended up in the third position in the Tertiary Education Volleyball championship, which was held in October and November.

February
All second year students participated in an intramural Futsal championship.

HTI students participated in the 4000 m (boys) and 2000 m (girls) cross-country race.

March
All second year students participated in an intramural Volleyball championship.

A seven -a- side Football Championship was organized for all HTI students.

The HTI team ended up in the fourth position in the Tertiary Education Basketball championship, which was held in February and March.

The HTI team ended up in the third position in the Tertiary Education volleyball championship, which was held in February and March.

May
The Ag Director of the HTI honoured winning teams and athletes of the Institute, in a ceremony that took place in the students' canteen in the presence of staff members and students.

Educational Activities Academic Year: 2002/2003

A. New Publications

1. Voskarides S, Pattichis C, Instepanian RSH Michaelides C, Schizas C "Practical Evaluation of GPPRS use in a Telemedical System in Cyprus" Proceeding of the 4th International IEEE-EMBS Special Topic Conference on Information Technology Applications in Biomedicine, Birmingham, UK, pp 39-42, 24-26 April, 2003.

2. Voskarides S, Pattichis C, Instepanian RSH, Kyriakou E, Schizas C, "Mobile Health Systems. A brief overview" Proceedings of SPIE Aerosence 2002: Digital Wireless Communications IV, Ed. by Rao, RM Dianat, S.A. Zoltowsk, M.D., Vol 4740, Orlando, Florida USA, p.p. 124-131, 2002.

3. Pattichis G.S., Kyriakou E., Voskarides S , Instepanian RSH "Wireless Telemedicing Systems: An Overview" IEEE Antennas and Propagation, Vol. 44,2, p.p.143-153, 2002

4. K. Kalli, A. Othonos and C. Christofides "Characterization of reflectivity inversion, · and , phase transitions and nanostructure formation in hydrogen activated thin Pd films on silicon based substrates" Journal of Applied Physics, Vol 91, No 6, p3829, 2002.

5. A. G. Simpson, K. Kalli, L. Zhang, K. Zhou and I. Bennion "Abnormal photosensitivity effects and the formation of type 1A fibre Bragg gratings" BGPP Monterey, California, September 2003. Post deadline.

6. M. Rajarajan, C. Themistos, B.M.A. Ratman, K.T.V. Grattan, K. Kalli and M. Komodromos. "Design issues for optical microring filters on deeply etched GaInAsP-InP waveguides" SPIE PhotonWest 2003, OPTO 2003 Integrated Optoelectronic Devices, January 2003.

7. M. Rajarajan, C. Themistos, B.M.A. Ratman, K.T.V. Grattan, K. Kalli and M. Komodromos. "Design issues for an ultra compact tapered MMI coupler based 3 dB splitter" SPIE PhotonWest 2003, OPTO 2003 Integrated Optoelectronic Devices, January 2003.

8. N. Angastiniotis, Tailor-Made Nanostructured Tungsten Heavy Alloy Powders

9. I. Angeli, P. Votsis , S. Kambanellas, Listening the voice of the Internal Customer, Proceeding at Quality Forum 2003, Athens 22-23 May 2003.

10. I. Angeli, Using Acceptance Sampling Standards to establish a methodology for calculating frequency and sample size to monitor SPC control charts, 6 Panhellenic Quality Forum, Nicosia, 17-19 September 2003.

11. Florides, G., Tassou, S., Kalogirou, S. and Wrobel, L., 2002. Measures Used to Lower Building Energy Consumption and their Cost Effectiveness, Applied Energy, Vol. 73, No. 3-4, pp. 299-328.

12. Kalogirou, S., 2002, Use of Artificial Intelligence for the Optimisation of Solar Systems, International Journal of Renewable Energy Engineering, Vol. 4, No. 3, pp. 499-505.

13. Kalogirou, S., Eftekhari, M. and Marjanovic, L. 2003. Predicting the Pressure Coefficients in a Naturally Ventilated Test Room Using Artificial Neural Networks, Building and Environment, Vol. 38, No. 3, pp. 399-407.

14. Kalogirou, S., 2003, The Potential of Solar Industrial Process Heat Applications, Applied Energy, Vol. 76, No. 4, pp. 337-361.

15. Florides, G., Kalogirou, S., Tassou, S. and Wrobel, L., 2003. Design and Construction of a Lithium Bromide-Water Absorption Machine, Energy Conversion and Management, Vol. 44, No. 15, pp. 2483-2508.

16. Kalogirou, S., 2003. The Energy Subsidisation Policies of Cyprus and their Effect on Renewable Energy Systems Economics, Renewable Energy, Vol. 28, No. 11, pp. 1711-1728.

17. Kalogirou, S., 2003, Generation of Typical Meteorological Year (TMY-2) for Nicosia, Cyprus, Renewable Energy, Vol. 28, No. 15, pp. 2317-2334.

18. Florides, G., Kalogirou, S., Theophilou, K. and Evangelou, E., 2003. Analysis of the Typical Meteorological Year of Cyprus and Typical House Load, Proceedings of the Building Simulation 2003 Conference, Eindhoven, Netherlands, Vol. 1, pp. 339-346.

19. Kalogirou, S., Florides, G. and Evangelou, E., 2003. Comparison of the Thermal Loads for Buildings Erected at Four Different Locations in Cyprus, Proceedings of the Building Simulation 2003 Conference, Eindhoven, Netherlands, Vol. 2, pp. 605-612.

20. Kalogirou, S., 2003. Use of Genetic Algorithms for the Optimal Design of Flat Plate Solar Collectors, Proceedings of the ISES 2003 Solar World Congress, Goteborg, Sweden.

21. Kalogirou, S., 2003. The Impact of Optical Properties on the Performance of Flat Plate Solar Collectors, Proceedings of the ISES 2003 Solar World Congress, Goteborg, Sweden.

22. Kalogirou, S., 2003. Entropy Generation Minimisation of Imaging Concentrating Solar Collectors, Proceedings of the ISES 2003 Solar World Congress, Goteborg, Sweden.

23. Kathijotes N. "Application Of Municipal Sludge To Forestland: Nitrogen Leachate Control", Jubilee International Scientific Conference, University Of Forestry, 1-2 April 2003 Sofia, BG

24. Koleva M. and Kathijotes N. "Application of Wastewater Sludge to Forestland- Possibilities and Prospects" International Scientific Conference UNITECH '03 Technical University of Gabrovo, Nov 2003 Gabrovo, BG

C. Short Courses/Conferences/Sminars Organized by HTI

The Engineering Practice Department in collaboration with the Institution of Incorporated Engineers (IIE) Cyprus Centre organize two courses on "PRINCIPLES OF DIGITAL T.V. - P.C. Networks" of 24 hours duration each, one between 26-29 September 2002 and one between 3-6 April 2003.
Both courses were approved and sponsored by the Cyprus Human Resources Authority.

D. Short Courses/Conferences/Sminars attended by HTI academic staff

1. Dr Marios Kassinopoulos, lecturer in Electrical Engineering Department, attended a 4-day International Conference on Engineering Education - ICEE03 organized by INEER (International Network on Engineering Education and Research) in Valencia Spain the 21-25 July 2003.

2. Mr Constantinos Loizou, Ag Director attended the 55th Annual Conference of IAESTE in his capacity as Chairman of IAESTE Cyprus between 18-24 January 2003 in Bangkok, Thailand.

3. Mr Charalambos Chrysafiades, Senior Lecturer in Electrical Engineering attended the 3rd Mediterranean Conference and Exhibition on Power Generation, Transmission, Distribution and Energy Conversion. Organized by I.E.E. Cyprus IEE Greece, IEE Israel and the Electric Energy Systems Laboratory of the national Technical University of Athens between 4 November and 7 November 2002 in Athens.

4. Mr Charalambos Chrysafiades, National Secretary of IAESTE Cyprus attended the 55th Annual Conference of IAESTE between 18 January 2003 and 24 January 2003 in Bangkok, Thailand.

5. Mr Spyros Spyrou, Senior Lecturer in Electrical Engineering Department attended a one half-day meeting on "The HellasSat Communications Satellite. Organised by the Hellas Sat Co Ltd at the Hilton Park Hotel, Nicosia (5 February 2003).

6. Mr Spyros Spyrou attended a one-day Seminar/workshop on "Learning Policy for Civil Service Organisations" organised by the Cyprus Academy of Public Administration (CAPA) at the CAPA Building, Nicosia. (/ February 2003).

7. Mr Spyros Spyrou attended a one-day meeting on "The sixth Framework Programme for Research and Technological Development" (2002-2006). Organised by the Cyprus Research promotion Foundation (Ιδρυμα Προώθησης Έρευνας) at the Hilton park Hotel, Nicosia.(11 February 2003)

8. Mr Spyros Spyrou attended a two-day intensive course on LATLAB Fundamentals & Programming Techniques, organised by The Mathworks Co at their Training Centre, Cambridge, UK. (13 May 2003).

9. Mr Spyros Spyrou attended a one-day seminar on "Cyclotron-PET/CT and Medical Applications", organised by the Cyprus Association of Medical Physical Physics and Biomedical Engineering at the Cyprus Institute of Neurology and Genetics, Nicosia, Cyprus. (7 June 2003).

10. Mr Spyros Spyrou attended on one-day Seminar on "CYS Standards Management System" (Το Ηλεκτρονικό Σύστημα Διαχείρισης Προτύπων), organised by the Cyprus Organisation for the Promotion of Quality, at the Holiday Inn Hotel, Nicosia, Cyprus. (19 June 2003).

11. Mr Spyros Spyrou attended a one-day seminar on the "Notification Procedure: Directives 98/34/ED and 98/48/EC" organised by the Cyprus Organisation for the Promotion of Quality and the European Commission Enterprise DG at the Hilton Park Hotel, Nicosia, Cyprus. (26 June 2003).

12. Mrs Chrystalla Demetriades attended a 3-day conference 3rd "Mediterranean Conference on Mathematical Education" between 3 to 5 January 2003 in Athens, Greece.

13. Mr Pavlos Christodoulides attended a 2-day workshop on stability and structure of interfacial waves organized by the Loughborough University (UK) between 15 May and 16 May 2003.

14. Mr. Panicos Masouras attended a 2-day conference on Information Security, organized by the Cyprus Computer Society, between 11-12 October 2002.

15. Mr. Panicos Masouras attended an 1-day conference on "Servers: The future of the Enterprise" organized by GARTNER on 17 October 2002.

16. Mr. Panicos Masouras attended a 2-day conference on "IT and Education" organized by the Cyprus Computer Society between 13-14 December 2002.

17. Mrs Maria Theodorou attended a 3-day conference on the "Beautiful Corporation giving Real meaning to business" organized by the Cyprus Quality Forum between 10-12 September 2002.

18. Mrs Maria Theodorou attended a 2-day conference on the 2nd conference of "Information Security from Theory to Practice" organized by the Cyprus Computer Society between 11-12 October 2002.

19. Mrs Maria Theodorou attended a 2-day seminar on "Measurement, Analysis and Improvement, - ISO 9001-2002 with the use of Statistical Process Control" organized by the Technocenter Ltd between 2-3 December 2002.

20. Mrs Maria Theodorou attended a 5-day educational program on "Internet Security and Firewalls" and on "Network Hacking and Defence" organized by the Cyprus Computer Society between 19-23 May 2003.

21. Dr. Marinos Ioannides attended a 8-day international conference on "Information Technology & Archaeology" organized by UNESCO at Amman, Jordan, between 3-10 August 2002.

22. Dr. Marinos Ioannides attended a 5-day International Workshop on "3D-Reconstruction & Culture Heritage" organized by CIPA in Corfu, Greece between 30 September - 4 October 2002.

23. Dr. Marinos Ioannides attended a 7-day E.U. Training Course on "VRML and Internet" organized, under the Herms project, in Athens, Greece between 4-10 July 2003.

24. Dr Despina Serghides as member of the International Advisory Committee of EuroSun 2002 participated in the 5 day "Solar Scientific Technical Congress & Policy Forum" at the University of Bologna, Bologna, Italy, June 23-27, 2002.

25. Dr Despina Serghides as member of the Board of Directors of the International Solar Energy Society (ISES), and President of ISES-Cyprus participated in the 5 day "ISES Solar World Congress 2003: Solar Energy for a Sustainable Future" in Goteborg, Sweden, in June between 14-22, 2003. During the Works of ISES Dr Serghides was elected Vice-President of ISES - Europe.

26. Mr Panayiotis Pelecanos attended a 2 day seminar/workshop on "Strengthening with externally bonded FRP reinforcement - Behaviour, Design and Applications" organized by International Federation for Structural Concrete between 4-5 May 2003.

27. Mr Savvas Savvides attended the European Higher Engineering and Technical Professional Association (EurEta) Annual General Meeting and Board, meetings that took place in Stockholm, Sweden between 5-6 June 2003.

28. Dr Soteris Kalogirou attended the 2003 Solar World Congress between 16-19 June 2003 held in Gothenburg, Sweden and presented three papers related to hew research work.

29. Dr G. Florides participated in "Buildings Simulation conference 2003" in Eindhoven Netherland from 11-15 August 2003. He presented two papers on Building Simulations.

30. Mr Costas Georgiades, Mr Soteris Avgousti and Mr Panayiotis Hadjimichael attended a course on Level II Maintenance Training Course & Fibre & Component overview organized by Fujikura Europe Limited in London U.K. from 9 - 10 June 2003.

31. Mr Costas Georgiades attended a course organized by the Cyprus Public Administration Academy για "Workshop for the identification of learning needs".

32. Mr Savvas Savvides and Mr Panayiotis Hadjimichael attended a course on Safety - Fire - Environment - Safety Systems of Work - Ergonomics organized by Cyprus Safety Health Association on 3-4 October 2003.

33. Mr N. Papanastasiou attended a 36 hours course on ADVANCE AUTOCAD 30 organized by International Computer Centre between 28/11/2002 - 24/1/2003.

34. Mr Theodoros Symeou attended a 2-day seminar on " Euro Mediterranean Energy Policy Training Network " organised by the Cyprus Institute of Technology at the Hilton Park Hotel, Nicosia. (26 Î-È 27 June)

35. Dr. L.G.Lazaris attended a 3-day seminar on Quality Management 6 Quality Forum, Cyprus ECOQ, 17/9 - 19/9/2003.

36. Mr. G. Katodrytis attended a 4-day 3rd International Conference on Non-destructive Testing and Engineering Technologies, Thessaloniki, 25-28 May 2003.

37. Dr. N. Angastiniotis attended a 3-day program organized by S.M.MHK on Surface and Coatings, between 25-27 September 2003.

38. Dr. I. I. Angeli attended and presented a paper at the Quality Forum 2003 in Athens, 22-23 May 2003.

39. Dr. I. I. Angeli attended and presented a paper at the 6th Panhellenic Quality Forum 2003 (3 days) in Nicosia 17-19 September 2003.

40. Dr. I. I. Angeli attended a 2-day course organized by the British Standards Institution in Auditing ISO 9000 2000 in Nicosia between 29-30 September 2003.

41. Dr. I. I. Angeli attended a 3-day course organized by the United Kingdom Accreditation Services in Windsord UK, on Assessor Training Laboratories ISO/IEC 17025, 13-15 October 2003.

E.Visits/Educational Exchange Programmes

1. Professor Christos Tzikas of TEI Thessalonikis visited the Electrical Department between 21 and 26 September 2003. During his visit he gave lecturer to the second year students of the Department.

2. Mr Diomides Lambrianides (Lecturer) visited the TEI of Thessaloniki between 26-30 May 2003. During his visit he gave lecturer in Electronics and Telecommunications.

3. Mr Charalambos Chrysafiades, Senior Lecturer in Electrical Engineering visited the Slovak University of Technology in Bratislava between 3 December 2002 and 7 December 2002. Within the "Protocol of the First Session of the Cypriot - Slovak Inter governmental Commission on Economic and Industrial cooperation.

4. Mr Spyros Spyrou visited the exhibition "The Embedded Systems Show ESS2003", at the ExCel exhibition centre, London UK. (15 May 2003).

5. Professor Csopaki Gyula Director of International Education Center of Budapest University of Technology and Economics visited the HTI between 8-11February 2002. During his visit professor Csopaki had meetings with the Director the Research Committee and members of staff of the Engineering Practice Department.

6. Dr Despina Serghides is the Scientific Co-ordinator on behalf of Cyprus of the European programme "Brundtland Solar Cities Energy Network" of the "EU 5th Framework" programme. In this context she had meetings in:

a. Downpatrick, Northern Ireland in April 11-12, 2002.

b. Vienna & Bruck, Austria, October 28-29, 2002.

c. Warsaw & Mszczonow, Poland, March 31-1 April, 2003.

7. Mr Constantinos Christodoulou, Laboratory Assistant, Mechanical Engineering Department, visited the Brunel University between 5 June – 10 June 2003 under the Socrates-Erasmus program . During his visit he had the opportunity to become familiar with new technologies and activities developed in the laboratories of Brunel University.

8. Dr Ioannis Angeli, Laboratory Assistant, Mechanical Engineering Department, visited the South Corelia Polytechnic in Finland between 6-11 April 2003 under the Socrates-Erasmus program. During his visit he delivered 8 hours lectures on Quality Function Deployment to final year students. He had also the opportunity to become familiar with the system used in their laboratories.

F.Curremt Research Projects / 2002 - 2003

Civil Engineering

1	Measures of optimal RES (Renewable Energy Resources) Integration Design in Architecture and Urban Planning	>Dr D. Sergides
2	Stability and Stress analysis of Tan Miller Dam in Austin, Texas, USA	>Dr Ch. Papaleontiou
3	Flexural Strengthening with Carbon Fiber-Reinforced Polymer Composites of Beams	>Mr P. Pelecanos
4	Use of Sludge as a Soil Conditioner: Environmental Effects on Soils in terms of Macro and Microelements Concentration	>Dr N. Kathijotes
	European programme	>Dr Chr. Chrysostomou

Computer Studies

1	e-Manufacturing/Rapid Prototyping	>Dr M. Ioannides
2	Qualitative reasoning and modelling of reasoning techniques for a single and multiple agents.	>Ms Chr. Panayiotou

Electrical Engineering

1	Digital Signal Processing	>Mr. D Lambrianides
2	Bispectral Analysis: Processing of the Interference Pattern of Electromyographic Signals	>Mr. S Spyrou
3	Switching Function Algebra: Analysis of Power Electronic Circuits	>Dr Chr. Marouchos
4	Mobile Transmission for Intelligent Telecardiology Management System	>Mr S. Voskarides

Mechanical Engineering

1	Background Work for the Development of Noise Models for the Road/Highway Traffic in Cyprus	>Dr P. Eleftheriou
2	Water Purification	>Dr P. Eleftheriou
3	Thermochemical Processing for the Synthesis of Nanostructured Composite Powders and the Consolidation into Net-shaped parts and Thermal Deposition	>Dr N. Angastiniotis
4	Fault diagnosis in gas cylinders using computational intelligence techniques	>Dr C. Neocleous, Dr A. Stassis, Mr C. Christodoulou
5	Intelligent Robotic Control	>Dr C. Neocleous, Mr P. Demetriou
6	Predict Future Failure of a Plant by Condition Monitoring	>Dr V. Messarites
7	Development of Mathematical Models, Software and Hardware for Improving the Dynamic Characteristics of Structures and Machine Tools	>Dr A. Stassis
8	Mechanical Rubish Collector from the Embarkments of Highways	>Dr L. Lazari
9	Optimisation of Thermal Insulation Thickness in Air-conditioned Buildings in Cyprus	>Dr I. Michaelides
10	Solar energy laboratory and e-Learning	>Dr I. Michaelides, Dr P.Eleftheriou
11	Investigation of the creativity/inventiveness of engineering students	>Dr C. Neocleous

General Studies

1	The pedal curve and Surface	»Dr Chr. Demetriadi
2	Femtosecond laser microstructured gratings and microstructure optical fibres	»Dr K. Kalli
3	Kinetic Parameters Estimation in Non-Linear Adsorption Systems	»Dr P. Christodoulides

Workshops

1	Hydrogen Fueled Internal Combustion Engines	»Mr. I. Antoniou
2	Design and construction of a spray evaporator for sea-water desalination	»Dr S. Kalogirou
3	Building Construction: Traditional Practices and Memories of the past	»Mrs Chr. Antoniou
4	Optmisation of the surface finish produced by various tools available in the local market under various cutting conditions for turning operation using the CNC lathe	»Mr Ch. Tsioutis, Mr C. Christofi
5	Design, Construction and Performance Evaluation of a Solar Air-Collector for Domestic Applications in Cyprus	»Mr Ch. Tsioutis
6	Optimisation of Building Design Characteristics for Houses in Cyprus	»Mr E. Evangelou, Mr G. Alexandrou
7	Thermal load of buildings and ground heat exchangers	»Dr G. Florides, Dr S. Kalogirou
8	Thermal analysis of windows constructed in Cyprus	»Dr S. Kalogirou, Dr G. Florides

An idealised method for the fabrication of temperature invariant IA-I strain sensors

George Simpson[1], Kyriacos Kalli[2], Kaiming Zhou[1], Lin Zhang[1], and Ian Bennion[1]
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2. Higher Technical Institute, P.O.Box 20423, Nicosia, 2152, Cyprus

Abstract
We demonstrate an idealised method for fabricating a dual fibre Bragg grating (FBG) temperature invariant Ia-I strain sensor, using a common phase mask. We show that the gratings have the same period but their central wavelengths are 14.4nm apart and have an +11.5% and -1.2% difference in temperature and strain coefficients respectively. We also show that blank beam pre-exposure may be used to create a mean refractive index profile in the fibre core enabling the inscription of complex grating profiles with simple and inexpensive phase masks.

1.Introduction
Type IA fibre Bragg gratings are a subtype of Type I gratings and are so named because they form only after the erasure of a standard grating in hydrogenated germanosilicate fibre by prolonged UV exposure. They are distinct from other grating types since they exhibit a uniquely large increase in the mean index of the core, which is readily identifiable by a large red shift seen in the λ_{BR} of the grating during holographic inscription. In Lemaire et al's well-known 1993 paper [1], it was shown that it was possible to induce strong index changes of up to 5.9×10^{-3} in hydrogenated germanosilicate fibre; Type Ia gratings have been shown to surpass this by a factor of six [2-5] since a red shift in the λ_{BR} of up to 20nm may be interpreted as an increase in the mean index of up to 1.9×10^{-2}. More importantly, Ia gratings have been shown to exhibit the lowest temperature coefficient of all gratings [2] which makes them ideal for use in a temperature invariant, dual grating sensor [3].

Initial reports on the fabrication of these dual sensors required the annealing of the fibre in between the fabrication of the IA and IIA gratings since IIA gratings may only be written in hydrogen free, germanosilicate fibre [6,7]. In this paper we show that blank-beam exposure may be used to significantly reduce the mechanical stability requirements of the inscription apparatus by pre-exposing the fibre. We further show that a combination of a standard grating and a IA grating, which we have termed a IA-I sensor, may be used to drastically reduce the inscription complexity.

Prolonged interferometric, or scanning phase mask exposure methods are generally unsuitable for inscribing regenerated gratings because they place great demands on vibration isolation and equipment stability; frequently, these methods result in untidy and / or weak gratings. In this paper we present an idealised method for inscribing regenerated gratings by blank-beam pre-exposure. This technique has been used to fabricate the strongest and cleanest Type IA gratings produced to date.

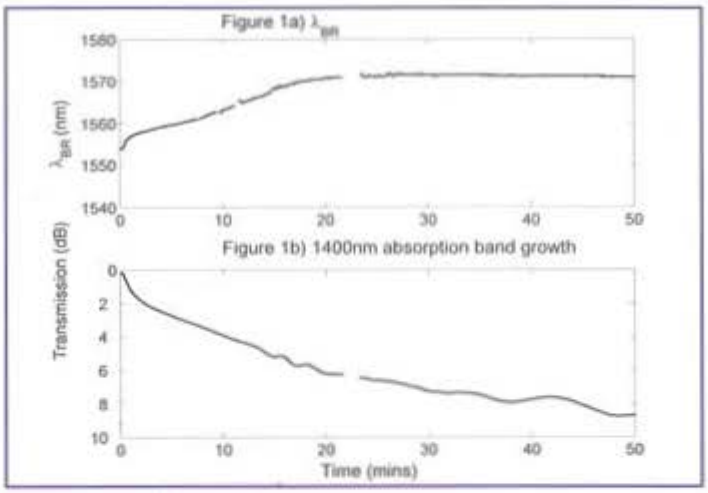

Figure 1. (a) The characteristic red-shift during the holographic exposure of a Type IA grating. (b) The associated OH- absorption band growth at 1400nm. From [5].

Figure 1a [5] shows the evolution of the mean index during the holographic inscription of a Type IA grating, which may be monitored by the characteristically large red shift in the Bragg wavelength. Also plotted on the same x-axis (Figure 1b) is the increase in the absorption band at 1400nm associated with OH- formation. This gives the best insight yet reported as to the mechanism behind the formation of these special gratings. Moreover, it is this observation of the link between OH- growth and the formation of Ia gratings that makes the blank-beam exposure method viable since the photochemical change may be monitored in the fibre without inscribing a grating.

2. Experimental setup

Hydrogenated B/Ge fibre was clamped between two posts and placed in close proximity to a phase mask mounted on a vibration isolated optical table within a draft excluding chamber. A UV source at 244nm was focused onto the core of the fibre. A mirror was mounted on a motorized translation stage to enable the beam to be scanned across the length of fibre or phase mask. With the phase mask removed, the UV beam was scanned 200 times across a length of 5mm. The phase mask was then re-introduced and a 4mm grating was written within the pre-exposed section of fibre. A second 1mm standard grating was then written just outside the pre-exposed area. The overall length of the sensor was 5.6mm. This process was repeated 8 times. The gratings were annealed at 80°C for 70 hours. During this time, an EXFO multi-channel tuneable laser characterisation system with 5pm resolution was used to save a spectrum for each grating pair every minute for the first 10 hours, and every 5 minutes thereafter. This data will be the basis of a future publication.

3. Results

Figure 2 shows an example spectrum of the IA-I dual grating sensor; the standard grating has a λ_{BR} of 1554.6nm which corresponds to a mean index of 1.450 whilst the Ia grating has λ_{BR} of 1569.0nm corresponding to neff = 1.464(after annealing).

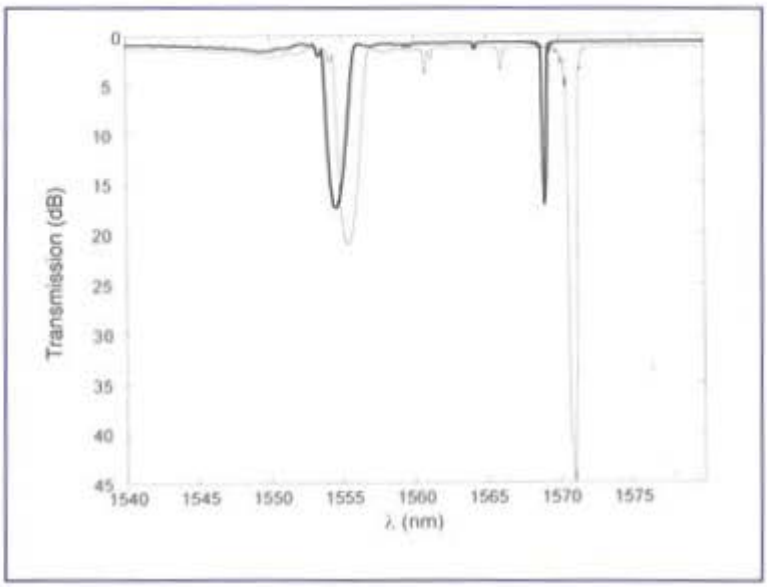

Figure 2: The spectra of the IA-I dual sensor pre- (dashed) and post- (solid) annealing.

The temperature and strain responsivities of the IA-I sensor were measured by placing the sensor in a small, insulated chamber whose internal temperature was controlled by a peltier device and temperature controller of the type used to stabilise laser diodes. The change in the gratings' wavelength resonance with temperature is represented in Figure 3; as anticipated there are different responses displayed under temperature excursions for each grating type. Clearly the thermo-optic coefficient of the pre-exposed section has been reduced to 8.52pm°C^{-1} making it 11.5% different from the virgin fibre. The wavelength to strain response is shown in Figure 4, where smaller but measurable differences are also recorded for the strain data. These primarily result from the differences in the centre wavelengths rather than differences in the material properties. In the aforementioned measurements the gratings were illuminated with a broadband light source combined with an optical spectrum analyser that calculated the λ_{BR} value according to the Centroid fitting method.

Six of the eight gratings fabricated showed similar spectral, annealing, thermal and strain properties; the two that differed may be attributed to discrepancies during the inscription process. This indicates superb potential repeatability for a properly constrained process.

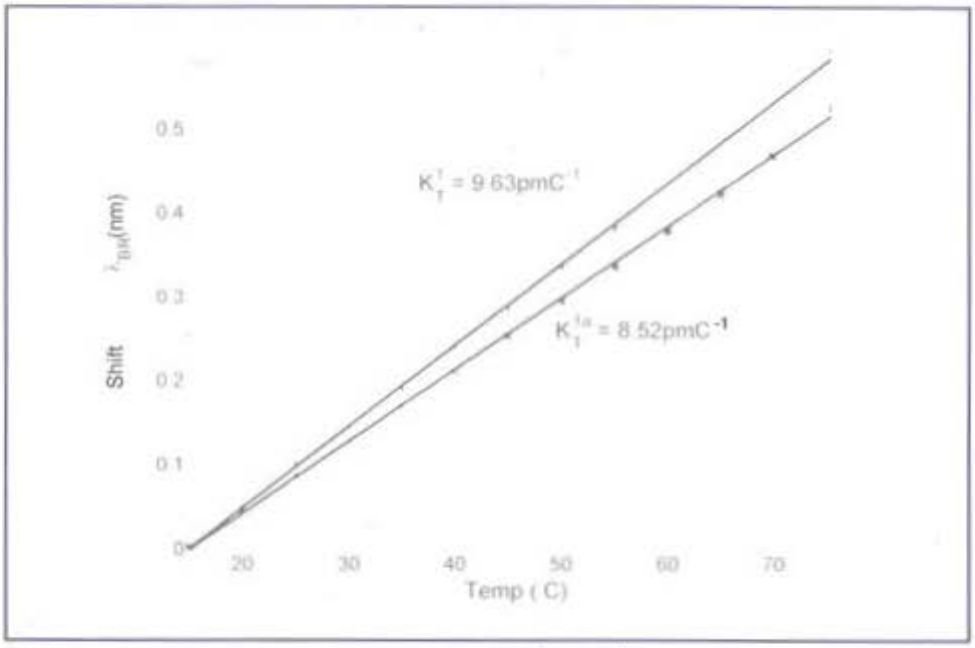

Figure 3: Determination of $K^1{}_T$ and $K^{1a}{}_T$

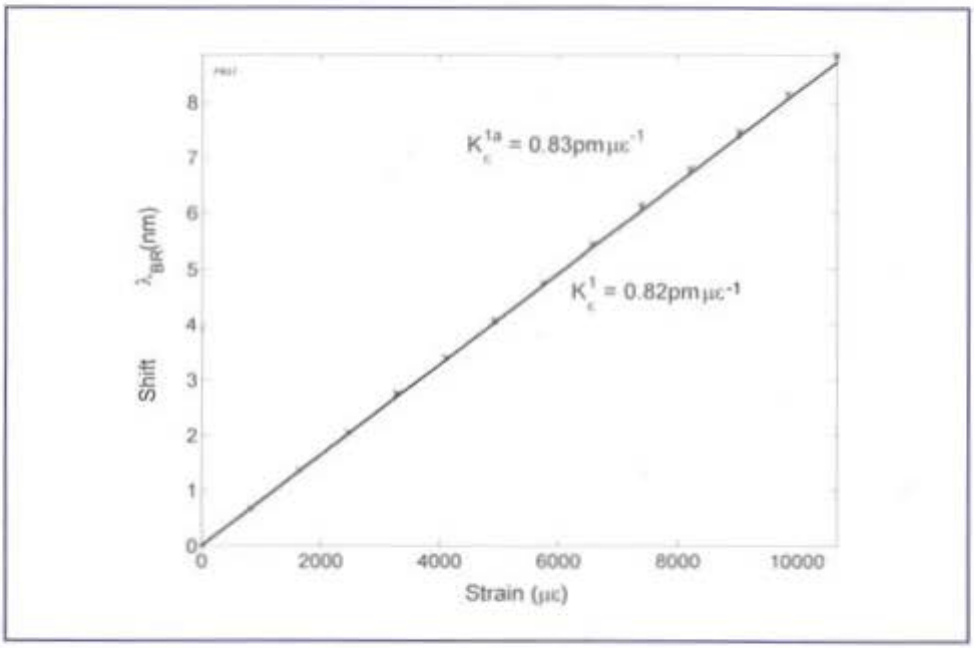

Figure 4: Determination of $K^1{}_\varepsilon$ and $K^{1a}{}_\varepsilon$

4. Discussion

We could, in principle, have fabricated several in-line sensors operating at different center Bragg wavelengths with the use of a single, phase mask; therefore there is great flexibility possible in our approach. Furthermore, the gratings may be located in close proximity, ranging from exactly adjacent to any physical spacing realizable with the UV beam scanning apparatus. Moreover, the exact degree of mean index change that can be induced within the fibre may be tailored by controlling the level of UV pre-exposure; this technique could be used to fabricate gratings with a non-uniform mean refractive index profile (such as chirped gratings), quickly inexpensively and accurately with a standard phase mask. This is the subject of a future publication.

In order to determine the validity of the sensor design we utilise the conventional matrix inversion technique, with the usual caveat; we assume that strain and temperature are essentially independent, that is, the related strain-temperature cross term is negligible [8]. This is acceptable given the temperature excursions to which the gratings will be exposed. For this approach to be successful, we must accurately know K_ε and K_T, the strain and temperature coefficients respectively. Assuming this is the case, the limitation becomes the conditioning of the matrix, which demands that the determinant be nonzero:

$$\begin{pmatrix} T \\ \varepsilon \end{pmatrix} \quad \frac{1}{(K_T^1 \; K_\varepsilon^{1a} - K_T^{1a} \; K_\varepsilon^1)} \begin{pmatrix} K_\varepsilon^{1a} & K_\varepsilon^1 \\ K_T^{1a} & K_T^1 \end{pmatrix} \begin{pmatrix} \lambda_1 \\ \lambda_2 \end{pmatrix} \qquad (1)$$

Therefore, a fundamental tenet is that the ratio of the strain responses of two gratings be different from the ratio of their temperature responses. If

$$\frac{K_T^1}{K_T^{1a}} = \frac{K_\varepsilon^1}{K_\varepsilon^{1a}} \qquad (2)$$

then the sensor loci are parallel and Equation 1 tends to infinity, thus invalidating the measurement. An equivalent description has been provided elsewhere [9], with the errors in wavelength measurements translated to an error ellipse in the (ε, T) plane. Using the data from Figures 3 and 4, we determine the following:

$K_T^1 = 9.629$ pm°C^{-1} (± 0.0168)	$K_\varepsilon^1 = 0.8181$ pm$\mu\varepsilon^{-1}$ (± 0.0005)
$R^2 = 0.9996$	$R^2 = 0.9992$
$K_T^{1a} = 8.519$ pm°C^{-1} (± 0.0213)	$K_\varepsilon^{1a} = 0.8283$ pm$\mu\varepsilon^{-1}$ (± 0.0005)
$R^2 = 1.0$	$R^2 = 1.0$

Table 1. Summary of strain and temperature coefficients

The ratios $\frac{K_T^1}{K_T^{1a}} = 1.130$ and $\frac{K_\varepsilon^1}{K_\varepsilon^{1a}} = 0.988$, and these translat accordingly; an increase of 1mε corresponds to temperature rise of 85.15°C for a Type 1, and 97.42°C for a Type 1A grating. Assuming a 1pm error in wavelength measurement; the strain and temperature errors associated with these coefficients are $\pm 12 \mu\varepsilon pm^{-1}$ and $\pm 1.2°Cpm^{-1}$, respectively. This compares with errors of $\pm 12 \mu\varepsilon pm^{-1}$ and $\pm 1.3°Cpm^{-1}$ measured by Xu et al. [10] for two superimposed gratings at markedly different wavelengths. Therefore our dual grating sensor can be used to differentiate between strain and temperature to a high resolution.

5. Conclusion

Two adjoining gratings were formed using the same phase mask, yet their central wavelengths were 14.4nm apart after annealing (corresponding to an increase in the mean index of 0.014) and had 11.5% different temperature coefficients. This was caused by the pre-exposure of one grating to blank-beam UV light, thus creating a Type Ia grating. We have shown what we believe to be the ideal method for fabricating a dual FBG, temperature invariant, Ia-I strain sensor. The approach offers great flexibility allowing for tailoring of the type Ia centre wavelength, the temperature coefficient, and the resolution of the dual sensor device. Our work has shown that by monitoring the OH- absorption band during blank-beam exposure, it is possible to inscribe any arbitrary refractive index profile. In addition to the ability to tune gratings over a 20nm range, this will enable complex chirped gratings to be formed using an inexpensive uniform phase mask.

References

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Acknowledgements

This work was carried out under the UK DTI-EPSRC LINK project EMPIRE and we acknowledge our project partners BAE SYSTEMS, Indigo Photonics Ltd (now Insensys) and Deutsch Ltd for their technical support and useful discussions.

We also acknowledge our useful discussions with Dr JAR Williams and Mr P Herbert.

AGS further acknowledges the generous studentship of the UK EPSRC and BAE Systems.

Modeling and Simulation of a Hybrid PV-Thermal Solar System

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Higher Technical Institute, Engineering Practice Department, P.O. Box 20423, Nicosia 2152

Abstract

A hybrid photovoltaic-thermal (PV/T) solar energy system is a combined system consisting of a normal PV panel at the back of which a heat exchanger with fins is embedded. The advantage of this type of system is that the PV panel operates at a lower temperature, thus more efficiently and also hot water is produced at the same time as electricity. The PV system consists of a series of PV panels, a battery bank and an inverter whereas the thermal system consists of a hot water storage cylinder, a pump and a differential thermostat. The system is modelled using TRNSYS and typical meteorological year (TMY) conditions for Nicosia, Cyprus. The results show that the optimum water flow rate of the system is 25 lt/hr. The hybrid system increases the mean annual efficiency of the PV solar system from 2.8% to 7.7% whereas in addition it covers 49% of the hot water needs of a four-person family house thus increasing the mean annual efficiency of the system to 31.7%. The life cycle savings of the system is £790 and the pay-back time is 4.6 years.

1.Introduction

A system, which can provide simultaneously both electrical and thermal energy, would be a very interesting application. Such a system could cover part of the electrical and thermal energy needs for a number of buildings, such as hospitals, schools, hotels and houses.

Photovoltaic (PV) panels convert solar radiation to electricity with peak efficiencies in the range of 5-20%, depending on the type of the PV cell. The efficiency of the solar cells drops with increasing operating temperatures. Natural circulation of air is the easiest way to remove heat from the PV modules and avoid the resulting efficiency drop. Hybrid photovoltaic-thermal (PV/T) collector systems may be applied in order to achieve maximum energy output by simultaneous electricity and heat generation. In this way the energy efficiency of the systems is increased considerably and the cost of the total energy output is expected to be lower than that of plain photovoltaic modules. The produced heat can be used either to heat the building or for the production of hot water for the needs of the occupants. Stabilising the temperature of the PV modules at a lower level is highly desirable and offers two additional advantages; the increase of the effective life of the PV modules and the stabilisation of the current-voltage characteristic curve of the solar cells. Also the solar cells act as good heat collectors and are fairly good selective absorbers.

Hybrid PV-thermal systems have been studied both analytically and experimentally by a number of researchers. Krauter and Hanitsch (1994) presented the actual optical and thermal performance of PV-thermal modules whereas Bergene and Bjerke (1993) performed a thermodynamic analysis of the efficiency and possible utilisation of such systems. Garg and Agarwal (1993) presented studies of a hybrid system with its solar cells used in a CPC type collector operated in thermosyphon mode. Bergene and Martin (1995) presented model calculations on a hybrid flat-plate solar heat collector with integrated solar cells. They also proposed possible applications of hybrid systems which can be used for a domestic system producing both electricity and low temperature heat for hot water preheating and for a large-scale system producing both hydrogen and fresh water through desalination. Tripanagnostopoullos et al. (1996) have examined experimentally a hybrid system and they found that the addition of a booster diffuse reflector increase the performance of the system giving possibilities for more interesting practical applications.

In hybrid PV/T systems the natural or forced circulation of a heat removing fluid can be used not only for PV cooling but also for heat generation. In this way the absorbed solar energy which is not converted into electricity can be utilised also for thermal applications. Heat removing fluid can be air or water. However, air is not suitable for countries with hot weather like Cyprus, because the temperature of the air is quite high which reduces its heat removal capacity. For the case of a liquid as a heat removing fluid, the efficiency of the hybrid PV/T systems is sensitive to the type of the heat exchanger used, because the efficiency in removing the thermal energy from the PV panel determines the conversion efficiency to both electricity and heat (Bergene and Martin, 1995). In this paper a PV/T system for a house is modelled with TRNSYS using meteorological data for Cyprus. The objective is to quantify the magnitude of the system advantages with respect to its output and life cycle savings, compared to the standard PV system, when a hybrid system is used in Cyprus.

2. Description of the system

As shown in Fig. 1 the system consists of a series of PV panels a battery bank and an inverter whereas the thermal system consists of a hot water storage cylinder, a pump and a differential thermostat.

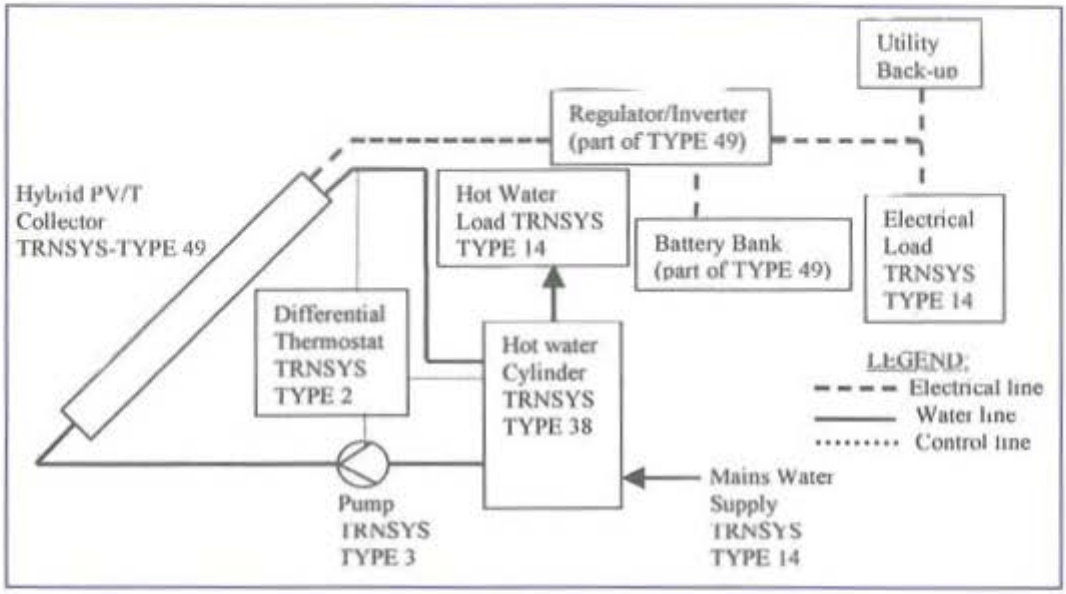

Fig. 1 Hybrid PV/T system schematic.

A heat exchanger is installed at the back of the photovoltaic panel and the whole system is enclosed in a casing in which insulation is installed at the back and sides and a single low-iron glass is installed at the front to reduce the thermal losses. Each "new" panel thus created consists of four (4) monocrystalline PV panels 1.2x0.53m as shown in Fig. 2a. The new panel dimensions are 2.12x1.2m. Two such panels are employed in the system under investigation as shown in Fig. 2b. A copper heat exchanger is used consisting of pipes with fins in contact with the backside of the PV modules and headers, as shown in Fig. 2c. Water is used as a heat transfer medium. The system employs also eight batteries connected in a 4x2 mode, i.e., 4 battery cells in parallel and 2 in series.

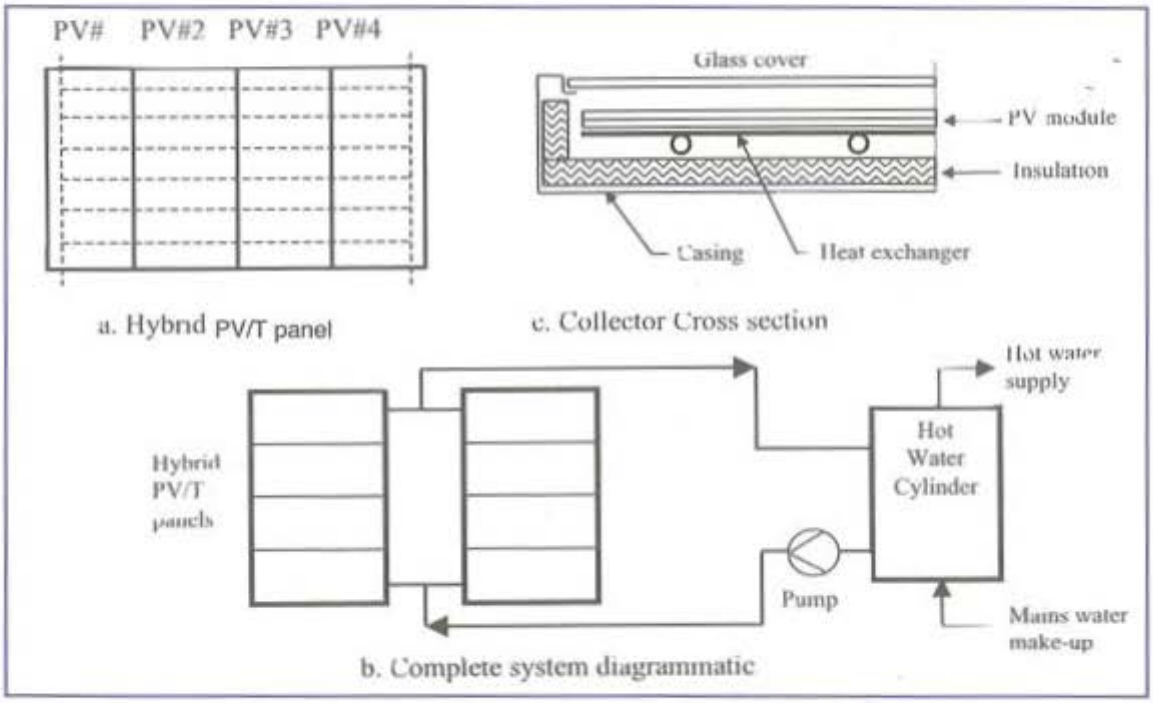

Fig. 2 Hybrid system construction details.

3.System Model

The system is modelled with TRNSYS program and typical meteorological year (TMY) conditions for Nicosia, Cyprus. TRNSYS is an acronym for a "transient simulation program" and is a quasi-steady simulation model. This program was developed by the University of Wisconsin by the members of the Solar Energy Laboratory (Klein et al., 1996). The program consists of many subroutines that model subsystem components. The mathematical models for the subsystem components are given in terms of their ordinary differential or algebraic equations.

With a program such as TRNSYS which has the capability of interconnecting system components in any desired manner, solving differential equations and facilitating information output, the entire problem of system simulation reduces to a problem of identifying all the components that comprise the particular system and formulating a general mathematical description of each.

Once all the components of the system have been identified and a mathematical description of each component is available, it is necessary to construct an information flow diagram for the system. The purpose of the information flow diagram is to facilitate identification of the components and the flow of information between them. Each component is represented as a box, which requires a number of constant PARAMETERS and time dependent INPUTS and produces a time dependent OUTPUTS. An information flow diagram shows the manner in which all system components are interconnected. A given OUTPUT may be used as an INPUT to any number of other components. A simplified information flow diagram for the hybrid PV/T solar system under investigation is shown in Fig. 3. As can be seen from Fig. 3 the main component of TRNSYS deck file constructed for this purpose is Type 49. This includes the hybrid collector, the inverter, and the battery. Type 14, load, was used three separate times in the deck file as follows:

1. To define the mains water temperature, for which a different value was considered for each month,
2. To define the flow rate to load, for which a total of 120 lt were considered per day, i.e., enough quantity to satisfy a family of four persons; and
3. To define the electrical load required.

From the flow diagram shown in Fig. 3 a deck file has to be constructed containing information on all the system components, weather data file, and the format the output is given.

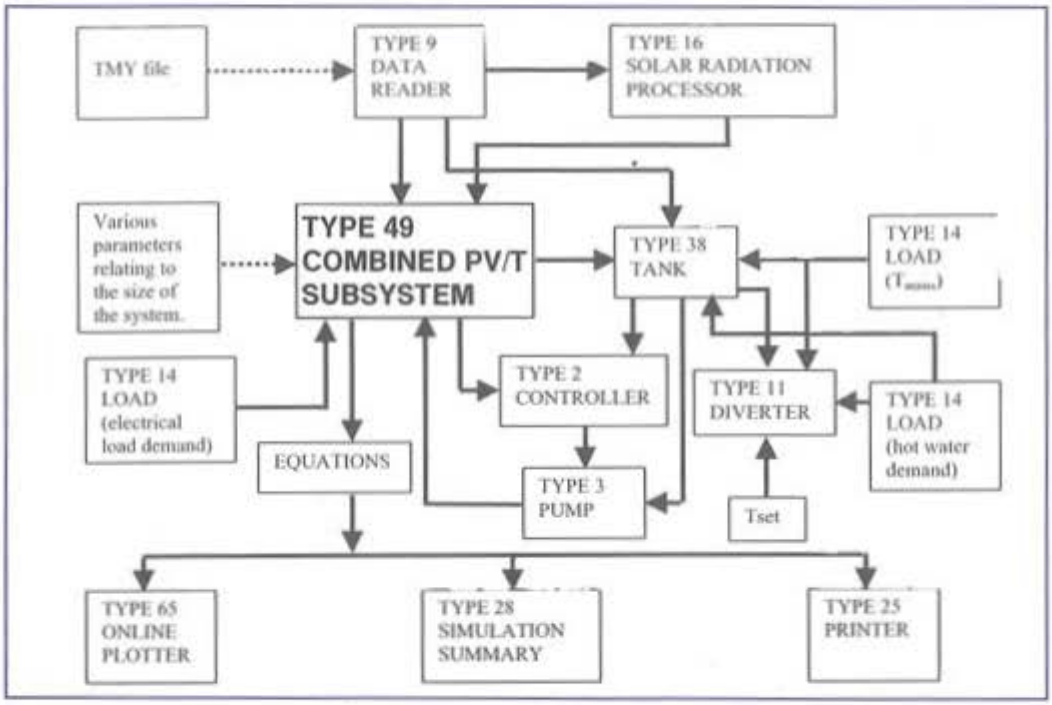

Fig. 3. TRNSYS information flow diagram for the hybrid PV/T solar system.

It is worth noting here, that the deck file reads information provided by the Typical Meteorological Year (TMY) weather data which was generated by Petrakis et al. (1998) for Nicosia, Cyprus. TMY was generated from hourly measurements of solar irradiance (global and diffuse on horizontal surface), temperature, wind speed and direction and humidity ratio for a seven year period, from 1986 to 1992 using the Filkenstein – Schafer statistical method. TMY is defined as a year which sums up all the climatic information characterising a period as long as the mean life of the system. The TMY is considered as a representative year for the Cypriot inland environment.

The selection of typical weather conditions for a given location is very crucial in computer simulations for performance predictions and has led various investigators either to run long periods of observational data or to select a particular year, which appears to be typical from several years of data. Klein et al. (1976) have constructed the "average year" by selecting the monthly data from an 8-year period which corresponded most closely to the average monthly insolation and ambient temperature.

The adequacy of using an average or typical year of meteorological data with a simulation model to provide an estimate of the long-term system performance depends on the sensitivity of system performance to the hourly and daily weather sequences. Regardless of how it is selected, an "average" year cannot be expected to have the same weather sequences as those occurring in the long term. However, the simulated performance of a system for an "average year" may provide a good estimate of the long term system performance if the weather sequences occurring in the average year are representative of those occurring in the long term or if the system performance is independent of the weather sequences (Klein et al., 1976).

The primary components of Type 49 are a combined collector (having both thermal and electrical output), power conditioning equipment (primarily a regulator and an inverter) and storage batteries. This type uses a numerical integration scheme to determine the battery state of charge. The use of this simple subroutine can reduce the computation required in some simulations and also simplify the set-up of the deck file. Type 49 has two modes of operation one for power peak operation of the solar collector and one for clamped voltage operation, when the collector voltage equals the battery voltage. The latter is applied in the present work.

The model parameters used in the program are shown in Table 1. The thermal characteristics of the system were obtained from Bergene and Martin (1995).

Table 1. TYPE 49-System design parameters.

Parameter	Description	Value
A_c	Collector area (m^2)	5.1
A_r	Ratio of aperture area to absorber area	1
C_p	Fluid thermal capacitance (kJ/kg °C)	4.2
α	Collector plate absorptance	0.9
U_b	Back loss coefficient to be used when no flowrate (kJ/hr-m^2 °C)	3.6
C_b	Thermal conductance between the cells and absorber (kJ/hr °C)	360
h_f	Heat transfer coefficient between fluid and absorber(kJ/hr-m^2 °C)	720
τ	Transmittance of the cover plates and concentrator	0.9
U_t	Coefficient for thermal loss from the front of the cells to ambient (kJ/hr-m^2 °C)	21.6
Eff1	Regulator efficiency. This multiplies the array output power.	1
Eff2	Inverter efficiency (DC to AC). The inverter-input power is multiplied by this parameter to get the inverter output power.	0.9
F_c	High limit on fractional state of charge F	0.95
F_d	Low limit of F	0.1
F_b	Charge-to-discharge limit of F, (i.e. first priority for solar generated power is to recharge the battery if F is less than F_b. Once recharge begins, it will continue until $F=F_b$)	0.3
PL,max	Output power capacity of inverter (kJ/hr)	3000
Qm	Rated capacity of each battery cell (amp-hrs)	120
F_i	Initial battery fractional state of charge	1
cp	Battery cells in parallel	4
cs	Battery cells in series	2
I_{max}	Maximum current (for charge) (amps/cell) (positive)	30
I_{min}	Minimum current (for discharge) (amps/cell) (negative)	-30

Note: No charging from the utility is considered

The present model considers that the system is applied to a house of four persons. For this application, both electricity and hot water consumption (load) profiles are required. Both of these loads are subject to a high degree of variation from day to day and from consumer to consumer, however, it is impractical to use anything but a repetitive load profile. This is not quite correct, for the case of the hot water load, during the summer period, where the consumption pattern is somewhat higher due to frequent bathing. However, during this period, the temperature requirement for hot water is not as high as during winter. Consequently, the total thermal energy requirement is reasonably constant throughout the year. For the present study, the electricity and hot water consumption profiles, illustrated in Figs. 4 and 5 respectively, are used. These assume a daily electrical consumption of 25700 kJ and a daily hot water consumption of 120 litres at 50°C for a family of four (30 litres/person).

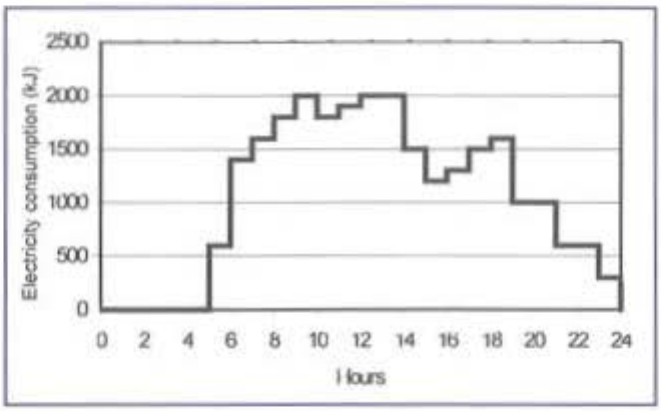

Fig. 4. Electricity daily consumption profile.

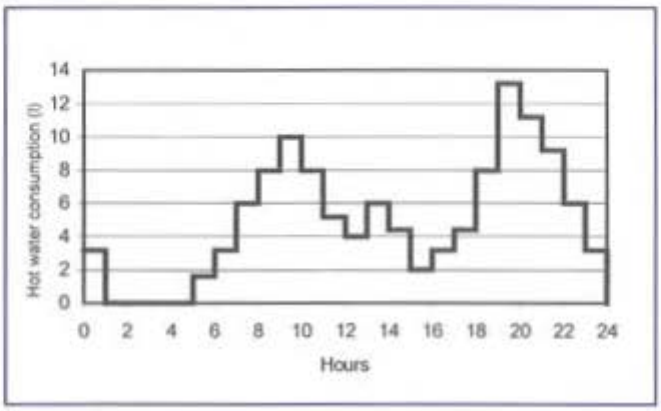

Fig. 5. Hot Water daily consumption profile.

4.Results/Discussion

Output can be provided by TRNSYS on a daily or monthly basis. The results for a particular day, chosen randomly, as well as total monthly values are presented in this paper. The former can give a better picture of the hourly behaviour of the system whereas the latter offers a more representative view of its long term integrated performance. The results for a particular day, chosen randomly, (April 21st) were used to plot graphs correlating the various parameters of the system.

4.1 Optimisation of Water Flow Rate

First the annual output of TRNSYS will be used in order to determine the optimum water flow rate. The system is modelled for a number of cases where the water flow rate in the collector was varied. The results are shown in Table 2. As can be seen the electrical energy output from the PV panel increases as the flow rate increases. This is due to the fact that panel is working at a lower temperature. The thermal energy output increases and then drops. The values shown in the columns representing Q_{util} and Q_{aux} indicate the extra energy required from utility to cover the electrical and thermal loads respectively, which cannot be covered by the solar energy. A comparison of the electrical energy output from the system (Q_e), between the cases with flow rate to that with no flow rate (standard system), indicates the advantage of the hybrid systems.

Table 2. Hybrid PV/T system model output for various flow rates

Water flow rate [lt/hr]	Electrical energy output (Q_e) [GJ]	Useful thermal energy output (Q_u) [GJ]	Electrical energy required from utility to cover the load (Q_{util}) [GJ]	Thermal auxiliary energy required to cover hot water load (Q_{aux}) [GJ]
0	0.977	0.000	8.589	8.296
20	2.584	6.721	7.397	3.634
25	2.646	8.293	7.142	3.742
50	2.737	4.308	7.061	4.936
100	2.763	2.769	7.037	6.355
150	2.770	0.000	7.034	6.987

Note: Total annual incident solar energy =34.47 GJ

The optimum value of flow rate can be found by adding the total system output energy (Q_e+Q_u) and the required extra energy ($Q_{util}+Q_{aux}$) and plotting the values against the water flow rate (see Fig. 6). The optimum value corresponds to 25 lt/hr. This low value of flow rate suggests that the system can be used in a thermosyphon mode, i.e., without a pump and a differential thermostat which will enhance the economic viability of the system.

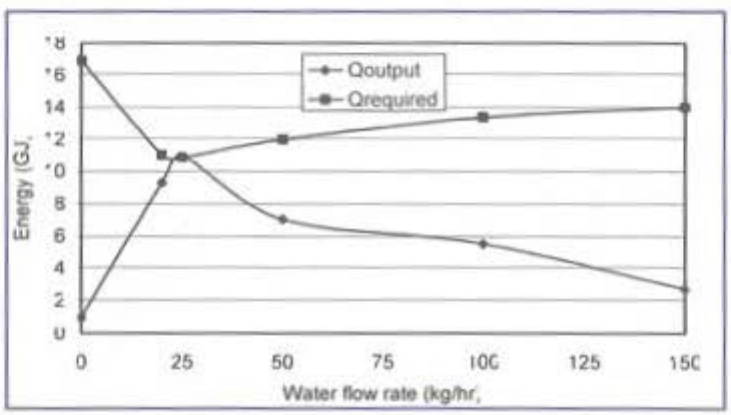

Fig. 6 Optimum flow rate selection.

The plots of the cell efficiency and the total system efficiency against water flow rate, are shown in Fig. 7. The system mean annual efficiency is defined as the total electrical energy output from the cell over the total incident energy from the sun, over a period of one year. For the hybrid system, operated at the optimum water flow rate of 25 kg/hr, this is equal to 7.7% whereas the maximum value reached is 8% corresponding to higher values of flow rate (see Fig. 7). It is important to note that the corresponding efficiency value of a standard PV system (without cooling) is only 2.8%. The hybrid system mean annual efficiency increases to 31.7% when the thermal output is also considered. This value corresponds again to the optimum flow rate of 25 kg/hr, as shown in Fig. 7.

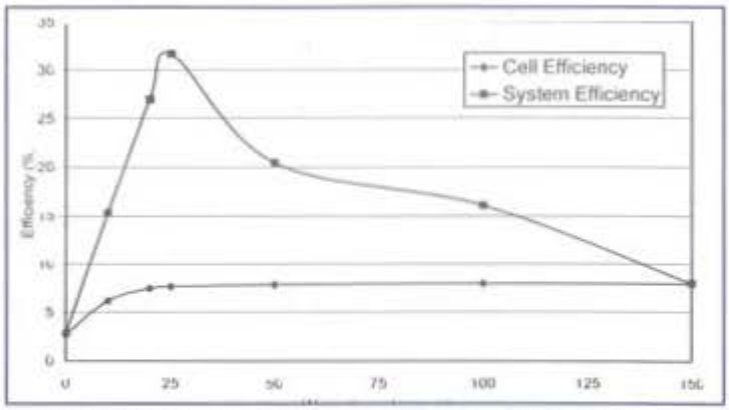

Fig. 7 Cell efficiency and total system efficiency against water flow rate.

4.2 Hourly Performance of the System

The performance of the hybrid system for April 21st is shown in Figs 8 and 9. Figure 8 shows both the electrical and thermal output (Q_e and Q_u) and input (Q_{util} and Q_{aux}) of the system on an hourly basis. Both Q_e and Q_u curves follow, as expected, the pattern of solar radiation (shown in Fig. 9 for clarity). The curves of the hourly variation of energy supplied from utility (electrical) and from auxiliary (thermal) show the energy required to cover the electrical and thermal loads imposed by the consumption curves shown in Figs. 4 and 5 respectively.

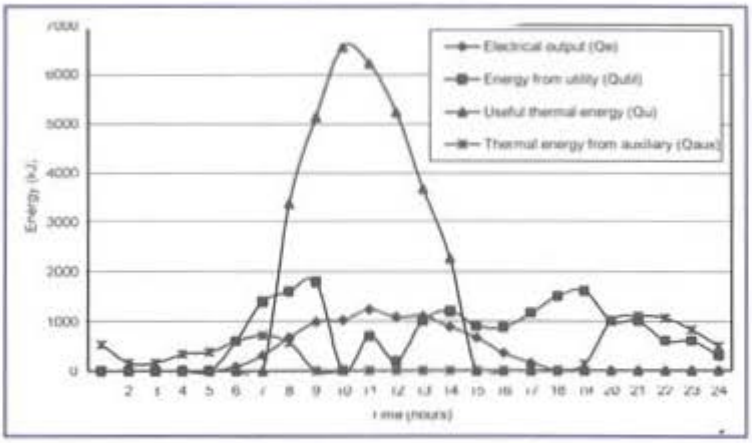

Fig. 8 Hybrid system performance working with optimum flow rate (April 21st)

A more representative figure, showing the solar energy input (Q_{ins}) and output of the system (Q_{out}), as well as its total efficiency on an hourly basis is shown in Fig. 9. It is interesting to note that the system efficiency reaches a value of 51.6% at 9.00 whereas the corresponding value for the non-hybrid system is 8.2%. This is in agreement with Imre et al. (1993) who found a total system efficiency of about 60%.

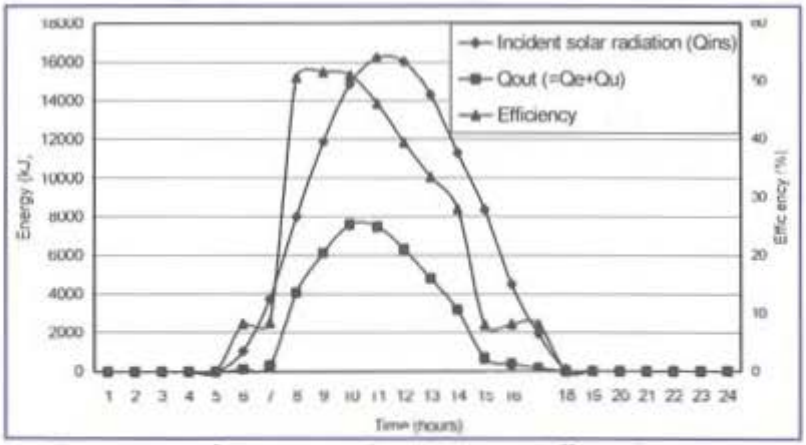

Fig. 9 Variation of system input and output energy and efficiency (April 21st)

4.3 Monthly performance of the system

The variation of the monthly mean electrical efficiency of the PV panel for flow and no flow conditions is shown in Fig. 10. The advantage of the hybrid system (with flow) is obvious. Additionally as it can be seen from this figure the efficiency drops during the summer months because of the higher ambient temperature and solar radiation available, which results in higher panel temperatures, thus relatively lower performance. This is more pronounced for the case of the standard PV panel.

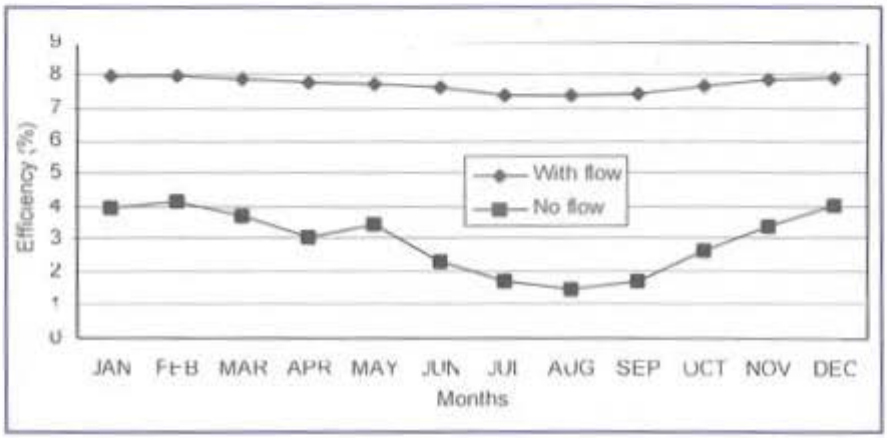

Fig. 10 Variation of monthly electrical efficiency of PV panel with and without flow.

The monthly variation of the various energy flows of the system is shown in Fig. 11. These include the total electrical output from the system (Q_e), the energy required from utility to cover the electricity consumption (Q_{util}), the useful thermal energy supplied to the tank (Q_u), the hot water energy requirements (HWLoad), and the thermal auxiliary energy demand (Q_{aux}). As it can be seen the maximum value of the useful thermal energy (Q_u), occurs in the month of June (8.6 GJ). The electrical energy supplied from the collector (Q_e) is almost constant throughout the year and is maximised in the month of August (2.6 GJ). The slight drop of the solar cells efficiency during the summer months, as depicted in Fig. 10, is counterbalanced by the extra radiation available during these months. It can also be seen from Fig. 11 that the thermal auxiliary energy required is considerably reduced during the summer months. Another important point is the drop of the useful energy collected during the month of May. This is due to the reduced solar radiation available during that month which is a characteristic of the climatic conditions of Nicosia and is due to the development of clouds as a result of excessive heating of the ground and thus excessive convection, especially in the afternoon hours.

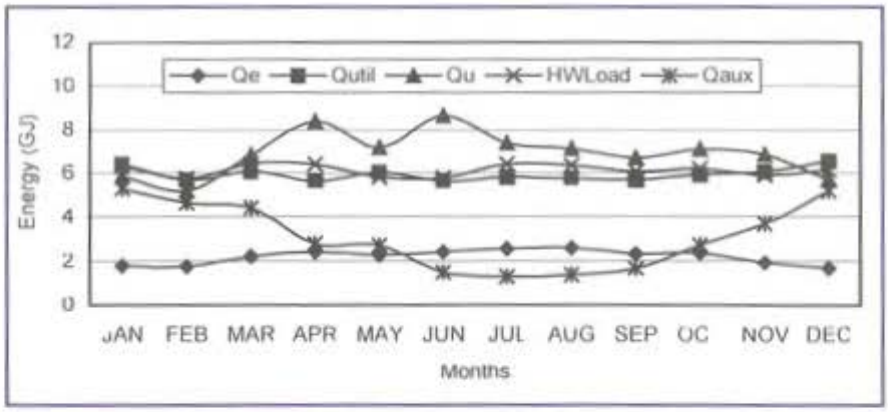

Fig. 10 Variation of monthly electrical efficiency of PV panel with and without flow.

The variation of the annual solar contribution with respect to hot water production is depicted in Fig. 12. In this figure the solar fraction, f, is defined as the ratio of the useful solar thermal energy supplied to the system divided by the energy needed to heat the water when no solar energy is used. Therefore, f is a measure of the fractional energy savings relative to that used for a conventional system and can be calculated from the following relationship:

$$f = \frac{Q_{HWLoad} - Q_{aux}}{Q_{HWLoad}}$$

Figure 12 implies that the solar fraction is lower in the winter months and higher in the summer months reaching a value of 0.8 in July. The annual solar fraction is determined to be 0.49, i.e., 49% of the thermal needs for hot water production is covered from the present system.

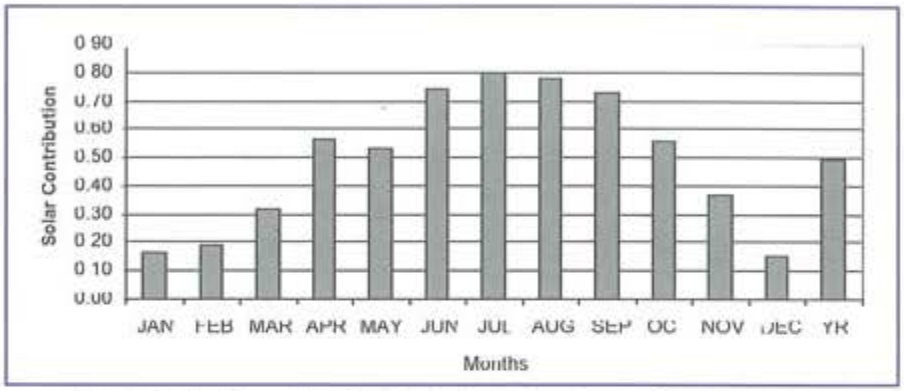

Fig. 12 Predicted monthly and yearly solar thermal contribution of the PV/T system.

4.4 Economic Analysis

The economic analysis of the system was performed by considering the extra cost required to modify the PV modules and the other equipment required for the construction of the hybrid system against the extra energy benefit obtained by the modified system, i.e., extra electrical energy above the one obtained from non-hybrid PV module and the thermal energy output.

It is estimated that the extra cost required to modify the system is £450, i.e., £250 to modify the panels and £200 for the cost of the pump, the differential thermostat, the electrical connections and the extra piping required. Electricity is assumed to be used for the auxiliary thermal energy required. The saving in electrical energy per year that results from the system modification (extra electrical plus the thermal energy output) is equal to £139. The economic viability study of the system is based on the life cycle analysis method and takes into account the fuel inflation rate, the market discount rate, the annual maintenance cost and the power required by the solar pump. The economic scenario used assumes that all the cost of the system is paid at the beginning (i.e., no credit payments are assumed). The period of economic analysis is taken as 20 years, whereas all the other figures (inflation rates and market discount rate) are the mean values of the last 10 years. A list of the parameters used in the economic analysis is shown in Table 3.

Table 3. Parameters used in the economic analysis.

Parameter	Value
Collector area	5.1 m^2
Period of economic analysis	20 years
% Down payment	100%
Nominal market discount rate	9%
Extra maintenance in year 1	1% or original investment
General inflation rate	5%
Resale value	10%
Conventional fuel inflation rate	3%

The results of the economic analysis show life cycle savings equal to £790. The pay back time is found to be equal to 4.6 years which is very satisfactory.

5. Conclusions

The daily and monthly performance of a hybrid PV/T system is investigated through modelling and simulation. Such a system provides more electrical energy compared to a standard photovoltaic system as it operates at a lower temperature and in addition thermal energy is obtained which can be used for water heating. The conclusions deduced from the present work are:

1. The optimum value of water flow rate through the hybrid PV/T system is 25 lt/hr.
2. The mean annual efficiency of the standard PV system is 2.8%. This increases to 7.7% for the hybrid system operating at the optimum flow rate when only electricity generation is considered. The total system efficiency increases to 31.7% when the thermal output is also taken into account.
3. The life cycle savings of the system are £790 and the pay back time is found to be equal to 4.6 years; both values are very satisfactory.
4. The solar contribution of the system with respect to thermal energy is 49%.

The findings presented in this paper are very promising. The low value of the optimum flow rate suggests that the system can run successfully in thermosyphon mode. This set-up will enhance further the economic viability of the system, as both the initial and running costs would be reduced.

Although a specific application is analysed here, the author believes that PV/T hybrid systems may be used in a variety of applications, requiring both electrical and thermal energy, especially when the price of solar cells decreases further.

Recently a research project was submitted to the Research Promotion Foundation in which, in cooperation with the University of Patras, Greece, a number of experimental pilot plants will be constructed in order to validate the above results and investigate the technical and operational problems of these systems.

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Application of Municipal Sludge to Forestland: NitrogenLeachate Control

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Abstract:
Serious research concerning the application of municipal wastewater and sludge on land has been carried the last four decades. Currently there is a much wider understanding of the ability of soil systems to treat wastewater and the acceptance of the view that sludge can be safely and beneficially applied to cropland, forest land and disturbed lands. However, non conventional quality of water and sludge may present a number of ecological and health risks. If applied to forestland, besides problems associated with actual spreading and transport costs, other constraints including nitrate leaching are evident. This paper will concentrate on the examination of nutrient leachate and the establishment of application and control methods.

Keywords: sludge, sludge disposal, forestland, nitrogen uptake, nitrogen leachate

Introduction:

The constituents removed in wastewater treatment plants as by-products include screenings, grit, scum and sludge. Sludge is usually in the form of a liquid or semisolid liquid which contain solids in the range of 0.25 to 12 percent. By comparing all by-products of wastewater treatment, sludge is by far the largest in volume and its handling and disposal is an important part of the wastewater treatment process as well as a matter of environmental concern. The composition of sewage sludge from municipal system varies widely from one location to another depending on a variety of factors. The presence or absence of industrial wastes can have a profound effect on the quantity and quality of wastewater sludge. The presence of storm water in the sewerage system will also affect the sludge quality. Sludge and treated wastewater effluents may contain toxic, metallic, and non-metallic elements, organic substances and pathogenic microorganisms. Some of the elements found in wastewater and sludge include, boron, cadmium, cobalt, copper, chromium, mercury, nickel, lead, selenium and zinc Sludge analysis of a dried sludge sample originated from the Larnaca wastewater treatment plant is shown in table 1. European Directives for maximum limits allowable if the sludge is to be used in agriculture are also shown in this table. Method of analysis was the atomic suction method. It may be concluded that the values of trace elements are very low and these originate from stormwater from streets, which infiltrates into the sewerage system.

Element	Conc. Mg/Kg	Limit mg/kg
Cadmium (Cd)	0.98	40
Lead (Pb)	24.52	1200
Copper (Cu)	138.69	1750
Zinc (Zn)	804.39	4000
Nickel (Ni)	25.76	400
Chromium (Cr)	3.80	1000

Table 1. Typical analysis of dried sludge, Larnaca Wastewater Treatment plant (Oct 2001)

Zinc, copper, nickel and boron may be toxic to plants. Sheep, which are very sensitive to copper, may be affected by excess amounts of this element. Mercury, copper and zinc may enter the food cycle. Lead may also enter the food cycle and be hazardous to animal and people [2]. Problems have occurred since chlorinated hydrocarbons including pesticides have been found in our water distribution system, possibly originating from our sewage treatment plants as well as industry. Wastewater sludge and treated effluents have shown a large amount of microbial organisms. It is not certain how long pathogenic bacteria, viruses, and parasites may survive, especially when wastewater is sprayed over fields, thereby creating aerosols that may be inhaled. The large amounts of degradable organics causing oxygen demand are generally measured in BOD or COD.

These pollutants deplete the dissolved oxygen in the waters . Unless the stream can assimilate additional oxygen, the loss of dissolve oxygen creates difficulties in the stream. Nitrogen and phosphorus are the primary nutrients for algae. When these chemicals are present, growth of algae increases substantially.

Eutrophication is a process by which streams and lakes may be converted into swamps and eventually meadows due to nitrogen and phosphorous enrichment have been introduced into the streams.

This is a naturally occurring process. However, humans have accelerated the process by allowing agricultural fertilizers and wastewater discharges which contain these chemicals to enter the water system. Suspended solids from wastewater effluents eventually settle in reservoirs, stream or lakes, forming sludge deposits on the bottom of such water areas. If decomposition takes place where oxygen is present it creates tremendous oxygen demand, and upon oxygen depletion, bad odors are created.

Disposal and Land Application

Sludge may be applied to land as a final disposal option treated or untreated. Treated sludge may be referred as dewatered, cake dried, compost or burnt as ash. Selecting an option will depend on economic and environmental factors.

The aim will be to select an efficient method of treating the sludge, which will certainly depend on the final disposal site selection. The site's geology, hydrology and soil conditions should be considered relative to the need for adequate protection of groundwater. Sludge in its dry form contains approximately 3 percent nitrogen, 2 percent phosphorous and 0.4 percent potassium. Sludge also has a high organic content, valuable in maintaining the soil structure. Sludge can then be regarded more as soil conditioners than fertilizers which contain higher amounts of nutrients and minerals.

Application of Municipal Sludge in Forestry

Land application in forestland is considered a beneficial end use.
Major constrains are due to the fact that forests are not usually close to urban wastewater treatment plants and this will result in high transportation costs. The mechanics of evenly application due to the presence of trees as well as the sludge constituents including pathogen and nitrate leaching, should be seriously considered.
The main aim of forest utilization of sludge is to enhance forest productivity through the nutrients contained in sludge.

The estimate nitrogen uptake by forest types ranges from about 100-300 Kg/ha/yr, with older trees having a higher uptake than tree seedlings.

Losses due to volatilization of ammonia N are estimated at up to 50 per cent for sludge applied in liquid form. No loses are accounted for applied dewatered sludge.

Accelerated tree growth to a range of 200-300 per cent can result from the application of sludge. This however is expected to change the characteristics of wood in relation to moisture content, structural properties etc.

Determination of Sludge Application Rate.

In order to establish ecologically acceptable application rates, it is important that these applications be limited by Nitrogen applied.

This practically means that the Nitrogen applied should not exceed the Nitrogen uptake by trees, plus various losses.

The above measure is considered as a conservative application and may be close to a safe activity in terms of groundwater aquifer protection.

A balance therefore can be established for Nitrogen input and output that will obey the equation:

$$N_f = N_{in} + \Sigma (N_{IN} - N_{OUT}) \quad \text{.....(1)}$$

It may be expanded to:

$$N_f = 10{,}000.H.a.C_s + IR.C_w + F.C_f - Y.C_c - N_L \quad \text{.....2)}$$

Where:

- N_f = total Nitrogen in soil volume at end of application period; g/ha
- H = depth of root zone or to G.W.T ; m
- C_s = concentration of N in soil; g/kg
- IR = Irrigation Rate (or Application Rate); m^3/ha
- C_w = concentration of N in the applied water or sludge; g/m^3
- F = fertilization rate; kg/ha
- C_f = concentration of N in fertilizer; g/kg
- Y = crop yield; kg/ha
- C_c = Concentration of N in crop; g/kg
- N_L = Nitrogen lost; g/ha
- a = bulk density of soil volume; kg/m^3

It may initially be essential to determine the amount of N in the sludge to be applied. If we plan a 5-year application program, N available in the sludge for the first year can be determined as follows.

$$N_1 = (NH_4 - N) - (NH_4 \times N \text{ Volatilized}) +$$
$$(\text{Organic N} \times \% \text{ mineralization rate in the first year}) - (\text{unaccounted losses}) \quad \text{.....(3)}$$

Yearly nitrogen mineralization rates (Rm), for a five year application period are obtained as 0.20 for the first year and 0.10, 0.05, 0.03, and 0.03 for the remaining years. [1]

It is therefore possible, after determining the amount of nitrogen applied (N_1)in kg/ton of sludge applied for the first year, to determine nitrogen applied for the each of the next years N_2 ,N_3, N_4 and N_5 as follows:

$N_2 = N_1 + (\text{Nitrogen in sludge}^* \times R_m \text{ for year 2})$
$N_3 = N_1 + N_2 + (\text{Nitrogen in sludge}^* \times R_m \text{ for year 3})$
$N_4 = N_1 + N_2 + (\text{Nitrogen in sludge}^* \times R_m \text{ for year 4})$
$N_5 = N_1 + N_2 + N_3 + (\text{Nitrogen in sludge}^* \times Rm \text{ for year 5})$

*usually 3 percent or 30kg/ton.

If we assume the value of the yearly nitrogen uptake by plants (N_u) in kg/ha, then the yearly sludge application rates in tons/ha can be obtained by dividing the nitrogen uptake by plants (N_u) ,with each of the above nitrogen yearly contribution amounts, N_1, N_2 etc. The sludge application rate for year1 then = N_u / N_1 in tons/ha, and will yield the desired amount of nitrogen contribution. The same calculation can be repeated for every year thereafter.

It is now evident that by determining N application rates, equation (2) demonstrates an all rounded picture of Nitrogen balance in our soil experimental volume. Any unknown term can be found if the rest are known.

Constrains and Comments

Sludge can be applied to forestland at various rates depending on soil tree species, sludge quality and other relevant factors. These rates vary from 10-220 tons/ha/yr.

Established forests over 10 years old seem to be less susceptible to sludge-induced changes in vegetation, and excellent growth response can be expected resulting from increased nutrient application.

Sludge application can be sprayed under the tree foliage so that it will not be necessary for the trees to be dormant.

It is usually feasible to make an initial heavy application of sludge (about 60 tons/ha) and achieve excellent tree growth response for up to 5 years without other sludge applications. This is due to the fact that forest soils under established forests usually have high C-to-N ratios resulting in excellent capability to store nitrogen for slow release in future years.

Conclusion

Application of municipal sludge to forestland is considered a feasible sludge disposal method. Wooded areas are traditionally not fertilized and thus nitrogen cycling with sludge additions needs further research. Sludge application on forestland should be done with great care and serious environmental concern. Nitrogen application should not exceed the ability of the forest plant to utilize the N applied. Extreme care should be taken if sludge contains metals and safety limits should not exceed those applied for cropland. The fertilization capability offered by sludge should not be underestimated

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Artificial Neural Network Learning: A Comparative Review

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Abstract:
Various neural learning procedures have been proposed by different researchers in order to adapt suitable controllable parameters of neural network architectures. These can be from simple Hebbian procedures to complicated algorithms applied to individual neurons or assemblies in a neural structure. The paper presents an organized review of various learning techniques, classified according to basic characteristics such as chronology, applicability, functionality, stochasticity etc. Some of the learning procedures that have been used for the training of generic and specific neural structures, and will be reviewed are: Hebbian-like (Grossberg, Sejnowski, Sutton, Bienenstock, Oja and Karhunen, Sanger, Yuile et al., Hasselmo, Kosko, Cheung and Omidvar), Reinforcement learning, Min-max learning, Stochastic learning, Genetics-based learning, Artificial life-based learning. The various learning procedures will be critically compared, and future trends will be highlighted.

Introduction:

Different models of learning based on mathematics, statistics, logic, neural structures, information theory, evolutionary systems, artificial life, and heuristics have been proposed in recent years. The dedicated scientific journals and books on computational intelligence are abundant with learning rules and procedures, both in the general artificial intelligence (AI) context and in specific subfields like in machine learning and neural networks. Many of these rules can be identified as special cases of more generalized ones, usually being of a minor variation and typically given a different name or simply of different terminology and symbolism. In particular, in neural networks, there appears to be considerable confusion on what is what, what is a new rule and what ultimately constitutes a neural learning rule. Extensive expositions of neural learning rules have been given in [1], [2], [3], [4] and many other relevant papers. Various existing neural learning rules have been surveyed, identified and classified in order to gain a global overview of the subject area, and hence explore the possibilities for novel and more effective rules or for novel implementations of the existing rules by applying them in new network structures or strategies. This exploration aims to: i) attempt a systematic organization and generalization of the various neural network learning rules, ii) propose a rational taxonomy, iii) identify what is a generic rule and what is a special case, iv) present a chronological rule scheme and finally v) present a comparison of the rules. The proposed taxonomy will help in identifying which rules can be used for a proposed neural structure and the relative merits of each. Only those considered as most important, employing parameter adaptation (mainly weight) are presented, and this is done in a concise manner in order to keep the extend of this report within reasonable size.

An all-encompassing systematic and comparative study of the effectiveness of the various learning rules is not available. Since humans have always tried to improve things, some of these rules are better than others at particular tasks. There is, thus, room for even more rules, which will hopefully produce even better results than the existing paradigms in both aspects of accuracy and speed of execution.

2. Definitions of learning - Learning in neural networks

2.1 Learning in general

The Webster's dictionary defines learning as: "To learn is to gain knowledge, or understanding of, or skill in, by study, instruction or experience". In the general AI context, learning may be defined as: "Learning is a dynamical process by which a system responding to an environmental influence, reorganises itself in such a manner that it becomes better in functioning in the environment". In machine learning: "Learning denotes changes in the system that are adaptive in the sense that they enable the system to do the same task or tasks drawn from the same population more effectively the next time" or "Learning involves changes to the content and organization of a system's knowledge, enabling it to improve it's performance on a particular task or set of tasks" [5]. Thus, a computational system learns from experience with respect to a

class of tasks and some performance measure, if its performance for some task(s), as evaluated by the performance measure, improves with experience. The three important issues are the Experience, Task, and Performance. Learning in artificial neural systems may be thought of as a special case of machine learning.

2.2 Learning in artificial neural networks

Once an apparently suitable neural network structure has been decided, it needs to be adapted in order to be able to provide the desired results at appropriate times. In most existing neural network paradigms a somewhat restrictive approach to learning is adopted. This is usually done by systematically modifying a set of suitable controllable parameters, the so-called synaptic weights. In this manner, learning is identified as any change in the weight set W (generally known as the synaptic weight matrix, or long term memory) that minimizes a suitable criterion [6], [7].

A more general approach is adopted by Haykin, where learning is defined as: "Learning is a process by which the free parameters of a neural network are adapted through a continuing process of stimulation by the environment in which the network is embedded. The type of learning is determined by the manner in which the parameter changes take place" [3].

The free parameters have been given different names such as synaptic weights, synaptic efficacies, controllable parameters and others.

An alternative, more general approach is [8]: "Learning is achieved through any change, in any characteristic of a neural network, so that improved meaningful results are achieved". Thus learning could be achieved, among others, through i) synaptic weight modification, ii) network structure modifications (creating or deleting neurons or synaptic connections), iii) use of suitable attractors or other suitable stable state points, iv) learning through forgetting [9], [10], v) through appropriate choice of activation functions [11], [12] or vi) even learning through modifying controllable parameters in a look-up table defining an activation scaling. Combinations of such rules (e.g. competitive learning systems) to make more diverse and versatile learning systems may also be explored and implemented.

By meaningful results it is meant that a desired objective is met with a satisfactory degree of success that improves prior state. When the objective is quantified by a suitable criterion or cost function, a process of minimization of the error function or maximization of a specified benefit function is usually adopted. In this respect, learning resembles the optimization.

Based on the previous general definitions, one may wonder how are knowledge discovery, recognition, creativity, memory, mapping, classification, and categorization, related to learning and to what extend are these processes considered as learning tasks. What are the basic differences among these tasks, and what is the difference between learning and knowing? How can systems operate in a self-organizing, self-learning, and unsupervised mode? What are the relations with statistical procedures used for data manipulation and feature extraction?

Table 1. Characteristic feature taxonomy

Characteristic feature	Comment
The degree to which a neural learning paradigm resembles learning in biological systems	One has to note that there is no universal agreement among researchers on what constitutes biological learning and how it is implemented. The rules that cannot be autonomous, cannot be considered as belonging to this class, unless one emphasizes a specific local interaction (e. g. the Hebbian locality). Thus, all algorithmically defined rules (PAC, EM, Boosting, ...) cannot be included in this category. Typical rules of the class are the basic Hebbian and its closely related rules, as well as Hebbian-like rules used in spiking neuron networks [13].
Extend of applicability	Learning rules may be classified according to their depth of applicability. That is, on whether the rule applies to diverse environments, or to some special cases.
External guidance during learning	The process of adaptation may be externally guided by a teacher, in which case it is known as supervised training or internally, in which case it is known as unsupervised training. It is debatable whether truly unsupervised learning does exist. Even in natural-biological systems, some guidance either internal or external, by analogy or necessity, exists. Learning through pure intuitional guidance is rather a largely philosophical question. Typical learning rules that may be used in unsupervised manner are those used in self-organized maps, in learning vector quantizers, in principal component analysis (PCA) and in independent component analysis (ICA) procedures.
The type of adaptable parameters	Learning rules may be classified depending on whether the parameters that are adapted are the synaptic weights or any others such as some activation function characteristics (slope, amplitude, offsets, ...) [14], [15].
The degree of "rigidity" of the neural structure	Inflexible structures (hardwired systems) In such cases, there is no learning. A random generation of parameters, is hoped to give some meaningful results. Constructive learning (growing networks) In constructive learning, groups of neurons (layers, slabs ...) or individual neurons or connections are added in the network during training. A popular constructive algorithm is the cascade correlation [16] and its variants such as upstart, tiling, etc. The Boosting algorithm [17], [18] has recently gained significant attention because by a combination of poorly performing nets one can get a very good classifier. Destructive learning (shrinking networks) In destructive learning usually groups of neurons (layers, slabs ...) or individual processing units (neurons) or connections are removed from a network during training. The process is usually called pruning [19], [20].
The degree of evolution as a dynamical system	Classification on whether the learning rule/algorithm is expressed in terms of differential equations where some time-dependent evolution is implemented. Learning with non-dynamical equations does not involve time evolution, delays or recurrencies. Instead, the various parameters are changed in a nearly instantaneous manner.
The degree of stochasticity employed	The neural learning rules may or may not include stochastic elements (eg Simulated Annealing, Boltzman machines ...) [21], [22].
On whether learning is algorithmic or non-algorithmic	Rules may be algorithmic (Genetic algorithm-based, artificial life-based, growing an pruning algorithms, ...), in the sense that a sequence of procedures is needed to define the rule. Non-algorithmic rules are those that can easily be expressed with a mathematical equation, such that the system may grow autonomously. This is a rather artificial distinction, and from a practical point of view, the end result is what counts most.

3.Characteristic features of neural learning

A taxonomy of neural learning and learning strategies may be done based on different characteristics. Such characteristics can be (among other possible features) the degree of resemblance to biological learning, the degree of extend of applicability, the degree of external guidance/supervision, the type of adaptable parameters, the degree of "rigidity" of the neural structure, the degree of dynamical system evolution, the degree of stochasticity, and finally on whether it is algorithmic or non-algorithmic. Suggested characteristic feature taxonomy may be as described in Table 1.

4.Taxonomy of neural learning rules

Various taxonomies have been used. For example, Haykin [3] uses the following categorization: Error correction, Hebbian, Competitive, Boltzman and Thorndike law of effects. Simpson [23] uses the following: Hebbian, PCA, Differential Hebbian (Basic form, Drive Reinforcement form, Covariance correlation form), Competitive, Min-max, Error correction, Reinforcement, Stochastic, and Hard-wired.

Based on the comments on characteristic features of the learning rules (section 3), a proposed taxonomy of distinct rules could be:

- Hebbian (and many of its special cases)
- Reinforcement learning
- Min-max
- Stochastic
- Stochastic search in combination with steepest descent
- Genetics based
- Artificial life based
- Principle of maximum information preservation

In this taxonomy the Error Correction and the Competitive rules are considered as special cases of the generalized Hebbian, while Haykin [3] considers them as distinct rules. Such taxonomy helps in organizing the learning paradigms and in identifying what is a truly new learning rule.

5.Optimization - type learning rules

The majority of learning rules are such that a desired objective is met by a procedure of minimizing a suitable associated criterion (also known as Computational energy, Lyapunov function, or Hamilton function), whenever such exists or may be constructed, in a manner similar to the optimization procedures. Thus, a network global criterion function is desired to be minimized. In many cases the form of these functions resembles the physical energy. Many methods have been proposed for the implementation of the desired minimization, such as the 0^{th} order, 1^{st} order gradient-descent (Newton's, Steepest-descent), damped Newton (Levenberg-Marquardt), quasi-Newton (Broyden-Fletcher-Goldfarb-Shanno, Barnes-Rosen) and conjugate gradient methods [2]. Many of these rules are special cases of the generalized uncon-strained optimization procedure, briefly described below:

For a neural network described by equation 1, the optimization procedure interpreted as learning may be defined as finding a W^* that minimizes the perturbed computational energy criterion given by equation 2.

$$\dot{y}(t) = \psi(x, y, W) \qquad (1)$$

$$E(x, y, W) = E_{cost} + E_{perturbation} \qquad (2)$$

Where, y is the network output, x the network input, E_{cost} a suitable cost (error, objective, or computational energy) function, and $E_{perturbation}$ a shake-up component used to enable the system to hopefully escape from local minima. W here, even though is generally known as the set of synaptic weights, it is considered to be a more general set of adaptable parameters that when adapted may drive a network to better minima as far as the error hyperlandscape is concerned.

If E is continuous in the domain of interest, the minima of equation 2 with respect to the adaptable parameter (weights), W, are obtained when the gradient of E is zero, or when:

$$\nabla_w E = 0 \qquad (3)$$

Due to the generally non-linear nature of the artificial neural networks, and the need for developing intelligent optimization techniques, an exact solution of equation 3 is not easily obtained an it is not usually sought. Different, non-analytical methods for finding the minima of E have been proposed as neural learning rules. These are mainly implemented as iterative procedures suitable for computer simulations. The general iterative approach is:

Starting from a $W^{(0)}$ find $E(W^{(0)})$, then use the iteration,

$$W[\kappa+1] = W[\kappa] + \eta_\kappa d_\kappa \qquad (4)$$

Where η_κ is the search step and d_κ the search direction. Then find $W[\kappa+1]$ and compare it with $W[\kappa]$. If $W[\kappa+1]$ is less than $W[\kappa]$, keep the change and repeat until an E minimum is reached. The search direction d_κ and the search step η_κ may be randomly picked or guided by an intelligent drive/guess. If this strategy is followed, a stochastic search approach is adopted. Alternatively, d_κ may be guided so that a speedier search may be implemented (hopefully). Typically, d_κ is proportional to the gradient (1st order methods), as for example in the steepest descent, damped Newton (Levenberg-Marquardt), quasi-Newton (Broyden-Fletcher-Goldfarb-Shanno, Barnes-Rosen), conjugate gradient and variable metric (or quasi-Newton) or it is proportional to the Hessian (2nd order methods).

A popular approach used in artificial neural network learning in order for the network to reach these minima, is based on allowing multidimensional dynamical systems to relax, driven by a scaled gradient descent. In such a case, the system is allowed to settle by following its trajectories. It will then, hopefully, reach the minima of the hyper-surface defined by E. A general parameter adaptation approach, which is a generalization of equation 4 may be adopted, as shown in equation 5.

$$f(w, \dot{w}, \ddot{w}, \ldots) = -\nabla_w E \qquad (5)$$

The function f is so-specified so that it drives the system to acceptable minima. It is rarely needed to be of higher than second degree, and in most cases a first degree model is used.

Let a second-degree dynamical system that is forced to seek the desired minima, in which the input of the system is the negative of the gradient of E (gradient descent).

$$\alpha(t)\ddot{w} + \beta(t)T\dot{w} = -\nabla_w E \qquad (6)$$

Where $\alpha(t)$ and $\beta(t)$ are positive real-valued functions and T a suitable matrix. Equation 6 may be considered as a generalized second order learning equation based on gradient descent. Specific instances of this equation, as maybe used in optimization-learning are described in Table 2.

Table 2. Specialization of equation 6

$E_{perturbation} = 0$	
If $\alpha(t)$ and $\beta(t) \neq 0$	➔Second degree optimization
If $\alpha(t) \equiv 0$, T positive definite and $\beta(t) = \beta_0 \neq 0$	➔First degree optimization
If $\alpha(t) \equiv 0$, $T \equiv I$ and $\beta(t) =$ Error!	➔ Steepest descent method
If $\alpha(t) \equiv 0$, $T \equiv \nabla^2 E$ and $\beta(t) = 1$	➔ Newton's method
If $\alpha(t) \equiv 0$, $T \equiv \nabla^2 E + \gamma(t)$ and $\beta(t) = 1$	➔ Levenberg-Marquardt method
$E_{perturbation} \neq 0$	

In this case different stochastic gradient techniques are obtained. The perturbation is generally used as a "shake-up" that will hopefully force the network to escape from local minima. As this is approached, the perturbation in E is gradually reduced to zero so that the system reaches a state near the global minimum and settles there. Thus, at the end of the procedure the network becomes deterministic. A commonly used form for the perturbation is that shown in equation 7 [24], [25], [2]

$$E_{perturbation} = c(t) \quad c(t) \sum_{j=1}^{n} y_j N_j(t) \qquad (7)$$

Where $c(t)$ is a suitable decaying function used to gradually reduce the effects of noise and $N_j(t)$ is noise applied to each neuron j.

6.Concluding remarks

A survey of learning rules has been done. It is evident that an extensive variety of rules is available. The rules most extensively used by researchers and application users are of gradient descent approach. They are closely related to optimization techniques developed by mathematicians, statisticians and researchers working mainly in the field of "operations research". It is apparent that the suitability of any learning rules for implementation to artificial neural network problems is problem-specific. A systematic examination of the effectiveness of these rules is a matter of extensive research being conducted at different research centers. Conclusive comparative findings on the relative merits of each learning rule are not presently available. Numerous claims are being made, but they need to be independently verified, a task which is extremely difficult, as there is usually little information provided on the specific conditions and assumptions under which the learning was implemented.

The problem of neural system learning is ultimately very important in the sense that evolvable intelligence can emerge when the learning procedure is automatic and un-supervised. The term "unsupervised" is debatable depending on the level of scrutiny applied when evaluating a rule. It is customary to consider some learning as unsupervised when there is no specific and well defined external teacher. In the so-called self-organizing systems, the system organizes apparently unrelated data into sets of more meaningful packets of information. Ultimately though, how can intelligent organisms learn in total isolation? Looking at supervisability in more liberal terms, one could say that learning is not well-specified supervised or unsupervised procedure. It is rather a complicated system of individual processes that jointly help in manifesting an emergent behavior that "learns" from experience. Ultimately, one may even ask whether consciousness is learned.

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Practical evaluation of GPRS use in a telemedicine system in Cyprus

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Abstract
The unceasing emergence of new technologies in wireless and mobile telecommunication networks, combined with the simultaneous rapid advances in information technology, are leading to many new solutions in the field of telemedicine, thus offering more opportunities for improving further existing and supporting new advanced services for healthcare. The objective of this paper is to carry out a practical evaluation of the performance of the GSM and GPRS systems in the transmission/reception of X-ray images and video in emergency orthopedics cases. As expected, the performance of GPRS is superior to that of GSM. The data transfer rate achieved with GPRS were in the range of 32 Kbps with the download time for typical X-ray images of a file size of 200 Kbytes to the mobile device to be in the region of 60 seconds. Similar performance was also recorded in the case of a moving station (simulating the ambulance) for the biggest part of the journey. In conclusion, although the medical imaging downloading timing was in the range of a few minutes, the physicians were very pleased by the benefits offered by the system through the freedom of access, anywhere and anytime even in motion.

Keywords - GSM, GPRS, UMTS, mobile, wireless, Telemedicine, Orthopaedics.

I.Introduction
Telemedicine can be defined as the distant delivery of health care and remote sharing of medical knowledge using telecommunication means. It aims at providing expert medical care to any place, anytime. Telemedicine as a concept was introduced in the early 70's when telephone and fax machines were the first telecommunication means used. In recent years, several telemedicine applications have been successfully implemented over wired communication technologies like POTS (Plain Old Telephone System), and ISDN (Integrated Services Digital Network).

However, nowadays, modern wireless telecommunication means like GSM and GPRS and the forthcoming UMTS (Universal Mobile Telephone System) mobile telephony standards allow the operation of wireless telemedicine systems freeing the medical personnel and/or the patient from fixed locations.

Telemedicine applications, which enable the availability of prompt and expert medical care, have been exploited for the provision of health care services at understaffed areas like rural health centers, ambulance vehicles, ships, trains, aeroplanes as well as for home monitoring [1]. In most of the wireless telemedicine projects the GSM technology was mainly used. GPRS which is a relatively new system was used only in a very few cases up to now [2].

Many times during emergency cases either in the accident department or the in the operating theatre there is the need of the prompt expert opinion of the specialist physician. The objective of this paper is to carry out a practical evaluation of the performance of the GSM and GPRS systems in the transmission/reception of X-ray images and video in emergency orthopedics cases. The target is the support of trainee doctors as well as doctors who may need a prompt second opinion for facing orthopedics injury cases by transmitting medical images and video with the use of wireless technologies.

2.The GSM and GPRS systems
The main wireless technologies that are being used in wireless telemedicine systems are the GSM, GPRS, satellite, Wireless Local Area Network (WLAN) and Bluetooth. The GSM is considered as the second generation (2G) of the mobile communication networks.

Table I. GSM and GPRS frequency bands and data transfer rates

Type	Frequency band	Data transfer rates
GSM	900/1800/1900 MHz	9.6 - 43.3 kbps
GPRS	900/1800/1900 MHz	171.2 kbps

When GSM is in the standard mode of operation, it provides data transfer speeds of up to 9.6 Kbps (see Table I). Throughout the years a new technique was introduced in the GSM standard called HSCSD (High Speed Circuit Switched Data). This technology makes it possible to use several time slots simultaneously when sending or receiving data, so that the user can increase the data transmission up to 43.3 Kbps [3].

The theoretical maximum downlink data rate for GPRS is 171.2 kbps assuming that CS-4 (coding scheme 4) and eight timeslots are simultaneously used (see Table I). Today, however, GPRS coding is limited to CS-2 and transmission can take place onto four timeslots at most, giving a maximum throughput of around 45 kbps (under ideal radio conditions) [4]. This means that pure data throughput approximates to 35 kbps given that overhead data comprises around 20% of the raw bit stream. Of course this can decrease under non-ideal radio conditions such as frequency interference, traffic congestion and poor radio coverage. The same applies to uplink data rates except that today one or two timeslots can be simultaneously used giving throughputs of 8-16 kbps.

It should be noted that in most cells GSM data channels have priority over GPRS channels. In addition, GPRS packet transmission offers a more user - friendly billing than that offered by circuit switched services.

The evolution of mobile telecommunication systems from 2G to 2.5G (iDEN-Integrated Digital Enhanced Network- 64 kbps, GPRS 171 kbps, EDGE - Enhanced Data rates for Global Evolution - 384 kbps) and subsequently to 3G Code Division Multiple Access (W-CDMA, CDMA2000, TD-CDMA) will enable faster data transfer rates thus facilitating the development of telemedicine systems that require high bandwidth and are currently only feasible on wired communication networks.

GPRS enabled networks offer 'always-connected', higher capacity, mobile data services, such as Internet/WAP (Wireless Application Protocol) browsing, e-mail on the move, powerful visual communications, multimedia messages and location-based services[3].
Satellite systems have the advantage of worldwide coverage but lack in flexibility. Wireless LANs offer much faster and flexible data communications within restricted geographical coverage (hot spots) and can be used in conjunction or as an extension to GPRS and UMTS networks as well as to other wired systems. Bluetooth is a very short-range radio technology that allows wireless data transmission between various computing and communication devices. It is expected to prove very useful as an overlay to other networks such as GPRS/UMTS.

3.Methodology

The network infrastructure in support of the emergency orthopedics medicine system is given in Fig.1. The Figure illustrates: (i) the server of the internet service provider (ISP), (ii) the accident and emergency department's server (and the departmental LAN) that is connected to the internet via ADSL and (iii) the GSM/GPRS mobile stations which may be a laptop PC or a handheld PC.

A simple scenario of the use of the system follows: X-ray images and/or video clips of orthopaedics cases captured at the accident and emergency department or the operating theatre of the hospital are uploaded to the server of the internet service provider. Figure 2 shows typical X-ray images. The physician is informed about the availability of the medical images to be assessed via SMS, voice or email. The physician is then connected to the server via GSM/GPRS modem installed in the laptop or the handheld PC and downloads the images. The physician evaluates the images on the screen of the mobile station and communicates with the accident and emergency department via SMS, voice or email so as to give his comments or instructions.

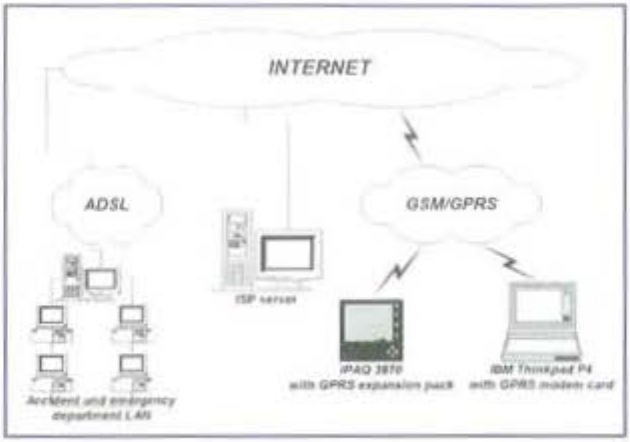

Fig.1. Network infrastructure of the Tele Biomedical Support System.

In some cases he may as well add part of his instructions on the X-ray image received and then send them to his colleagues via the ISP server.

Fig.2. Sample X-ray images transmitted. Left image: right hand. Right image: pelvis. (Image size 210 Kbytes (tiff format), resolution 2000x1400).

The performance of the system was evaluated using wireless communication channels in the transmission of medical images of varying size in the following cases:

i. Downloading of X-ray images via SMTP (as email attachment) or via FTP using both GSM and GPRS, and
ii. Downloading of images via FTP over GPRS.

In addition the performance of the GPRS system using FTP access was evaluated in the cases of:

iii. Repetitive downloading of a video file of size 450 Kbytes for 20 hours from a fixed location, and
iv. Downloading of an image file of size 180 Kbytes on a moving handheld PC at a speed of 100 km/hr.

For the handheld PC the Compaq iPAQ 3870 equipped with the GSM/GPRS expansion pack modem was used, whereas for the laptop PC, the IBM Think Pad with a Globe Trotter high speed GPRS wireless PCMCIA modem card was used. The laptop PC was also used with the Ericsson R520 mobile phone serving as a modem that allowed the Ericsson TEMS GSM/GPRS monitoring software to be used for field measurements.

4.Results

The results presented in this study were carried out using the Compaq iPAQ 3870 handheld PC with the medical images and videos varying in size between 10 Kbytes to 2 Mbytes.

Figure 3 illustrates the comparison of GSM and GPRS for both SMTP and FTP protocols. The throughput for GPRS FTP varied between 30 to 35 Kbps, whereas for the GPRS SMTP varied between 13 to 19 Kbps. The throughput performance for GSM for both SMTP and FTP varied between 5 to 10 Kbps. It is clearly shown that for FTP the throughput performance of the GPRS is approximately triple to that of the GSM, whereas for SMTP the GPRS performance is 1.5 times to four times to that of GSM.

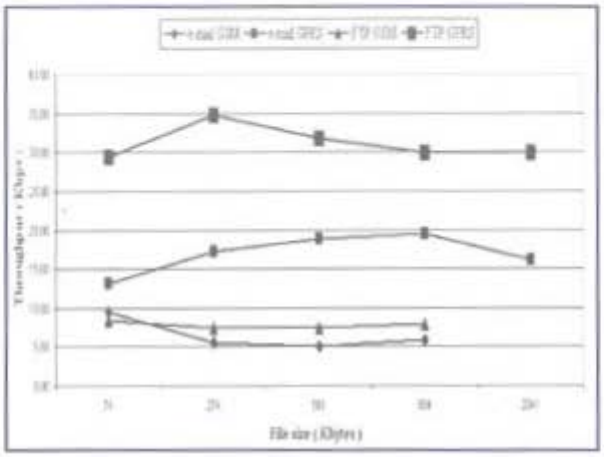

Fig. 3. Comparison of SMTP and FTP protocols over GSM and GPRS.

Figure 4 illustrates the FTP download timing for varying size of image files carried out from a fixed point. As expected, the download timing is increasing proportionally with the increase in the size of the file. It is seen that for files of about 200 Kbytes (size of a typical X-ray image) the download speeds are about one minute.

The corresponding download speeds for the above experiment are shown in Fig. 5 for that specific time and point. The download speed was in the region of 30 Kbps, varying between 23.5 to 34 Kbps. Figure 6 illustrates the repeated downloading of a 450 Kbytes video clip file from a fixed location to the iPAQ pocket PC over a period of 20 hours. Speeds in the range of 30 Kbps were achieved where with the exception of two cases this varied between 27 to 32 Kbps. The download speed versus distance in the case of a mobile station (i.e. the case for an ambulance) traveling in a highway at 100 km/h, downloading repeatedly a 180 Kbytes image file using FTP over GPRS is given in Figure 7. The performance of the system for a significant length of the journey was very satisfactory, with throughput values in the range of 30 to 32 Kbps. However, there were segments of the journey both in the normal and the return journeys where poor performance was recorded, with data transfer rates in the range of 7 to 11 Kbps. In the region of 30 Km in the normal journey there were very bad weather conditions, which must have affected negatively the performance of the wireless network.

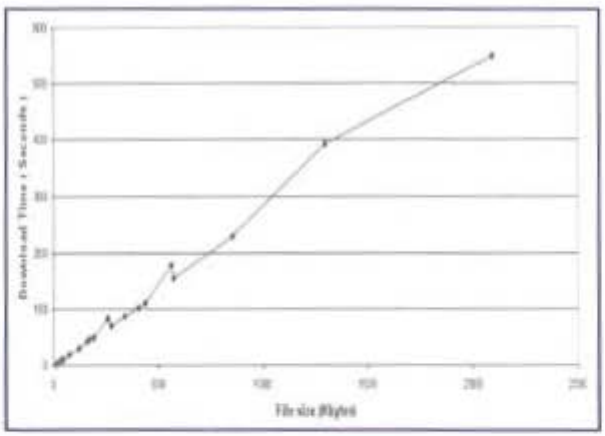

Fig.4. Download timing for files of varying size using FTP over GPRS.

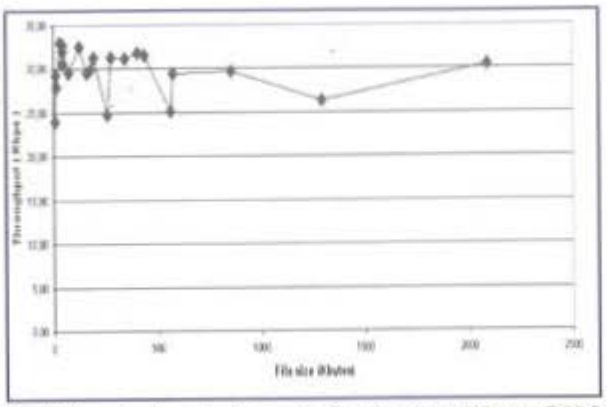

Fig. 5. Download speeds for varying file size using FTP over GPRS.

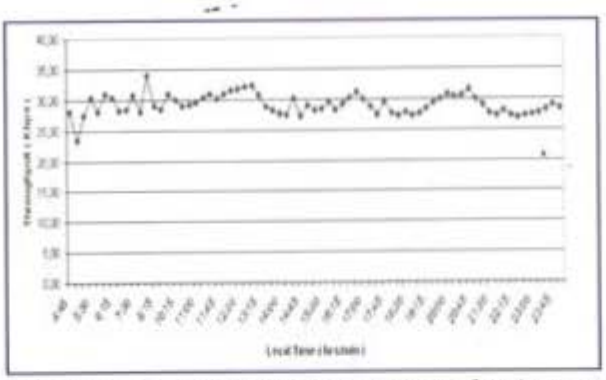

Fig. 6. Repeated downloading of a 450 Kbyte video clip over a period of 20 hours using FTP over GPRS.

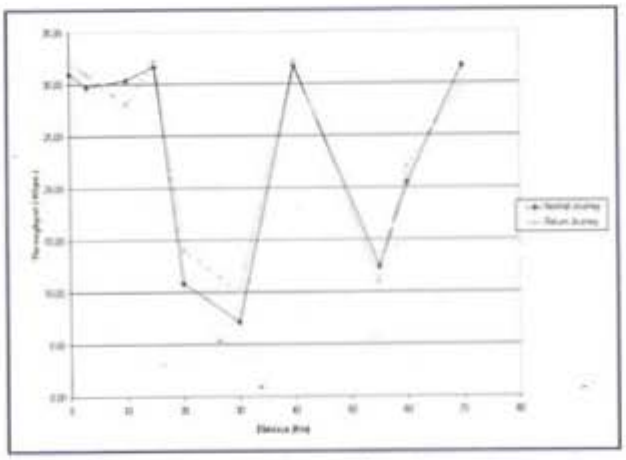

Fig. 7. Download speed versus distance in the case of a mobile station traveling at 100 Km/hr when downloading repeatedly a 180 Kbytes image file using FTP over GPRS.

5.Concluding remarks

The experiments carried out showed that the GPRS system can be used successfully for the transmission of medical images and video employing the Tele Biomedical Support System using – so far - the store and forward method. The results showed clearly that the method of using FTP over GPRS was by far superior to e-mail.

In this study, a practical evaluation of the performance of the GSM and GPRS systems in the transmission/reception of X-ray images and video in emergency orthopedics cases was carried out. The target is to support trainee doctors as well as doctors who may need a prompt second opinion for handling orthopedics injury cases by transmitting medical images and video with the use of wireless technologies.

As expected, the performance of GPRS is superior to that of GSM. The data transfer rates normally achieved with GPRS were in the range of 32 Kbps which is what was expected since the downlink bit rate for a 4+1 phone connection is between 5 Kbps and 40 Kbps [5].

The download time for typical X-ray images of file size 200 Kbytes to the mobile device was in the region of 60 seconds. The system was also used in an emergency scenario where a prompt second opinion was requested remotely from the orthopedics surgeon in the case of a serious operation. In this case, the doctors in the operating theatre transmitted X-ray images and a video clip to the mobile station via the ISP server, and then the X-ray images were retransmitted back including the surgeon's notes/instructions as well as text and/or voice files. The whole teleconsultation scenario was carried out in less than five minutes.

The performance of the system was also evaluated in the case of a moving station (simulating the ambulance) for the downloading of an X-ray image with speeds reaching 32 Kbps for the biggest part of the journey.

Furthermore, it should be noted that the experts rated the quality of the medical images and video clips transmitted as very satisfactory.

Concluding, a simple and cheap telemedicine system was evaluated that supports wireless access for the transmission of medical images in emergency orthopedics cases. Although the medical imaging downloading timing was in the range of a few minutes, it was compensated by the benefits offered by the system through the freedom of access, anywhere and anytime even in motion.

Future work will focus in the provision of a wireless telemedicine support system covering the needs of the whole island. The system will focus primarily in emergency services covering both the accident and emergency department as well as the ambulance services. Moreover, the UMTS system envisioned to be investigated by CYTA in the near future will greatly leverage telemedicine services, thus enabling the offering of a better service to the citizen.

Acknowledgment
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"Using Acceptance Sampling Standards to establish a methodology for calculating frequency and sample size to monitor SPC control charts"

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Abstract

Statistical Process Control (SPC) control charts has been used with success for years to monitor processes, minimize variation and remove special courses of variation (in manufacturing and service organisations).

There is a proliferation of textbooks guiding practitioners on how to implement SPC. In the great majority of the books you can find topics dealing with the sample size and the sampling frequency. Sampling plans are of great importance when you are trying to control a process using control charts. In all books suggestions are given on the parameters affecting the selection on the sample size and frequency. They advice the writer what he should consider. But, only in a limited number of textbooks the authors had tried to give some specific numbers or a table, where practitioners can refer. On this article the author will demonstrate a model methodology on how to select the sample size and the sampling frequency using the existing internationally accepted standards for "Acceptance Sampling by Attributes and Variables" to be used for control charts.

This methodology has already been used in Cyprus and it was found to be very useful to organisations that have already implemented SPC.

I.Background

Most quality improvement activities begin by establishing process control and then continuously improve operating limits. However a more structure approach would start with Quality Function Deployment as a way of establishing the requirements (customer), following by process capability studies, Taguchi experiments and finally SPC would establish on key process characteristics.

SPC is a method, which gives confidence that components or services delivered are within tolerance/ specifications, without having to measure every product or service. It is associated with the theme of controlling the process not the product and is a form of feed forward technique.

There are some fundamental ways of controlling the quality of the product. They are:

i. Action on the output Detection oriented (sampling on the final product)
ii. Action on the process (process performance by sampling). Prevention oriented.

It is important to realize that at least 20 to 25 subgroups should be taken. This is to assume that the main sources of variation have had a change to appear [McMillan, 1991].

Is well recognised that sampling/ sample size and frequency of sampling is of great importance on SPC control charts. To further understand sampling and sampling frequency important extracts from textbooks are presented below. The sample size is dependent on the operating policy of each organisation. If the sample size is too small the reliability is questioned. If it is too large it may be impractical to collect (as well as being statistically unsound).

As for the sampling frequency it will be impractical to measure every single unit produced in a high volume output. Using statistical theory we can get information about a process from sufficient samples over a period of time. The aim is to collect samples often enough and at appropriate times that they highlight any possible changes. Some of the basic tools of SPC are Control Charts for variables (X bar, XMR) and attribute data p, np, c, u charts.

In quality engineering sampling is the science that guides the quantitative study of quality. Conceptually a sample is merely surrogate for a larger population of interest. Samples are drawn for a number of purposes. The system needed to

control sample integrity depends on the purpose for which the sample is drawn. There are various reasons for sampling:

a) Acceptance samples - are drawn to determine whether or not an acceptable proportion of a defined inspection lot conforms to requirements. These are acceptance samples for inspection by attributes with reference standards BS 6001, 1972 or ANSI/ASQC 1.4-1993 and inspection by variables BS 6002:1973 or ANS/ASQC 1.9-1993. These standards will be used in this article to develop a model for SPC samples.

b) Statistical Process Control Samples are drawn to determine if the process is stable. These samples are going to be specified through this paper.

c) Process validation samples - are taken to show that the proper processing conditions were met during a production run.

d) Measurement system correlation samples - are taken to allow a comparison between two different methods of measurement. [Pyzdek, Th., 1996]

e) Industrial and customers research samples are taken to identify the feeling or the preferences of consumers (usually in questionnaires and interviews). There are occasions for industrial sampling when circumstances resemble consumer markets. Mostly, however, they are different and difficult to select the formula. Usually in industrial research the sample size is related with the probability of errors. Some important formulae are given below.

Standard error of proportion (SE) = $\sqrt{(p\,q/n)}$

Where p = population proportion expressed as a decimal fraction and not as a percentage.

q = 1 - p

n = sample size

The reliability of results obtained, of sample size can be derived as follows: [Hague NP, 1984]

$N = 4(p\,q) / E^2$

Where

n = the sample size

p = the proportion of the sample of the attribute we are trying to measure

q = the proportion of the sample not having the attribute we are trying to measure (i.e. q = 1 - p)

E = the derived level of accuracy as a decimal fraction

The answer to the question "how often should I take samples from the process?" depends on many thinks. The most important are the consequences of running out of control, the cost of inspection, the process stability, availability of resources etc. The rule of thumb offered from Juran's QC Handbook, 3rd edition is that "One in 25 subgroups outside of control limits". The basic idea of rule is to take the samples frequently enough that when an out of control indication appears the operator will be able to identify the cause.

Developing the model by adopting a new methology

As it has been demonstrated before in a variety of bibliography no numbers are given to help practitioners to have a rough number of the sample and the sampling frequency. In the following paragraphs the steps for implementing the suggested methodology will be explained starting with the needs identification up to the point where data will start to be collected for plotting the specific control chart. This new methodology is based on the authors experience and knowledge and the American and British Standards for Inspection by Attributes and Variables and Standard Switching rules. In order to better understand the steps and methodology an example will be used in Italics, drawn from service organisations where customers are receiving a service in the front desk.

Step 1. Top management write down the vision the policy and objectives of the organisation. Management make sure that these are communicated and understood by all employees i.e. improve performance.

Step 2. Individual Departments or sections cascade downwards the objectives and through departmental meetings set the department's objectives and targets. i.e. improve performance by 5%.

Step 3. Each Department should identify the critical processes based on two criteria, what is important or affecting the customer and what is important to the shareholders (profitability, performance etc). i.e. customer servicing time

Step 4. Analyse the steps (flow diagram) of individual process considering the following:

- Who is responsible for each step?
- Who is responsible for implementation?
- What are the targets of each step based on the departmental objectives?

Step 5. Can those targets been measured using performance indicators?
i.e. measure service time in minutes.

Step 6. Try to identify which objective can be measured. Then identify the method and how can be monitored or measured. i.e. service time by measuring time devoted to each customer.

Step 7. Identify the parameters that should be measured and distinguish if the data collected are variables or attributes. Then decide which chart will be used. Figure 1 "which chart to use" will help the practitioners to select the right chart. (SPC Control Charts). i.e. time is using variables data and the chart is x bar R.

Step 8. Using employees past experience find the total population of the production or people served per day in the organisation. i.e. 750

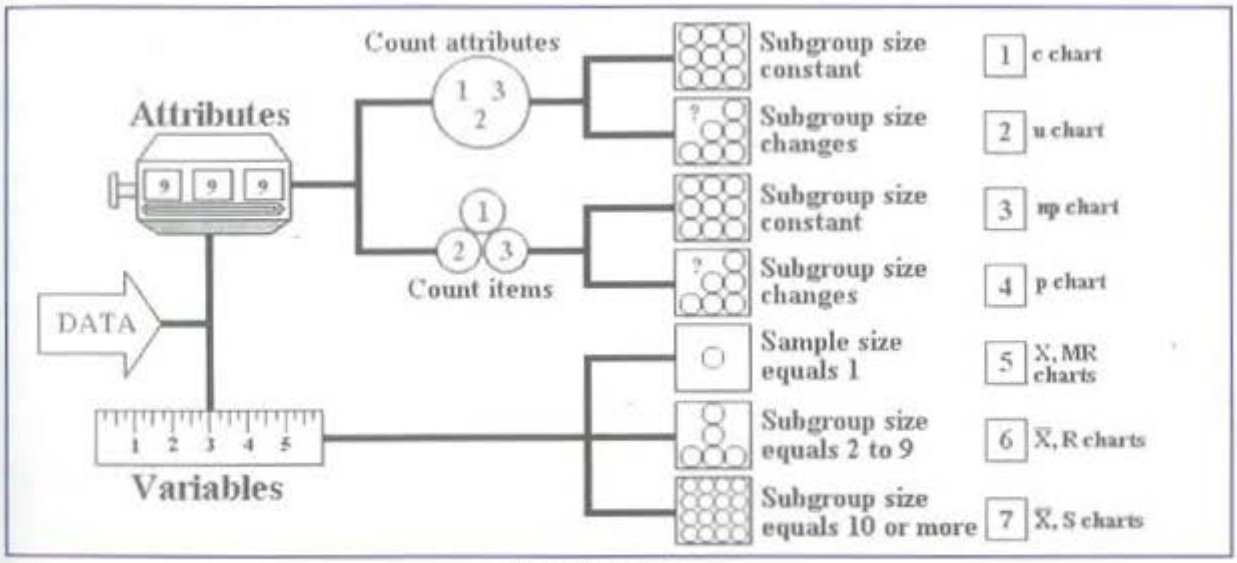

Fig. 1. Which chart to use

Step 9. Based on specifications, designs, management policy or instructions, decide the inspection level. Looking on the table 1 "Master table for sample size and code letters", which has been developed by the author using the above mentioned standards, there are 3 general inspection levels and 4 special. As a general rule starting from S.1. and going towards general level III the sample size increases. As a rule, if no special cause is involved (i.e. expensive samples, destructive test, availability of resources) start with the inspection level II and find the corresponding code letter for the lot or batch size. i.e. for 750 people, variable data, and inspection level II the code letter is "J".

Step 10. Based on the previously mentioned criteria (affects on going out of control or specifications, cost, time, accuracy, company's risk, errors etc.) desite if reduced normal or tightened inspection will be used. Obviously in reduced inspection the sample size is smaller than normal and tightened. If no constrains are mentioned it is recommended to start with normal inspection.

Step 11. Looking on table 2 "Sampling master plan sample size for variables and attributes data" find the sample size for the code letter found on step 9 i.e. For code letter J, variable data, normal inspection the sample size for one day should be 40

Step 12. Decide about the subgroup size n. How many consecutive people/ products will be measured each time.
i.e. Five people's servicing time will be measured.

Step 13. Divide the sample size found on step 11 by the subgroup size decided on Step 12 to find how many times samples will be taken during the day in order to help us to find sampling frequency.
i.e. sample size 40/subgroup size 5 = 8
So 8 samples of 5 customer's servicing time each time will be measured during the day.

Step 14. Calculate sampling frequency by dividing the working time during the day by the number of samples found on step 13.
i.e. 7 working hours x 60 minutes / 8 samples = 53. So every 50 minutes a sample of 5 customers will be measured to find servicing time.

Step 15. Start collecting data with normal inspection unless one of the following switching rules is applied. (ANS/ASQC 1.4-1993 page 4)

- Normal inspection will be used at the start of inspection, unless otherwise directed by the responsible authority.
- Tightened inspection shall be instituted when 2 out of 5 consecutive productions, in our case samples are rejected (out of specifications, authors opinion)
- Normal inspection shall be instituted when 5 consecutive samples have been considered acceptable i.e. within specifications.
- Reduced inspection shall be instituted from normal inspection provided that 10 consecutive samples are accepted i.e. within specifications. Another 3 conditions for switching should be considered

1. The samples will be still accepted with the next Acceptable Quality Level i.e. more tightened specifications.
2. The production line or service process is at steady state and under Statistical Control. i.e. all points within Upper and Lower Control Limits.
3. The responsible Authority considers reduced inspection desirable.

- When reduced inspection is in effect, normal inspection shall be instituted if any of the following occur on original inspection:

1. A sample is rejected i.e. out of specifications
2. Production or process becomes irregular or delayed or unsteady.
3. Other conditions warrant that normal inspection shall be instituted.

Step 16. Continue sampling and plotting the points on the control charts considering all theory and background of SPC. You should aim to minimize common causes of Variation and remove Special causes appeared in the system.

Summary

Professor Barrie Dale during his speech at the PanHellenic Quality forum in 1999, said that all knowledge acquired thought studying techniques, quality tools etc should be considered as "recourses", where an individual or company will recall or use in accordance with their needs for a specific purpose to enhance progress, productivity, profitability and above all value added.

The author extract from his "resources" accumulated in the past decades thought knowledge, experience and personal experience, useful information for the development of a sampling model to be used by practitioners trying to implement SPC control charts. Trough the precise methodology explained in this article, one can now somehow estimate a sample number and the sampling frequency, which should be used when someone is trying to monitor any process.

The necessity of proving the validity of the empirical model and tables is of limited importance, compared with the usefulness of giving real numbers for sampling, instead of recommendations and advices. The tables have been used in many organizations in Cyprus who initiated quality programs and SPC. The model revealed to be very useful and practical.

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Population size or Production size	Special control levels						General control levels					
	S-1	S-2	S-3		S-4		I		II		III	
			A	V	A	V	A	V	A	V	A	V
2 to 8	A	A	A	B	A	B	A	B	A		B	C
9 to 15	A	A	A	B	A	B	A	B	B	B	G	D
16 to 25	A	A	B	B	B	B	B	B	C	C	D	E
26 to 50	A	B	B	B	C	B	C	C	D	D	E	F
51 to 90	B	B	C	B	C	B	C	D	E	E	F	G
91 to 150	B	B	C	B	D	C	D	E	F	F	G	H
151 to 280	B	C	D	B	E	D	E	F	G	G	H	I
281 to 500	B	C	D	C	E	E	F	G	H	H/I	J	J
501 to 1200	C	C	E	D	F	E	G	H	J	J	K	K
1201 to 3200	C	D	E	E	G	G	H	I	K	K	L	L
3201 to 10000	C	D	F	F	G	H	J	J	L	L	M	M
10001 to 35000	C	D	F	G	H	I	K	K	M	M	N	N
35001 to 150000	D	E	G	H	J	J	L	L	N	N	P	P
151001 to 500000	D	E	G	I	J	K	M	M	P	P	Q	P
Above 500001	D	E	H	J	K	L	N	N	Q	P	R	P

A= Attributes data V= Variables data

Table1. Master Sampling Plan table for population and code letters for Attribute and Variable data

A= Attributes data V= Variables data

Sample code letter	Attributes data. Sample size			Variables data. Sample size			
	Normal	Tightened	Reduced	X-S or σ		X-R	
				Nor.& Tig	Reduc.	Nor.&Tig	Reduc.
A	2	2	2				
B	3	3	2	3	3	3	3
G	5	5	2	4	3	4	3
D	8	8	3	5	3	5	3
E	13	13	5	7	3	7	3
F	20	20	8	10	4	10	4
G	32	32	13	15	5	15	5
H	50	50	20	20	7	25	7
I				25	10	30	10
J	80	80	32	35	15	40	15
K	125	125	50	50	20	60	25
L	200	200	80	75	25	85	30
M	315	315	125	100	35	115	40
N	500	500	200	150	50	175	60
P	800	800	315	200	75	230	85
Q	1250	1250	500				
N		3150					

Table 2. Master table for sample size selection for Attribute and Variable data

Comparison of thermal loads of a model house located in typical microclimates in Cyprus

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Abstract

The climate of Cyprus is characterised by abundant sunshine and by moderate to heavy winter conditions. The microclimate though, varies considerably from location to location and is strongly affected by the elevation of a particular location and the proximity to the sea. In this study, four locations are considered which are representative of all the microclimates encountered in Cyprus; coastal, lowland, semi-mountainous, and mountainous. The weather pattern in these locations presents distinct characteristics. Dry weather with high summer and low winter temperatures are encountered in lowland, high humidity and moderate temperatures in coastal areas whereas dry weather with moderate summer and very low winter temperatures in semi-mountainous and mountainous areas. These weather patterns affect the thermal loads of buildings. A typical house layout with three different construction characteristics is used in this study and is simulated with TRNSYS for a complete year. The weather data file used includes the mean monthly values of ambient air temperature, solar radiation, humidity ratio and wind velocity. TRNSYS Type 54 is used in the simulations to generate the hourly weather data required. The results show that the lowland, coastal and semi-mountainous locations exhibit high cooling and heating loads whereas mountainous locations exhibit high heating loads and very low cooling loads.

Introduction

The objective of this study is to show the variation of the heating and cooling loads of typical building constructions with respect to the ambient weather conditions. Cyprus although a small island presents four distinct weather patterns, discussed in this paper. However detailed weather data are available for only one of these locations in the form of Typical Meteorological Year. Therefore, to simulate the thermal load of buildings on an hourly basis it is required to generate hourly data from mean values.

In the past a lot of simulations and detailed analyses were carried out for houses erected in Cyprus (Florides et al., 2000; 2001; 2002; Kalogirou et al., 2002). All these however refer to buildings located in Nicosia. This is due to the fact that TMY data are only available for this town. It is therefore of interest to investigate the thermal loads of buildings erected at other locations, which have different weather conditions than that of Nicosia. Such a detailed analysis for the other three distinct locations is done for the first time.

In the present study, the thermal loads of a typical building with three different construction types are compared. Four different locations, which are representative of the four distinct weather patterns that can be encountered in the island, are considered.

Weather Data

The four locations considered in this study with their corresponding height above mean-sea-level (amsl) are:

1. Nicosia (Lowland), height: 160m amsl
2. Poli (Coast), height: 15m amsl
3. Saittas (Semi-mountain), height: 640m amsl
4. Prodromos (Mountain), height: 1380m amsl.

For the above four locations mean monthly values of ambient air temperature, solar radiation, humidity ratio and wind velocity are available. These values were recorded for a 20-year period by the Meteorological Services. A TMY type of data is available for only one location of the four, that of Nicosia. Tables 1 to 5, give the mean monthly weather data for the four locations and also the mean values for Nicosia as estimated from the typical meteorological year file data file (Table 2).

Table 1. Monthly average weather data for Nicosia (h=160m amsl) estimated from meteorological service data

Month	Daily radiation (kJ/m^2)	Mean dry bulb temperature (°C)	Mean wind velocity (m/s)	Humidity ratio (g of moisture/kg dry air)
January	8824	10.0	3.0	5.8
February	11452	10.3	3.5	5.8
March	15901	12.4	3.7	6.5
April	20801	17.1	4.1	7.5
May	22889	21.2	4.3	9.0
June	24984	25.6	4.5	11.3
July	25225	28.4	4.5	13.5
August	22568	28.1	4.2	13.5
September	18677	25.6	3.8	12.5
October	13752	20.7	3.3	9.8
November	10170	14.9	2.9	9.8
December	8046	11.6	2.9	6.5

Table 2 Monthly average weather data for Nicosia estimated from data included in the TMY file

Month	Daily radiation (kJ/m^2)	Mean dry bulb temperature (°C)	Mean wind velocity (m/s)	Humidity ratio (g of moisture/kg dry air)
January	8594	9.9	3.0	5.7
February	10543	9.6	2.6	7.0
March	15561	11.5	3.8	6.4
April	20280	17.0	3.6	7.8
May	21019	19.8	4.0	7.5
June	24600	26.0	3.4	10.3
July	25432	28.9	4.4	11.7
August	24120	27.8	3.8	13.8
September	17651	25.9	3.6	12.2
October	14160	19.2	2.5	9.0
November	9406	15.1	2.0	8.6
December	8280	10.7	2.4	7.2

Table 3 Monthly average weather data for Poli (h=15m amsl) from meteorological service

Month	Daily radiation (kJ/m^2)	Mean dry bulb temperature (°C)	Mean wind velocity (m/s)	Humidity ratio (g of moisture/kg dry air)
January	8834	11.4	3.1	6.3
February	11434	11.5	3.3	6.3
March	15437	12.7	3.0	6.8
April	19526	16.2	2.9	8.3
May	22378	19.7	3.0	9.5
June	24822	23.8	3.1	11.5
July	24433	26.7	3.1	13.0
August	22331	26.7	3.0	13.8
September	19037	24.5	3.0	12.3
October	14022	20.6	3.0	9.8
November	10177	16.2	3.0	7.8
December	7834	13.2	3.0	6.5

The data presented in Tables 1 and 2 refer to the town of Nicosia. Table 1 presents the mean weather data, obtained from the meteorological service and Table 2 those estimated from the TMY. By comparing the values in these two tables it can be seen that the various monthly values are rather similar. Greater differences concern the values of humidity ratio.

In Nicosia, the capital of Cyprus, temperatures vary between 10°C and 15°C during winter whereas in summer temperatures often exceed 40°C. The annual average wind velocity is 3.7m/s.

In Poli, a coastal city located southwest of Cyprus, temperatures are moderate both in summer and winter compared to Nicosia. The humidity levels are high and the annual average wind velocity is 3m/s.

Saittas is situated at Troodos range. Temperatures are moderate in summer and low in winter. Humidity values are within acceptable limits and the annual average wind velocity is 2.4m/s.

Table 4 Monthly average weather data for Saittas (h=640m amsl) from meteorological service

Month	Daily radiation (kJ/m^2)	Mean dry bulb temperature (°C)	Mean wind velocity (m/s)	Humidity ratio (g of moisture/kg dry air)
January	7103	8.2	2.6	4.5
February	10519	8.2	2.8	4.3
March	14296	10.2	2.6	4.5
April	18821	14.7	2.5	5.0
May	21046	19.5	2.3	6.3
June	23360	24	2.3	7.3
July	23092	26.8	2.4	8.5
August	21449	26.6	2.3	8.8
September	18716	23.5	2.2	7.3
October	13795	19.8	2.3	6.8
November	9148	14.1	2.3	5.5
December	6390	9.9	2.4	5.0

Table 5 Monthly average weather data for Prodromos (h=1380m amsl) from meteorological service

Month	Daily radiation (kJ/m^2)	Mean dry bulb temperature (°C)	Mean wind velocity (m/s)	Humidity ratio (g of moisture/kg dry air)
January	6577	2.7	2.8	3.5
February	8500	2.5	2.8	3.5
March	12208	5.1	2.6	3.8
April	17006	10.3	2.5	4.3
May	18292	14.2	2.4	5.0
June	20732	18.5	2.2	6.0
July	20952	21.7	2.1	6.5
August	19966	21.2	2.0	6.0
September	17064	18.4	2.1	5.8
October	11653	12.9	2.3	5.3
November	8237	8.0	2.3	4.5
December	6163	4.5	2.6	4.0

Prodromos is also located at Troodos range but much higher compared to Saittas. Severe conditions are experienced in winter with temperatures down to -10°C in some cases. Humidity levels are within acceptable limits and wind velocities are 2.4m/s on the average.

The selection of typical weather conditions for a given location is very crucial in computer simulations for performance predictions and has led various investigators either to use observational data of long periods or to select a particular year, which appears to be typical from several years of data. Typical meteorological year data file is only available for Nicosia.

This was generated from hourly measurements, of solar irradiance (global and diffuse on a horizontal surface, ambient temperature, wind speed and direction, and humidity ratio). The recorded data refer to a seven-year period, from 1986 to 1992 using the Filkenstein – Schafer statistical method (Petrakis et al., 1998). The measurements were performed by the Meteorological Service of the Ministry of Agriculture, Natural Resources and Environment of Cyprus, at the Athalassa region, an area very close to the town of Nicosia. Athalassa is at a latitude of 35°09', longitude 33°24' and 162 m high above the mean sea level.

For the modelling of the buildings the TRNSYS program was used (Klein et al., 1996). TRNSYS runs through hourly values of various weather parameters included in a typical meteorological year (TMY) file or data generated within the program by a special routine (Type 54) estimated from mean monthly weather data. The results thus obtained can be used to determine the hourly load of buildings throughout the year and the annual energy use and the maximum load for equipment selection.

Description of buildings

TRNSYS model 19 is used in order to simulate the temperature variation observed within a model house. The model house illustrated in Figure 1 has a floor area of 196 m^2 and consists of four identical external walls, 14 m long by 3 m high, with a total window opening of 5.2m^2 in each wall. The window area is approximately equal to the area that a typical house would have, but instead of considering a number of single windows on each wall, only one double glazed window is considered. The model house is further divided into four identical zones and the partition walls are considered as walls separating the four zones.

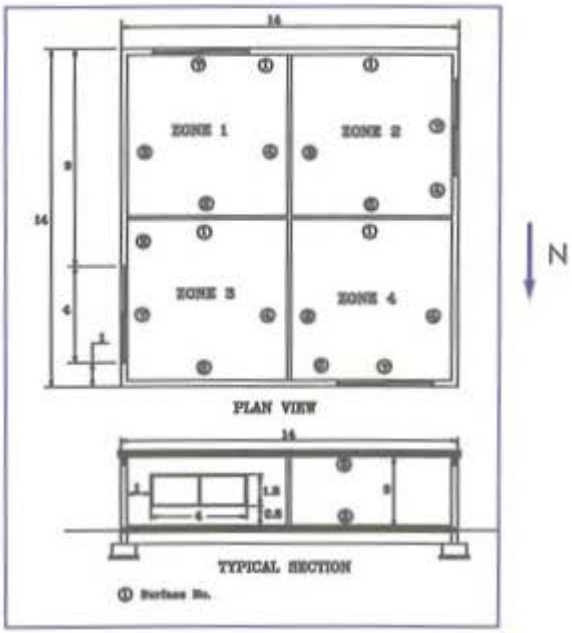

Fig.1 Model house.

Details of the input parameters required to model the typical house shown in Figure 2 are given in Florides et al. (2000). Three different construction cases are considered one with no insulation one with insulated roof and walls and one with light construction and insulation. Details of the construction cases are indicated in Table 6.

The loads of the above constructions are analysed in respect to the monthly cooling and heating loads for keeping the house temperature at 25°C during summer and 21°C during winter.

Weather data generator

TRNSYS Type 54 is the weather data generator. This component is used for the generation of hourly weather data when the monthly average values of solar radiation, humidity ratio and wind velocity are given. The aim, is to generate typical data for a single year similar to those of a Typical Meteorological Year. TRNSYS can then be used for load estimations for any location for which standard yearly average weather statistics are known.

Table 6. Details of the construction cases.

Case	Wall type	Roof type
A	Single wall, hollow brick 0.2 m and 0.02 m and plaster on each side	Flat non-insulated roof, constructed from fair-faced 0.15 m heavy- weight concrete
B	Double-wall, 0.1 m hollow brick, 0.02 m plaster on each side and a layer of 0.05 m polystyrene insulation in between	Flat insulated roof, fair-faced 0.15 m heavy weight concrete, 0.05 m polystyrene insulation, 0.07 m screed and 0.004 m asphalt covered with aluminum paint of 0.55 solar absorptivity
c	0.1 m face brick, 0.1m insulation, 0.025 m wood	Clay tile, 0.01 m felt and membrane, 0.1 m insulation and 0.025 m wood

Type 54 component requires a data file with the monthly average radiation, humidity and temperature values. It is possible within TRNSYS to add new data for specific locations. Any number of locations can be entered into the data file.

Radiation is often described as a dimensionless form called the clearness index, which is the ratio of the total radiation on a horizontal surface to the extraterrestrial global solar radiation on a horizontal surface at the same time. The instantaneous values can be integrated into any time period. Hourly values of clearness index for each day of the month are calculated from the daily clearness index cumulative distribution function. A correlation is used to approximate the distribution as a function of the monthly clearness index. To determine the order in which the days should occur a sequence is used by assigning integers 1 to 31 to the 31 daily clearness index values obtained from the distribution. The sequence consists of the integers 1 to 31, ordered such that when the daily clearness index values corresponding to the integers are placed in that order, the appropriate daily clearness index autocorrelation is reproduced. A similar process is used for the other weather variables. More details of the weather data generator model are given in Knight et al. (1991).

Other additional parameters required by the Type 54 model are the hourly radiation correction which is suitable for systems non-sensitive to hourly autocorrelation of radiation data. When the radiation values are summed, the daily total of the generated radiation is not necessarily equal to the "target" daily radiation value. Over a month, these discrepancies tend to average out.

For the temperature a stochastic model is used in which the hourly values are determined from a second order autoregressive model. In this model 24 hourly monthly-average dry bulb temperature values are computed, and the hourly deviations from these average values are then calculated with a Second Order Autoregressive Model (SOAM). The coefficients in the SOAM have constant values. To ensure the correct monthly-average dry bulb temperature value, the entire month's hourly values are generated on the first hour of the month. A month average value is computed from the hourly values and compared to the input monthly-average value; the hourly values are then adjusted by adding the difference to each hourly temperature. This model represents better the hourly autocorrelation structure of the dry bulb temperatures; however, it does not always generate temperature data with correct daily autocorrelation and daily distribution.

The relative humidity model is actually a dewpoint temperature model. The input humidity ratios are converted to monthly average dewpoint temperatures. Daily-average dewpoint temperatures are obtained from a normal distribution and ordered according to a "sequence". A special algorithm is used to determine the dewpoint depressions at the hours corresponding to the maximum and minimum dry bulb temperature each day. Hourly dewpoint depressions are computed by linearly interpolating between the dewpoint depressions at the minimum and maximum dry bulb temperatures. Dewpoint temperatures and relative humidities are calculated from the dewpoint depressions (Degelman, 1976).

Results and Discussion

Simulation results for the three construction cases of the houses considered are given in this section. Initially the load estimated by running TRNSYS with the TMY data and Type 54 generated data from mean weather conditions (Table 1) is compared.

A comparison between the results obtained by running TRNSYS with TMY and hourly values generated with Type 54 from mean monthly data obtained from the TMY file (Table 2), for the annual cooling and heating loads is shown in Tables 7 and 8 respectively. As can be seen the bigger differences occur for the annual heating load. The loads obtained from the Type 54 are greater than the TMY estimated ones whereas the difference of the cooling loads is smaller.

Table 7. Comparison between TMY and Type 54-generated data from TMY for the annual cooling load (kWh)

Weather file used	Case A	Case B	Case C
TMY 54-TMY	42398 42208	21732 20840	21058 20151
Absolute difference % difference	190 -0.45	892 -4.1	907 -4.3

Table 8. Comparison between TMY and Type 54-generated data from TMY for the annual heating load (kWh)

Weather file used	Case A	Case B	Case C
TMY 54-TMY	16012 17485	3480 4303	2880 3671
Absolute difference % difference	1473 9.2	823 23.6	791 27.5

The greater percentage differences observed in the case of the heating load is due to the relatively small numbers that are compared. This can be seen from the values of the absolute differences which are similar in most cases but give much smaller percentage difference in the case of the cooling load.

A similar comparison for the TMY data and Type 54 generated data from mean values obtained from the meteorological service (shown in Table 1) for the two cases is shown in Tables 9 and 10.

The percentage differences presented in Tables 9 and 10 are similar, or even better, to the percentage differences given between the TMY and the Type 54 generated weather data obtained from the TMY hourly values, presented in Tables 7 and 8. The above analysis proves the adequacy of the weather data produced by the Type 54 Weather Data Generator. It can therefore be concluded that the Type54-generated weather data can be used with a degree of confidence to estimate the thermal loads of buildings in the other three locations where TMY data are not available.

Table 9. Comparison between TMY and Type 54-generated data for the annual cooling load (kWh)

Weather file used	Case A	Case B	Case C
TMY 54-Nicosia	42398 41654	21732 21764	21058 21216
Absolute difference % difference	744 -1.8	32 -0.15	158 -0.75

Table 10. Comparison between TMY and Type 54-generated data for the annual heating load (kWh)

Weather file used	Case A	Case B	Case C
TMY 54-Nicosia	16012 16382	3480 3876	2880 3362
Absolute difference % difference	370 2.3	396 11.4	482 16.7

The annual results for Nicosia and the other three locations considered using Type 54 generated data from mean monthly values obtained from the meteorological service are shown in Table 11. As can be seen in the mountainous locations (Prodromos) the need for cooling is less than half than the rest of the locations considered. All the other three locations, lowland (Nicosia), coastal (Polis) and semi-mountainous (Saitas) have very similar cooling requirements with the actual load decreasing with altitude. The reverse is true for the heating load where the lowland and coastal areas benefit from a very mild climate whereas the heating requirement in the mountains is more than three times that of the coastal and lowland locations.

Insulation also plays a major role in the loads of buildings and its effect can be evaluated from the results presented in Table 11. As can be seen the insulated (Case B) and light construction (Case C) houses have very similar loads and are much lower than the non-insulated house (Case A). Insulation is important in all locations considered especially for the summer time in lowland and coastal locations and for wintertime in semi-mountainous and mountainous locations.

A monthly analysis of the cooling and heating loads estimated with Type 54, for the four locations is shown in Table 12 and 13 for the building cases A and B respectively. The respective loads for the building case C is very similar to those of case B and therefore are not presented here.

Table 11. Annual thermal loads obtained from simulations

Location	Cooling loads (kWh)			Heating loads (kWh)		
	Case A	Case B	Case C	Case A	Case B	Case C
Nicosia	41654	21764	21216	16382	3876	3362
Poli	41735	20071	19511	13292	2655	2386
Saitas	40714	16887	15770	22177	6288	5160
Prodromos	20879	7439	7508	47144	16428	13505

Table 12 Monthly cooling loads in kWh for the building cases A and B erected in the three locations considered.

Month	Nicosia-A	Nicosia-B	Polis-A	Polis-B	Saitas-B	Saitas-B	Prodromos-A	Prodromos-B
JAN	4539	1436	3717	1089	2074	2074	10070	4041
FEB	3500	941.9	2751	614.9	1524	1524	8855	3528
MAR	2157	302.6	1832	199.2	712.6	712.6	6765	2479
APR	631.6	13.6	675.7	19.5	104.8	104.8	2954	821.3
MAY	73.2	0	98.4	0	74.3	74.3	1141	98.2
JUN	23.9	0	55.6	0	0	0	598.5	108.8
JUL	0	0	0	0	0	0	4.4	0.3
AUG	0	0	0	0	0	0	47.5	0
SEP	12.1	0	17.7	0	0	0	402.0	12
OCT	41.7	44.7	36.7	0	2.4	2.4	1948	240.5
NOV	1631	192.2	1170	80	350.1	350.1	5467	1773
DEC	3772	989.3	2939	652.3	1520	1520	8890	3326
Year	16382	3876	13292	2655	6288	6288	47144	16428

Table 12 Monthly cooling loads in kWh for the building cases A and B erected in the three locations considered.

Month	Nicosia-A	Nicosia-B	Polis-A	Polis-B	Saitas-A	Saitas-B	Prodromos-A	Prodromos-B
JAN	4539	1436	3717	1089	5961	2074	10070	4041
FEB	3500	941.9	2751	614.9	4681	1524	8855	3528
MAR	2157	302.6	1832	199.2	3101	712.6	6765	2479
APR	631.6	13.6	675.7	19.5	1078	104.8	2954	821.3
MAY	73.2	0	98.4	0	109	74.3	1141	98.2
JUN	23.9	0	55.6	0	66.2	0	598.5	108.8
JUL	0	0	0	0	0	0	4.4	0.3
AUG	0	0	0	0	0	0	47.5	0
SEP	12.1	0	17.7	0	45.5	0	402.0	12
OCT	41.7	44.7	36.7	0	80.5	2.4	1948	240.5
NOV	1631	192.2	1170	80	2066	350.1	5467	1773
DEC	3772	989.3	2939	652.3	4991	1520	8890	3326
Year	16382	3876	13292	2655	22177	6288	47144	16428

It should be noted that the program counts loads when the temperature in summer is above 25°C and below 21°C in winter. This is the reason that in some months very small loads are presented. These are not actual loads as they occur at very small time intervals during which the occupants of a building do not actually use mechanical heating or cooling. They are preserved however in the tables in order to have agreement with the total loads.

Some very important conclusions can be drawn from the monthly data presented in Tables 12 and 13. The higher cooling load occurs during the month of July, which is the hotter month of the year and the higher heating load occurs in January, which is the colder month of the year. The monthly cooling loads in the three locations, lowland, coastal and semi-mountainous are very similar whereas the respective ones for the mountain location is considerably reduced. Similarly, the monthly heating loads in lowland and coastal locations are very similar whereas the heating load requirements increase with the elevation of a location. From the monthly loads the advantage of insulation of buildings is also clearly shown.

Conclusions

The data presented refer to the simulated results obtained for the three cases of buildings considered by using the mean monthly weather data for the four distinct locations considered. The following conclusions can be derived from this work:

1. In the mountainous locations (Prodromos) the need for cooling is less than half than that of the rest of the locations considered.

2. All the other three locations, lowland (Nicosia), coastal (Polis) and semi-mountainous (Saitas) have very similar cooling requirements with the actual load decreasing slightly with altitude.

3. The heating load of the buildings in the various locations has great differences. This is due to the fact that in lowland and coastal areas there is a very mild climate whereas the heating requirement in the mountains is more than three times that of the coastal and lowland locations.

4. The maximum monthly cooling load occurs during the month of July, which is the hottest month of the year and the maximum heating load occurs in January, which is the coldest month of the year.

5. The monthly cooling loads in the three locations, lowland, coastal and semi-mountainous are very similar whereas the respective ones for the mountainous location is much more reduced.

6. The monthly heating loads in lowland and coastal locations are very similar whereas the heating loads increase with the elevation of the location.

7. Insulation is important in all locations considered especially for the summer time in lowland and coastal locations and winter time in semi-mountainous and mountainous locations. As can be seen from the results presented here the insulated (Case B) and light construction (Case C) houses have very similar loads which are much lower than those of the non-insulated house (Case A). The advantage of using insulation in buildings is also clearly shown from the monthly loads.

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