

# Sustainability Dimensions

Annual Report of the Laboratory of Heat Transfer and Environmental Engineering - Mechanical Engineering Department, Aristotle University Thessaloniki, Greece

# 2005

The Laboratory of Heat Transfer and Environmental Engineering belongs to the Energy Section of the Mechanical Engineering Department of the Aristotle University Thessaloniki, Greece. The Laboratory is responsible for eleven pre-graduate courses in the Mechanical Engineering Department, while also supervising 24 doctoral candidates in the frame of their post-graduate studies. Furthermore, it has a long record of research and consulting activities, both at national and international level. The staff of the Laboratory includes 5 senior scientists, 27 young researchers and 7 technical and administrative members. Most of the research funds of the Laboratory originate from competitive programmes of the European Commission, although 2005 we received also substantial grants from national funding agencies. In the last years, the total annual turnover of the Laboratory has been of the order of 1 million €.

As in previous years, also 2005 our Laboratory has been quite successful regarding research conducted and services provided. Seven new projects were launched during this year, and a large number of new tasks were initiated in the frame of our long-term involvement in various networks and actions. Examples for the latter are five different COST actions, in which we play a major role, and the Initiative for Harmonisation in the use of Atmospheric Dispersion Models for Regulatory Purposes. The most challenging network to which we contribute is ACCENT, the European Network of Excellence on Atmospheric Composition Change.

An important milestone for us in 2005 was the preparation of the report “Air Pollution at Street Level in European Cities”, which will soon appear as a Technical Report of the European Environment Agency. In the context of the EU “Clean Air For Europe” programme, this report summarises the current situation and the expected future development of air quality in urban hotspots. The results presented may prove useful in identifying which local emission reductions are needed in streets in order to reach certain air quality thresholds.

Our numerous research collaborations force us to travel quite frequently for participating at various workshops

and meetings. In addition, we are hosting on a regular basis project meetings and other events in various places in Greece. Although several important events took place in 2005, the one that deserves to be mentioned in this context is the Air4EU project meeting in Athens (Air4EU is a STREP within EU’s 6<sup>th</sup> Framework Programme). This meeting was combined with the Workshop on Air Quality Assessment for Europe – From Local to Continental Scale. The workshop was held on 29 June under the auspices of the Mayor of Athens Mrs. Dora Bakoyanni. It brought together leading European researchers and stakeholders to discuss practical recommendations on integrated air quality assessment.

It is no exaggeration to say that 2005 has been the year of various celebrations, the most important one being associated with the 50<sup>th</sup> anniversary since the foundation of Aristotle University’s School of Engineering. Among other events for commemorating this anniversary, the Department of Mechanical Engineering organised a ceremony for presenting its achievements in the first three decades of its lifetime. While maintaining high standards in teaching and mentoring, we consider our research skills to be our main strength: Although small in size (32 faculty members), our Department ranks first in our University with regard to international research funding sought in the period 2002-2004 (more than 20% of the entire University).

As another reason for us to celebrate, fifteen years were completed in 2005 since the foundation of our Laboratory. Two important developments coincide with this anniversary: Firstly, it is likely that some of our (current or former) co-workers will soon be employed in permanent positions in our University. Secondly, by the end of the year our Laboratory will have obtained officially the certificate for implementation of ISO 9001-2000. We consider the latter as a confirmation for our devotion to quality and our wish to enforce, strive and ensure constant satisfaction of our partners in research, training and education.

Prof. Dr. Nicolas Moussiopoulos  
Laboratory Director

## Energy and Indoor Environmental Evaluation of the Buildings of the German School of Athens

Schools, especially older ones, are buildings with low energy performance, this resulting in a high energy consumption. Also because of the fact that the vast majority of the people inside the school buildings are children, it is quite important to retain high levels of thermal comfort and indoor air quality. In that sense, indoor environmental quality is a dominant feature that has to be combined with energy conservation.

The objective of the project co-ordinated by our Laboratory is to conduct an energy and IEQ audit of the buildings of the German School of Athens in order to determine and evaluate the conditions prevailing in the building, to run building simulations, so as to suggest measures for rational use of energy, in order to increase the energy efficiency of the buildings, whilst improving IEQ conditions.

After the completion of the energy audit, the heating and cooling loads of the buildings were calculated using building simulation software. This led to the proper dimensioning and re-design of the various HVAC systems. The capital and operational costs for upgrading the buildings' systems are based on their required performance and on the necessity to take account of the energy consumption of each one of the complex's buildings. The implementation of innovative HVAC systems and systems that can use renewable energy sources, like thermal solar systems, evaporative cooling solutions or shallow-depth geothermal applications were also thoroughly examined. The final step of this project is a feasibility study, which will allow the selection of the most appropriate system based on their economic expediency.

The most suitable system to accommodate the remaining loads was found to be a Ground Source Heat Pump (GSHP). The reasons why this is an excellent solution for the GSA are:

1. The remaining thermal loads occur at medium temperatures.
2. The available area at the adjacent sports field is large enough for the installation of the required piping.
3. A GSHP can be used for space heating and cooling and additionally for the production of hot water.
4. The ground temperatures in the area of Athens are favorable for the use of such technology.

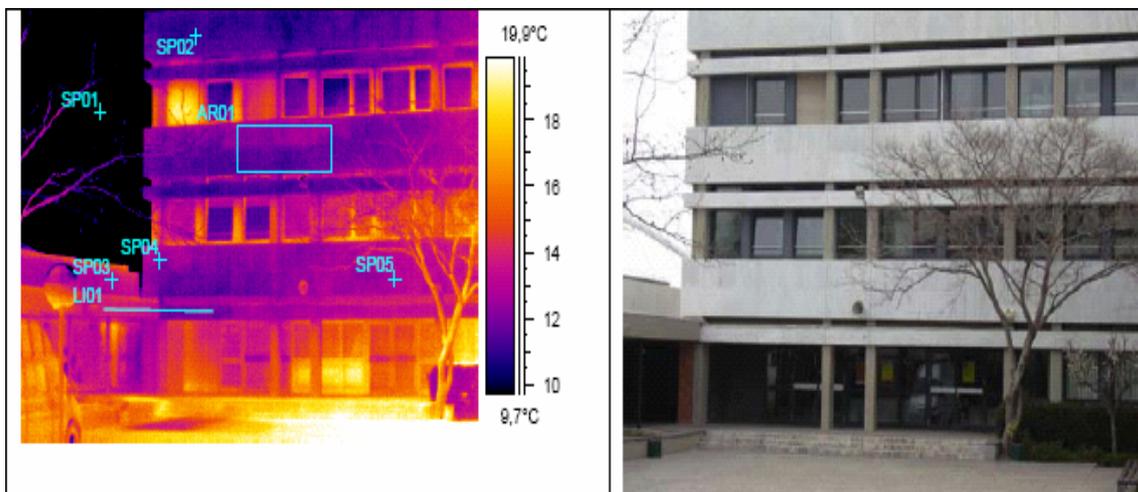
The already installed photovoltaic systems can produce a significant part of the electricity that will be consumed for the GSHP allowing certain energy autonomy in the GSA.

Another intervention on the energy systems of the GSA concerns the change of end use for the already installed thermal solar collectors. It is proposed to use the solar collectors for covering the swimming pool heating loads rather than those related to the hot water production. That is because the pool temperature is much lower than that of hot water; hence, the collector efficiency will significantly increase producing more thermal energy and saving more than 10 m<sup>3</sup> of diesel.

Finally, a bouquet of secondary measures was proposed for rationalizing the energy balance at the GSA, including (i) the connection of the GSA to the natural gas network, (ii) the increase of the thermal solar collector surface and (iii) the retrospective reinforcement of the insulation at the roof of the Swimming Pool building. The latter intervention would lead to a energy consumption reduction by 24%.

Project funded by the German School of Athens (2005). Major Partner: University of Athens.

Contact: Assoc.Professor A.M.Papadopoulos, agis@eng.auth.gr



*Thermal image of the building's facade, indicating a uniform behaviour*

## Urban Air Quality in EEA's State of the Environment and Outlook Report 2005

The European Topic Centre on Air and Climate Change (ETC/ACC) provided support to the European Environment Agency in the production of sub-reports 6 and 7 of the State of the Environment and Outlook Report 2005. Through its participation in the ETC/ACC, our Laboratory's contribution consisted of a set of air quality reference year and scenario calculations for 20 urban areas across Europe, for the pollutants PM<sub>2.5</sub>, PM<sub>10</sub>, NO<sub>2</sub> and O<sub>3</sub>. Details of all model results are presented in the ETC/ACC Technical Paper 2005/2, version June 2005.

The two scenarios studied were variants of the Low Greenhouse gas Emissions Pathways (LGEP) scenario on alternative emission control policies, referred to as LGEP-CLE and LGEP-MFR scenarios:

- the "current legislation" (**CLE**) scenario, where emission control policies according to the current legislation that have been implemented (or are in the pipeline) until the end of 2003 in each country are considered and
- the "maximum feasible reductions" (**MFR**) where the effects of implementing in each economic sector the presently available most advanced technical emission control measures are considered, but no premature retirement of existing equipment before the end of its lifetime was assumed.

The study focused on 20 urban areas across Europe, which varied in size, specific characteristics and geographical location, for covering as many different situations as possible: Antwerp, Athens, Barcelona, Berlin, Brussels, Budapest, Copenhagen, Gdansk, Graz, Helsinki, Katowice, Lisbon, London, Luxembourg, Marseille, Milan, Paris, Prague, Rome, Stuttgart and Thessaloniki.

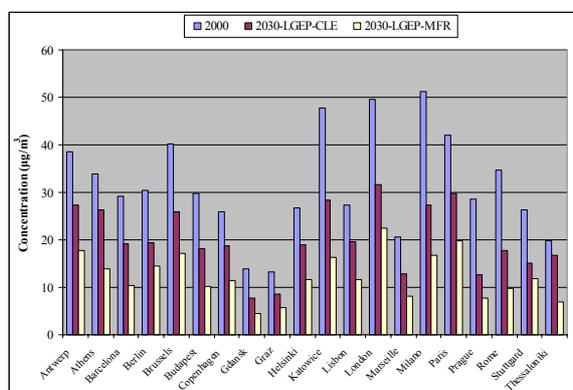
An important aspect of the scenario work performed within the State of the Environment and Outlook Report

was to ensure consistency between the model assumptions and results. Consistency between the scenario assumptions at the regional and the urban scale was ensured through the application of an air quality model cascade approach, where the boundary conditions required by the urban scale OFIS model were obtained from the regional scale model (EMEP). As a further step and for studying local air quality, the OSPM model was applied using urban background air quality concentration results from OFIS. Country scale emission reductions per SNAP category (CORINAIR) per pollutant for both LGEP-CLE and LGEP-MFR scenarios were assumed to apply at urban scale and the resulting attenuation factors were applied to the gridded urban emission inventories. In order to evaluate the influence of meteorology on the actual concentrations at urban scale, two meteorological conditions were studied. The year 1997 was assumed to represent average meteorology observed in the '90s, whereas the year 2003 was assumed to represent more 'extreme' conditions observed in recent years.

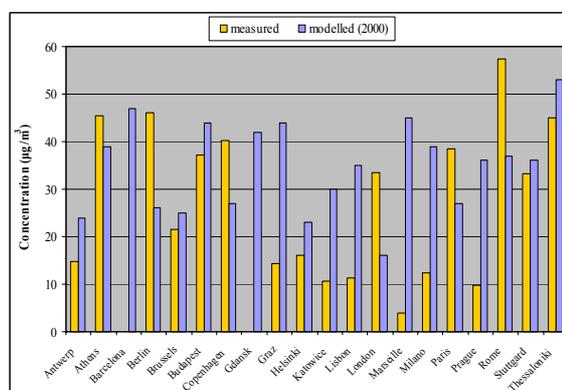
The concentrations measured at urban traffic stations across Europe are higher than those at urban background stations, due to the increased local emissions from road traffic. In order to study this particular type of urban hotspots, the street increments (difference between the street and the urban background concentrations) for NO<sub>2</sub>, PM<sub>10</sub> and PM<sub>2.5</sub> were calculated with the OSPM model for a narrow canyon configuration with a traffic volume of 20 000 vehicles per day. The street orientation was assumed to be East to West and the streets were assumed to be centrally located. The fleet composition for each city was obtained from the TRENDS and TREMOVE models and the emissions were calculated using the COPERT 3 model.

Project funded by the European Environment Agency. Major Partners: RIVM, The Netherlands, Norwegian Meteorological Institute, Norway, IIASA, Austria, JRC, Italy, AEAT, UK.

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Trend annual average NO<sub>2</sub> concentration in European cities 2000-2030



Mean annual NO<sub>2</sub> street increments (µg/m<sup>3</sup>) in 20 European cities: OSPM model results compared with observations.

## Quantitative Evaluation of Thermal Pollution due to the Operation of the Planned Power Plant in the ‘Hellenic Petroleum’ Refinery (Thessaloniki)

The main objective of the project was to investigate the impact to the climatological conditions from the thermal pollution caused by the planned operation of a power plant unit inside the industrial installations of the refinery corporation ‘Hellenic Petroleum’ (ELPE) in the west Thessaloniki Area.

In order to draw reliable conclusions, two different approaches were followed:

- According to a standard method used in Environmental Assessment Studies, the dispersion of the plumes around the studied area was described with the analytical relations of the S/P model, as it was prescribed in the Directive 3784/2 of the Technical Chamber of Germany (VDI 3784/Blatt 2, March 1990).
- Moreover, calculations were made using MEMO, a prognostic mesoscale model which allows describing the air motion and the dispersion of inert pollutants over complex terrain, suitable for air pollution problems at a regional scale.

At the power plant under construction, flue gas will be discharged into the atmosphere through a 40m chimney, while a cooling tower is foreseen for the rejection of waste heat (estimated at around 226 MW). Based on various operational details, the heat flux emitted to the atmosphere through the flue gas was calculated at 70 MW, under the most unfavourable conditions (use of diesel, ground temperature 0°C). Therefore, the total rejected heat amounts to 300 MW.

The possible negative effects of rejected waste heat in the atmosphere were the key research topic of the ‘German Waste Heat Commission’ for the last 20 years. The Commission especially dealt with the thermal pollution issues and its potential impacts to climatological conditions in the vicinity of the plant. In particular, the outcomes of various inventory projects as well as other research activities were assessed and included in the final report of the Commission.

The Commission suggests that the diffusion of heat to the atmosphere may affect the climate only in case that the total emitted heat load exceeds the limit of 10 000 MW. Under such conditions clouds could be formed, leading to additional precipitation that can manifest as

thunderstorms, especially under unstable atmospheric conditions.

Meanwhile, the Commission strongly supports that the abovementioned phenomena cannot occur in situations when the total eliminated heat is below 5000 MW. Excess fog can probably result in situations of lower levels of eliminated heat, though within short distance from the point source (few hundred meters). The latter holds also in cases of homogenous orography (e.g. heat dispersion in plain grounds).

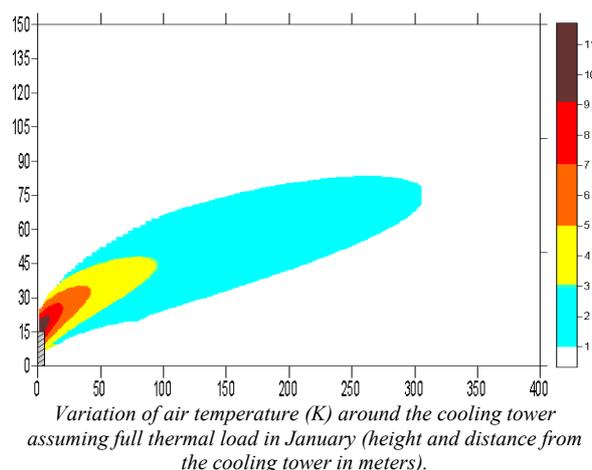
Taking those findings under consideration in the framework of this project, it was concluded that negative impacts to the climatology caused by the heat diffusion via the cooling tower and the chimney are almost insignificant, given that the total thermal load is under the limit of 300 MW, and at the same time the regional orography lacks any kind of peculiarity.

The final project results can be summarised as follows:

- The waste heat rejected from both the cooling tower and the chimney seems not having considerable effects on the thermal characteristics of the surrounding atmosphere.
- The heat rejection does neither have a significant effect on the naturally occurring energy fluxes, nor to the ground temperature of the whole area of the ELPE installations. Consequently, it can be stated that there is no distortion of the climatic characteristics of the region.

Project funded by Paraskevopoulos-Georgiadis Ltd.

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## Development of Action Plans for Abating Air Pollution in Athens and Patra

EU air quality limit values are being regularly exceeded in several large Greek cities. One year before the 2004 Olympic Games, the Hellenic Ministry for the Environment launched a series of studies aiming to analyse the situation in the cities hosting Olympic events, the objective being to develop action plans for improving air quality in order to comply with the current EU legislation. Our Laboratory was involved in the studies associated with Athens and Patra.

The analysis for all cities should address:

- The definition of specific actions (projects, activities, measures) for controlling air pollution sources, improving the city functional operation and shaping the urban environment, according to the present and future (2005, 2010) EU Directives about air quality.
- The efficient implementation and management of the above actions.
- The development of strategies that can be used as guidelines for the authorities for taking decisions on 'emergency actions', such as restrictions on traffic, industrial units or other urban activities, during episodes of high air pollution levels.

Thus, the suggested action plans would eventually contribute to reducing air pollution concentrations to levels in compliance with limit values.

For meeting the study objectives, the following actions were performed:

- The current air quality situation in each study area was described.
- Air pollution levels were evaluated in accordance to the relevant legislation taking into account structural, traffic related and other interventions in the area.
- Formulation of realistic and attainable suggestions, on the basis of achievable environmental goals at the anticipated time periods, combined with working plans, implementation costs and implementation and validation procedures.

The study requirements were approached through: a) the development of several alternative solutions and the hierarchy according to their efficacy, b) the selection of the optimum solution(s) and the evaluation of the cost-benefit relation, c) application and evaluation of the optional solution.

Suitable model tools were implemented, aiming at

- assessing urban air quality and its dependence on the various air pollution sources in the study area,
- estimating emissions for all pollution sources, putting emphasis on road traffic emissions and their relation to traffic load and vehicle speed,
- defining traffic data (loads, velocity etc.), also in relation to possible interventions to the city function,
- prioritizing intervention scenarios studied.

Four scenarios were investigated, including:

- the baseline scenario describing the 'current' air quality situation resulting from all emission sources in the reference year (2002),
- reference scenarios (business as usual) taking into account the EU legislative framework, as well as foreseeable trends, such as the increase in the number of cars, the penetration of natural gas etc.
- alternative (mitigation) scenarios describing recommended solutions for the mitigation of high air pollutant concentrations during periods of limit value exceedances,
- 'divergence' scenarios (diverging from the reference scenarios): in cases that substantial actions are not completed on time.

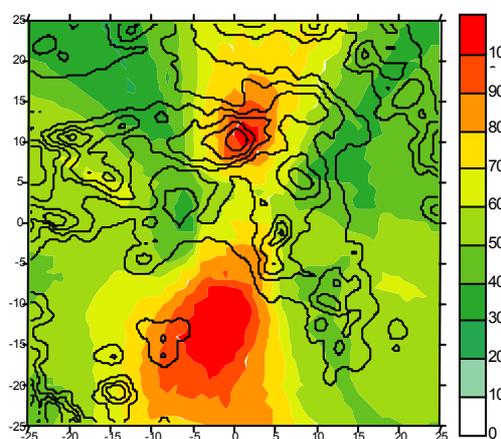
Overall research issues under investigation were:

- air quality issues, origin and sources of air pollution, computational models and evaluation tools,
- transportation and traffic issues, urban traffic management,
- legislation issues,
- economic issues,
- physical planning and development related issues,
- industrial emission issues,
- development of a decision support system,
- assessment of social effects.

The contribution of our Laboratory was focused on evaluating the contribution of several sources to air pollution and on identifying the effect of interventions on air pollution abatement, based on major findings of the model simulations. Moreover, the Laboratory assessed alternative solutions/scenarios, as well as the feasibility of the suggested measures and actions, so as the goals of the project to be achieved.

Project funded by Hellenic Ministry for the Environment, Physical Planning & Public Works. Major Partners: *Athens* ENVECO S.A., Athens, Greece, EPEM S.A., Athens Greece; *Patra* ADK S.A., Athens, Greece.

Contact: Prof. Nicolas Moussiopoulos, moussio@eng.auth.gr



Number of days with the O<sub>3</sub> 8hr moving average in the Great Athens Area exceeding the EU limit value

## Integrated Methodology for Monitoring, Decommission, Sanitation and Restoration of Uncontrolled Sites for Solid Waste Disposal - IDRUS

Solid waste management has become a major subject of environmental planning in Greece, presenting at the same time a complex combination of various administrative scenarios. Furthermore, the location of related facilities has evolved into a dominant issue for the treatment and final disposal of wastes.

In this framework, the existence and operation of uncontrolled waste disposal sites introduce a particularly acute problem that needs direct and profound confrontation. Such sites pose significant environmental threat in the following ways:

- Pollution of underground waters.
- Pollution of wetlands.
- Air pollution and odors.
- Open combustion of wastes.

The overall aim of the project is the development of an integrated methodology for the monitoring, reclamation, rehabilitation, restoration and remediation of uncontrolled waste disposal sites in the framework of an integrated waste management system. In this context, the following objectives have been shaped:

- Formulation of an integrated framework of evaluation of alternative solutions in regard to relative administrative strategies.
- Optimization of the management of the selected monitoring and restoration plan.
- Planning and development of a geographic database and a flexible and efficient monitoring framework.

- Estimation of environmental, economic and sociopolitical consequences and impacts.
- Development of a functional and practical guidebook for municipalities and communities.

The environmental consequences caused by the operation of uncontrolled waste disposal sites are being evaluated by calculating the toxic emissions in the air, soil and water. Apart from consulting the existing literature, sampling and the assessment of dangerous and toxic substances has also taken place in the waste disposal site of Chalastra (near Thessaloniki), providing field information on openly dumping wastes. The collected data is being used for the estimation of air pollution and the consequences of open dumping in the environment and public health. The above results are then used as input for the development of a model system, providing functions for the estimation of environmental impacts and the evaluation of different management and aftercare scenarios of uncontrolled waste disposal sites. Administrative plans for the remediation and rehabilitation of greater downgraded regions because of the existence of uncontrolled waste disposal sites are also studied. The development of alternative restoration plans will contribute significantly to solving the problem. Multi-criteria analysis tools in the frame of rationalized and integrated waste management will allow evaluating the plans.

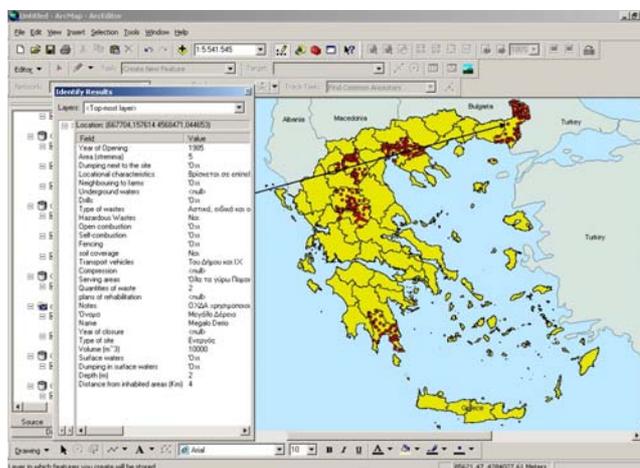
The final outcome from the implementation of the objective and the achievement of the individual targets of the project will be the significant facilitation of decision-making process in regard to the subjects that are related to the uncontrolled waste disposal sites.

Project funded by Ministry of Education, Pythagoras programme (2004-2006). Major Partners: Department of Chemistry, Aristotle University Thessaloniki, Technological Educational Institute of West Macedonia.

Contact: Ass. Prof. Avraam Karagiannidis, akarag@auth.gr



Uncontrolled waste disposal site



Geographic database of waste disposal sites

## Development of Practice Oriented Guidelines for the Preparation of Feasibility Studies on the Production of Renewable Energy from Organic Waste and Biomass by Biogas Plants and Biomass Combustion Plants, with an Applied Example for Phu Quoc/S.R.Vietnam - RENEW

The objective of this project is to develop practice oriented guidelines for the preparation of integrated feasibility studies on the generation of renewable energy in ASEAN countries, and the development of an applied example for Phu Quoc/S.R.Vietnam. The main activities are the development of guidelines, including development of methodologies and tools, and the preparation of the feasibility study for Phu Quoc, including inventory, risk assessment, comparison of options and recommendations.

The guidelines are produced to facilitate the development of cost-efficient and goal oriented feasibility studies considering technical, economical, environmental, social and legislative aspects, for the production of renewable energy from organic substrates by biogas or biomass combustion processes. The guidelines will specifically aim at feasibility studies in ASEAN countries.

Overall Objectives of the RENEW project are:

- to support the export of European products and services of the renewable energy sector into the ASEAN market,
- to promote the installation of a renewable energy facility on Phu Quoc,
- to contribute to the cooperation between countries of the European Union and ASEAN member countries by transfer and exchange of knowledge and know-how in the field of renewable energy,

- to promote the ASEAN Plan of Action for Energy cooperation 1999-2004,
- to promote environmental protection at global level by supporting the implementation of renewable energy solutions,
- to promote the reduction of pollution at local level by supporting the implementation of renewable energy solutions.

Methodologies and tools which can be applied for the preparation of feasibility studies are developed or compiled. All relevant aspects are covered: data collection (how and where to collect data and what data are required), selection of sites and options, and how to assess the feasibility of options. A practical plan of procedures is produced which guides the user through a feasibility study. A detailed inventory of the quality and quantity of substrates, which are available for the generation of renewable energy is created, while data for the simplified Life Cycle Analysis of the options considered are gathered. The feasibility study includes economic issues as well as global and local environmental impact assessment. Furthermore legislative aspects are evaluated. A major element of the feasibility study is the assessment of risks which comprise of hard components (physical, technical) and soft components (environmental, social, political). A final weighing of all accumulated data will be done in conjunction with the decision-makers and stakeholders linked with the project.

The project is implemented by a consortium of five partners. Data and information are compiled from desk studies, site visits, dedicated surveys and own evaluation of experiences. The end product will be written guidelines for feasibility studies and the case study will be analysed in a comprehensive report.

Project funded by EC-ASEAN Energy Facility. Major Partners: Institute for Recycling and Environmental Protection, Germany; Dresden University of Technology, Germany; University of Can Tho, Vietnam; Institute of Energy, Vietnam.

Contact: Ass. Prof. Avraam Karagiannidis, akarag@auth.gr



*Diesel generator currently used for energy generation.*



*Closed tunnel reactors for dry fermentation.*

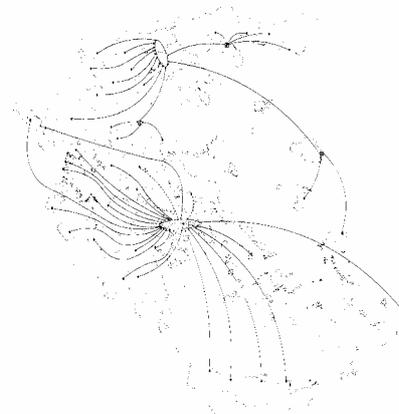
## Cost Analysis of the Management of Electrical and Electronic Products at the End of Their Useful Life

Electrical and electronic equipment (EEE) consist of many high-value materials, some of which present toxic impacts for human receptors. For these reasons the environmentally sound management of waste electrical and electronic equipment (WEEE) should be of top priority for every community. Additionally, WEEE represent a constantly increasing component of the total volume of municipal solid waste, which makes their management exigent. The recent Presidential Decree 117/04 regarding the alternative management of WEEE highlights the problem in the most urgent way. Our Laboratory was contracted to develop the alternative WEEE management system for Greece.

One of the most important prerequisites for the successful enforcement of an administrative system for the alternative management of WEEE is cost analysis of its operation phase. We selected the following approach for the cost analysis of WEEE management:

- Collection of input data, concerning the volume of WEEE per equipment category and its geographical distribution (volume of WEEE per region).
- Determination of the administrative system's philosophy.
- Analysis of all cost elements for the management of WEEE.
- Assessment of the cash flow and the cost elements per equipment category.
- Estimation of the total operational cost for the administrative system.

For the study's needs EEE are divided into seven product categories; large household appliances, freezing & refrigerating equipment, lighting equipment, IT equipment, CRTs, small household appliances, consumer equipment & other EEE.



Optimum siting of Intermediate Storage Centres

In the time that the WEEE reverse logistics network will be fully operational, WEEE is anticipated to be collected in Municipal Collection Points. Thereafter, WEEE will be transported either to Prefectural or Regional Intermediate Storage Centres. From there, WEEE will be delivered to Recycling Centres for further processing.

The operational cost elements were divided into nine discrete cost categories, which embody all the necessary activities for the system's successful operation. The cost structures defined by the research team were:

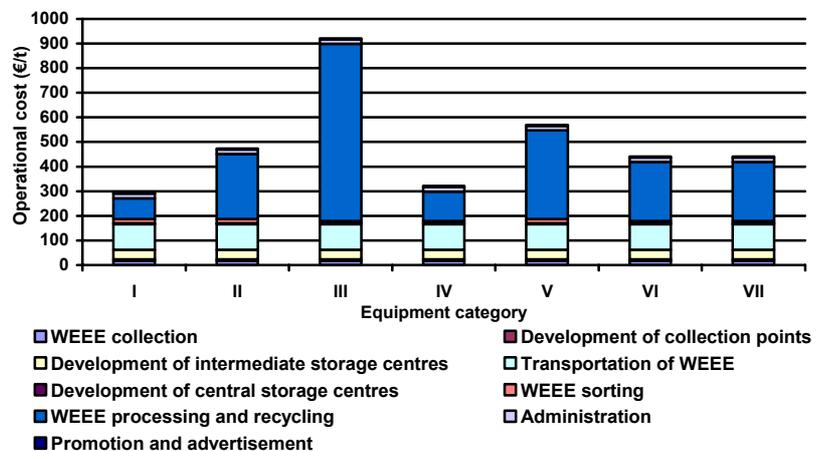
- WEEE collection from the end users of electrical and electronic products.
- Development of collection points.
- Development of intermediate storage centres.
- Transportation of WEEE.
- Development of central storage centres.
- Sorting of WEEE into the seven discrete categories.
- Processing and recycling of WEEE.
- Administration.
- Promotion and advertisement.

The optimised network consists of 1033 Municipal Collection Points (one in every municipality of Greece), 43 Prefectural Intermediate Storage Centres, 3 Regional Intermediate Storage Centres (in Kavala, Larisa and Mitilini) and 2 Recycling Centres (one in the Greater Athens area and the other in the Greater Thessaloniki area). The average cost for the management of electrical and electronic products at the end of their useful life is ranging from 380 €/t up to 431 €/t, depending on the volume of WEEE that will pass through the established network.

The scheme suggested is currently being implemented.

Project funded by "Recycling of Appliances S.A" (2004).

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Operational cost analysis per equipment category

## Technical and Economical Optimization of Industrial Application's Insulation

Insulation has been and still remains one of the fundamental tools for achieving energy conservation both in the buildings' and in the industrial sector. Scope of this study is to extract a completed tool that calculates insulation thickness and the replacement period of the insulating material, while some safety, environmental and operational restrictions are accomplished. Primarily, the available insulation materials are presented. Taking in notice the industrial insulation's requirements, stone wool seems to be the most appropriate insulating material that can be used in a big account of the industrial applications.

Furthermore, the interest is focused on the change of stone wool's thermal conductivity factor. A mathematical model based on relative heat transfer equations, is created. This model calculates the thermal conductivity as a function of temperature. The results are compared with experimental results of previous relative reports. The compared values are similar and therefore the created model is efficient.

Other parameters that affect thermal conductivity are discussed, such as moisture and physical damage due to material aging. For the first case, some suggestions present a calculation method that checks whether water vapour condensation is possible. For the case of physical damage, a model that calculates the change of thermal conductivity relatively to time, within a range of temperatures, is created.

The next step is to create mathematical models for some different cases of industrial applications that need insulation, which are:

- a) Hot liquid or steam networks
- b) Hot liquid storage tanks
- c) Furnaces – blast furnaces
- d) Cryogenic applications

In this study, models for the first three applications are developed. In cryogenic applications, vacuum spaces are used instead of insulation materials, because they are rather different from the other applications. This case is out of the scope of this study.

Firstly, a general mathematical model is created for calculating the general cost of insulations. Then, the specific methods that calculate the heat loss cost in each kind of installation are presented. The final step is to combine all the above mathematical models. After the combination, the mathematical model that describes the total insulation cost is created. Also, safety, environmental and process restrictions are taken into account. All the above consist of a linear programming problem, where the objective function represents the total insulation cost and it should be minimized.

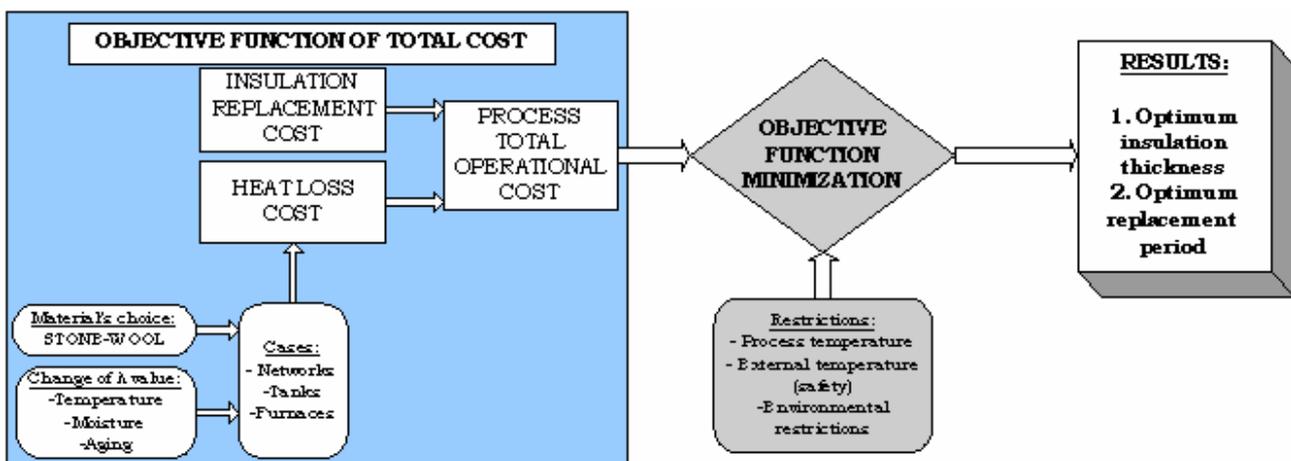
The points that make this study innovative are:

- Industrial insulation problems that are solved with analytical methods. Until today, experiential methods are used.
- Regulations related to safety and environment protection are taken into account.
- The mathematical model is flexible and it can receive new additions and updates, e.g. new safety or environmental regulations.

Finally, this study can be used as guideline for further research in the field of Industrial Insulations.

Project funded by Ministry of Education, Heraklitos programme (2004-2006).

Contact: Assoc. Professor A.M.Papadopoulos, agis@eng.auth.gr



Methodological approach of the optimisation scheme

## Research

### **Rural Advice and Support Units for R.E.S. in Heat Systems and Integrated Energy Management in Buildings (RURASU)**

*Objective:* To provide energy management, energy conservation consultancy and services in rural areas in order to reduce the heating demand in those areas with the use of Renewable Energy sources, systems and high quality materials.

*LHTEE Contribution:* Major subcontractor, HVAC systems study, design and feasibility of solar systems. Academic, supplemental and dissemination activities.

*Funded by:* CEC, ALTENER Programme (2005-2007).

### **Social and Professional Reinstatement of Handicapped People and Gypsies through Reuse and Recycling of Waste Electric and Electronic Equipment in Greece (PRUWE)**

*Objective:* Development of social services for WEEE reuse and recycling through the accession of handicapped people and gypsies in the corresponding market.

*LHTEE Contribution:* Participation and contribution in most workpackages.

*Funded by:* (EQUAL program), Hellenic Ministry of Employment and Social Protection (2005 – 2007).

### **Ecological and Aesthetical Rehabilitation of Inactive Mines and Quarries (ECOLAN)**

*Objective:* Ecological and aesthetical rehabilitation of inactive mines and quarries utilizing solid wastes from construction and demolition facilities, underbrush and woody plants.

*LHTEE Contribution:* Participation and contribution in most workpackages.

*Funded by:* Hellenic Ministry of Education, Pythagoras II programme (2005-2006).

### **Studying the Management of Wastes Generated in a Dental Unit (DAST)**

*Objective:* To inform and educate the students and the personnel of the School of Dentistry of Aristotle University of Thessaloniki on the environmental impacts of wastes generated by a dental unit. Furthermore, to design and plan a waste management system for the specific university dental unit. The final output will be a handbook concerning dental waste management.

*LHTEE Contribution:* Risk assessment, environmental impacts.

*Funded by:* Hellenic Ministry of Education, Pythagoras II programme (2005-2006).

### **Study of the Factors that affect Secondary Aerosol Formation in the Urban Environment**

*Objective:* The project aims at the investigation of factors that lead to the formation of secondary aerosols in the atmosphere of urban areas.

*LHTEE Contribution:* Measurement of air quality and meteorological parameters. Air pollution simulations with the MEMO / MUSE-AERO mesoscale models for the Greater Thessaloniki Area and simulation of pollutant concentrations in street canyons with the SEP-SCAM model.

*Funded by:* Hellenic Ministry of Education, Pythagoras II programme (2005-2006).

### **Information System for Demolition Waste Management**

*Objective:* The development of an information system, taking care of all aspects related to demolition waste management. The ultimate aim is to minimise the waste of building materials that are discarded to landfills without any prior processing and to increase their recycling and reuse.

*LHTEE Contribution:* Project co-ordination, architecture design and development of information system, study on the re-use and recycling of building materials at the end of their useful lifetime.

*Funded by:* GSRT, Hellenic Ministry of Development, Reinforcement Programme of Human Research Manpower - "PENED" (2005-2008).

### **Development of a Methodology for Fair and Efficient Charging of Waste Services in Urban Areas**

*Objective:* Development of a methodology for the formation and the evaluation of municipal solid waste management scenarios on urban level. Study of the economical aspects of the present municipal solid waste management situation and evaluation of alternative scenarios of waste service charging, collection and sorting of MSW. Study of the perspectives and the possibility of the adaptation of an "Pay-As-You-Throw" (PAYT) charging system by the Greek society. Special emphasis will be put upon the organics' fraction of the waste stream and its potential for viable and environmentally friendly management.

*LHTEE Contribution:* Project management and contribution to all workpackages.

*Funded by:* GSRT, Hellenic Ministry of Development, Reinforcement Programme of Human Research Manpower - "PENED" (2005-2008).

## Papers in Journals

**Koroneos C., Dompros A., Roumbas G. and Moussiopoulos N. (2003)**

Life cycle assessment of kerosene used in Aviation, *The International Journal of Life Cycle Assessment*, <http://dx.doi.org/10.1065/lca2004.12.191>.

**Koroneos C., Stylos N.D. and Moussiopoulos N. (2004)**

Life Cycle Analysis (LCA) of Multicrystalline Silicon Photovoltaic-Part I, Present and future perspectives, *The International Journal of Life Cycle Assessment*, <http://dx.doi.org/10.1065/lca2004.12.192.1>.

**Koroneos C., Stylos N.D. and Moussiopoulos N. (2004)**

Life Cycle Analysis (LCA) of Multicrystalline Silicon Photovoltaic-Part II, Application on an island economy, *The International Journal of Life Cycle Assessment*, <http://dx.doi.org/10.1065/lca2004.12.192.2>.

**Papakostas K.T., Papadopoulos A.M. and Vlahakis I. (2004)**

Optimization of thermal protection in residential buildings using the variable base degree days method, *International Journal of Sustainable Energy* **24**, 19-32.

**Avgelis A. and Papadopoulos A.M. (2004)**

Indoor Air Quality guidelines and standards: A state of the art review, *International Journal of Ventilation* **3**, 267-278.

**Karavides G., Papadopoulos A.M., Athanasaki M. (2004)**

Green certificates for electricity production, *Energy and Law* **2**, 65-70.

**Karagiannidis A., Perkoulidis G., Papadopoulos A., Moussiopoulos N. and Tsatsarelis Th. (2005)**

Characteristics of wastes from electric and electronic equipment in Greece: Results of a field survey, *Waste Management and Research* **23**, 381-388.

**Karagiannidis A., Xirogiannopoulou A. and Moussiopoulos N. (2005)**

Studying the applicability of variable rate pricing in solid waste management in Greece, *International Journal of Environment and Pollution* **23**, 189-204.

**Nitis T., Kitsiou D., Klaic Z.B., Prtenjak M.T. and Moussiopoulos N. (2005)**

The effects of basic flow and topography on the development of the sea breeze over a complex coastal environment, *Quarterly Journal of the Royal Meteorological Society* **131**, 305-327.

**Koroneos C., Zairis N., Charaklias P. and Moussiopoulos N. (2005)**

Optimization of energy production system in the Dodecanese Islands, *Renewable Energy* **30**, 195-210.

**Koroneos C., Roumbas G., Gabari Z., Papagiannidou E. and Moussiopoulos N. (2005)**

Life cycle assessment of beer production in Greece, *Journal of Cleaner Production* **13**, 433-439.

**Papadopoulos A.M. (2005)**

State of the art in thermal insulation materials and aims for future developments, *Energy and Buildings* **37**, 77-86.

**Koroneos C., Fokaidis P. and Moussiopoulos N. (2005)**

Cyprus energy system and the use of renewable energy sources, *Energy* **30**, 1889-1901.

**Koroneos C., Roumbas G. and Moussiopoulos N. (2005)**

The Dodecanese energy system, *International Journal of Global Energy Issues* **23**, 43-70.

**Koroneos C., Roumbas G. and Moussiopoulos N. (2005)**

Exergy analysis of cement production, *International Journal of Exergy* **2**, 55-68.

**Koroneos C., Theodosiou G. and Moussiopoulos N. (2005)**

Alternative scenarios analysis concerning different types of fuels used for the coverage of the energy requirements of a typical apartment building in Thessaloniki, Greece, Part II, *Building and Environment* **40**, 1602-1610.

**Koroneos C., Dompros A., Roumbas G. and Moussiopoulos N. (2005)**

Advantages of the use of hydrogen fuel as compared to kerosene, *Resources Conservation and Recycling* **44**, 99-113.

**Moussiopoulos N., Ossanlis I. and Barmpas Ph. (2005)**

A study of heat transfer effects on air pollution dispersion in street canyons by numerical simulations, *International Journal of Environment and Pollution* **25**, 131-144.

**Moussiopoulos N. and Douros I. (2005)**

Efficient calculation of urban scale air pollutant dispersion and transformation using the OFIS model within the framework of CityDelta, *International Journal of Environment and Pollution* **24**, 64-74.

**Karagiannidis A., Xirogiannopoulou A. and Moussiopoulos N. (2006)**

On the effect of demographic characteristics on the formulation of solid waste charging policy, *Waste Management* **26**, 110-122.

## Participation at Conferences

*The list contains only the titles of papers given as oral presentations. In several conferences also poster presentations were made.*

### **1st National Conference on Alternative Fuels, Athens, 27-28 January**

Hydrogen production from renewable energy sources - An environmental assessment (C. Koroneos)

### **HELECO 2005 - 5th International Exhibition and Conference on Environmental Technology, Athens, 3-6 February**

Application and development of the OFIS model in the framework of CITY-DELTA European exercise (N. Moussiopoulos)

Dispersion modelling in the frame of the evaluation of the depollution effectiveness of photocatalytic wall coatings (N. Moussiopoulos)

Comparative evaluation of stonewool and extruded polystyrene (A. Karamanos)

Optimization of regional management of municipal solid waste: A modelling approach with application (G. Perkoulidis)

Environmental impacts of the domestic use of different energy forms (C. Koroneos)

ECOSMEs - A tool for the implementation of IPP in SMEs (C. Koroneos)

Life cycle assessment of hydrogen fuel production processes (C. Koroneos)

### **3rd National Conference on the Application of Renewable Energy Sources-RENES, Athens, 23-25 February**

The renewable energy sources and the energy conservation through the energy centres (K. Papageorgiou)

Low enthalpy geothermal energy, applications in Greece and environmental benefits from its use (C. Koroneos)

### **AWARE-Avoidance and management of municipal solid Waste in the EU/25 and Mediterranean countries: New and future Research, Orléans, France, 14-15 March**

Planning of composting schemes for solid waste in the prefecture of Pieria (A. Karagiannidis)

### **8th International Management Congress ARISTOTELIS "Asymmetry, Uncertainty, Cultural Diversity, Management Requested", Thessaloniki, 17-18 March**

Energy uncertainty and oil crisis – Impact on daily life of enterprises (A. M. Papadopoulos)

### **1st National Conference of Mechanical - Electrical Engineers, Athens, 28-30 March**

Sustainability in production – The application of environmental tools (H. Achillas)

Variable rate pricing of solid waste management in Greece: Preliminary results from an applicability study (A. Karagiannidis)

The thermal protection of the buildings' shell and the role of a new generation of thermal insulation materials (K. Papageorgiou)

Covering the buildings' cooling load under in a liberalised electricity market (K. Papageorgiou)

The Greek electricity generation system under a systems' dynamics approach (K. Papageorgiou)

### **5th International Conference on Urban Air Quality, Valencia, Spain, 29-31 March**

Ozone forecasting supported by data mining statistical methods (K. Karatzas)

The Street Emission Ceilings project (E.A. Kalognomou)

European emission control strategies and the urban environment-lessons learned from the EU research project Merlin (N. Moussiopoulos)

Numerical and experimental results: evaluation of the depollution effectiveness of photocatalytic coverings in street canyons (Ph. Barmpas)

High resolution meteorological simulations over Athens using MM5 and MEMO mesoscale models (N. Moussiopoulos)

SEP-SCAM: A simplified 3-dimensional approach in street canyon modelling (N. Moussiopoulos)

Physical modelling of flow and dispersion in and around an idealised street canyon-replicating the PICADA field experiment in a boundary layer wind (Ph. Barmpas)

Database on atmospheric model evaluation (DAME) in ACCENT (N. Moussiopoulos)

Cost-effectiveness assessment of photocatalytic covering techniques (N. Moussiopoulos)

### **Solid Waste: The Social Issue, Edmonton, Canada, 11-14 May**

Investigation of key-factors influencing individual behavior and attitude towards/against illegal waste dumping and source separation activities in a potential PAYT-system in Greece (A. Karagiannidis)

On social issues related to municipal solid waste: modelling the citizens' annoyance and convenience from temporary storage containers (A. Karagiannidis)

### **2nd International Conference "Sustainable Development Indicators in the Minerals Industry"-SDIMI, Aachen, Germany, 18-20 May**

ISO 14040-42 (LCA) standard implementation to stonewool's production for environmental indicators development – interaction with ISO 14031 standard (E. Giama)

### **Passive and low energy cooling for the built environment (PALENC 2005), Santorini, Greece, 19-21 May**

Evaluation of solar driven thermal systems for urban buildings (A. Karamanos)

On the impact of energy pricing policies on low energy design of buildings (A.M. Papadopoulos)

### **14th Symposium Transport and Air Pollution, Graz, Austria, 1-3 June**

MERLIN: The study of urban air quality in 20 European cities (N. Moussiopoulos)

Street Emission Ceilings exercise (N. Moussiopoulos)

### **12th International Symposium on Toxicity Assessment-ISTA12, Skiathos, Greece, 12-17 June**

Inventory of the accumulated pollution in the uncontrolled landfill of Eukarpia (Th. Tsatsarelis)

Locational and environmental characteristics of waste disposal sites in the prefecture of Evros (P. Rakimbei)

### **1st International Conference on Harbours and Air Quality, Genova, Italy, 15-17 June**

Photochemical air pollution levels in Athens: analysis of the current situation and future projections with emphasis on the impact of shipping emissions (I. Douros)

### **International Hydrogen Energy Congress & Exhibition (IHEC 2005), Istanbul, Turkey, 13-15 July**

Hydrogen production from Fossil Fuels – A Life Cycle Analysis approach (C. Koroneos)

### **9th Conference on Environmental Science and Technology - CEST 2005, Rhodes, Greece, 1-3 September**

Life Cycle Analysis of solid oxide fuel cells (C. Koroneos)

Cost analysis of the management of electrical and electronic products at the end of their useful life (G. Perkoulidis)

Comparison of experimental results and model simulations and cost-effectiveness assessment of photocatalytic covering techniques (N. Moussiopoulos)

Promoting integrated tools for landfill restoration: the case of Kozani prefecture in the region of Western Macedonia (G. Perkoulidis)

MERLIN: The study of urban air quality in 20 European cities (N. Moussiopoulos)

### **2nd International Conference on Life Cycle Management (LCM 2005), Barcelona, Spain, 5-7 September**

Life cycle management in electrical and electronic equipment (C. Koroneos)

### **The Changing Chemical Climate of The Atmosphere, ACCENT, Urbino, Italy, 12-16 September**

Meteorological simulations over Athens using MM5 and MEMO mesoscale models (N. Moussiopoulos)

### **AIVC Conference 2005-Ventilation in Relation to the Energy Performance of Buildings, Brussels, Belgium, 21-23 September**

On the implementation of the energy performance directive in a real world (A.M. Papadopoulos)

### **2nd International Conference on Manufacturing Engineering (ICMEN), Kassandra, Chalkidiki, 5-7 October**

Implementation of recycling and environmental aspects in an integrated product policy, in electrical and electronic equipment (H. Achillas)

### **2nd Environmental Conference of Macedonia, Thessaloniki, Greece, 8-12 October**

Air Quality in 20 European cities – Conclusions of Merlin project (I. Douros)

Photocatalytic innovative coverings applications for urban air quality improvement (Ph. Barmpas)

Determination of air pollutant emissions ceilings in street canyons – Street Emission Ceilings Exercise (E.A. Kalognomou)

### **13th International Environmental Pollution and its Impact on Life in the Mediterranean Region, Thessaloniki, Greece, 8-12 October**

Sustainability in production - The application of environmental tools (H. Achillas)

Cost analysis of the management of electrical and electronic products at the end of their useful life (H. Achillas)

Avoidance and minimization of solid wastes from public social events (A. Karagiannidis)

### **10th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, Crete, Greece, 17-20 October**

Effects of topography on the urban heat island (Ph. Barmpas)

Air pollution levels at hotspot areas of selected European cities (Ph. Barmpas)

Street canyon model intercomparison exercise and validation study (Ph. Barmpas)

Comparison of results from physical and numerical modelling of flow and dispersion in and around the Picada field site street canyon configuration (Ph. Barmpas)

Numerical model inter-comparison for a single block building within ATREUS (Ph. Barmpas)

### **36th International Congress on Heating, Refrigeration and Air-Conditioning (HVAC&R), Belgrade, Yugoslavia, 30 November-2 December**

Energy conservation in the hotel sector (A.M. Papadopoulos)

Strategies for reducing air-conditioning demand in insular energy systems (A.M. Papadopoulos)

## Events

As in previous years, also in 2005 the Laboratory was involved in various scientific events. On 22 February we organised together with the Hellenic Solid Management Association and the Technical Chamber of Greece a workshop on waste management in Thessaloniki. Furthermore, we had a significant role in the preparation of the ceremony of our Department on 14 June, combined with the granting of a honorary doctorate to Professor Brian E. Launder. Finally, together with the Environmental Council of our University, we organised an event in honour of Professor George Tchobanoglous on 9 October. On 25 November we had another distinguished visitor, Professor Erhan Erkut, Bilkent University, Turkey.

Professor Nicolas Moussiopoulos had in 2005 several opportunities to present research results of our Laboratory in Greece and abroad. Invited by the University of Thessaly, on 2 February he spoke on "Assessing Urban Air Quality: The State-of-the-Art". On the following day, he chaired a round table discussion on air quality in the frame of the HELECO 2005 conference in Athens. Professor Moussiopoulos organised on 1 April in Valencia the ACCENT hosted workshop on Atmospheric Transport and Transformation at the Urban and Local Scales. Furthermore, he actively contributed to several events organised to commemorate the 50<sup>th</sup> anniversary of Aristotle University's School of Engineering, including the participation at a round table discussion on 7 October related to environmental problems that Thessaloniki is facing. Finally, on the occasion of the MESAEP 2005 Symposium he chaired on 9 October the round table discussion on "Recent advances on European Commission policy and environmental themes".

In the period 19-21 May the 1<sup>st</sup> International Conference on Passive and Low Energy Cooling for the Built Environment took place on Santorini. More than 260 speakers from 25 countries participated, whilst Assoc. Professor Agis Papadopoulos, who was a member of the Scientific Committee, presented results of the research carried out at the Laboratory and chaired a session on measurements in Low Energy Buildings. In September he was invited to hold a presentation on the implementation of the Energy Performance Directive in a real world at the 26<sup>th</sup> AIVC Conference in Brussels, discussing some key points of this directive that becomes mandatory in January 2006.

On 4 April, the Goulandris Museum of Natural History organised in Thessaloniki an important event within the framework of its activities on "Mankind and the Environment: Critical Problems of the 21<sup>st</sup> Century". The event, which was under the auspices of the President of the Hellenic Republic, was dedicated to the issue of Urban Environment and Mega Cities. Assoc. Professor Agis Papadopoulos and Ass. Professor Avraam Karagiannidis gave presentations about Energy and Waste Management problems, respectively.

Ass. Prof. Avraam Karagiannidis was invited speaker in a series of environmental and waste management related events, including: (a) European AWARE conference on 14-15 March, in Orleans, France; (b) Workshop 'Critical approach on the use of models for planning waste management systems', on 6 June, in Athens; (c) Postgraduate teaching course on environmental management, at the University of Thessaly; (d) European workshop of the minimization of risk from oil spills, on 21-25 September, in Bremen, Germany. He was also invited at the Grantholders and Roundtable meetings of the ASEAN University Network Programme (AUNP), on 25-30 August, in Manilla, the Philippines. On this occasion, he was pleased to learn that the ISTEAC project was awarded a price from the Government of the Philippines.

## News

Four previous staff members left our Laboratory in 2005: Avraam Avramidis, Maria Frangou, Stergios Kostidis and Panagiotis Panagiotidis. We wish them all the best for their professional career in the future. At the same time, seven young researchers joined the Laboratory: Dimitrios Anastaselos, Georgios Baniyas, Sofia-Natalia Boemi, Lia Frangou, Apostolos Malamakis, Georgios Tsegas and Vasilena Mitsiadi. Edward Debry stayed with us as a trainee for almost 6 months in 2005. Ioannis Papaioannou returned to our Laboratory after his military service, while Ioannis Ossanlis and George Kotriklas had to leave us for serving their duty.

In 2005, Professor Nicolas Moussiopoulos was re-elected Chairman of the Mechanical Engineering Department for another two years. Since July he is representing Aristotle University in a Commission supervising the construction of Thessaloniki's sanitary landfill.

## Laboratory Personnel

Nicolas Moussiopoulos	Professor, Dr.-Ing. habil (Director)
Agis Papadopoulos	Associate Professor, Dr.-Eng., MSc
Avraam Karagiannidis	Assistant Professor, Dr.-Eng., MSc
Afedo Koukounaris	Administration Officer

## Researchers with Co-ordinating Functions

Christopher Koroneos	PhD
Ioannis Douros	Physicist, MSc
Evangelia-Anna Kalognomou	Physicist, MPhys

## Researchers and PhD Students

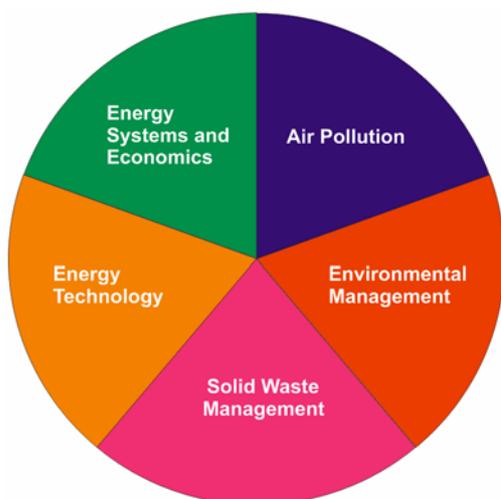
Georgios Perkoulidis	Dr.-Eng.	Vasilena Mitsiadi	Mech. Engineer
Harisios Achillas	Mech. Engineer, MSc	Christos Naneris	Environmentalist
Dimitrios Anastaselos	Mech. Engineer	Symeon Oxizidis	Mech. Engineer
Aristotelis Avgelis	Mech. Engineer	Kostantinos Papageorgiou	Mech. Engineer
Georgios Banias	Mech. Engineer	Apostolos Papatthanasiou	Physicist, MPhys
Photios Barmpas	Aersp. Engineer, MSc	Panagiota Rakimbei	Environ. Engineer, MSc
Sofia-Natalia Boemi	Environmentalist	Theodora Slini	Mathematician
Aristidis Dobros	Chem. Engineer	Maria Theodoseli	Environ. Engineer, MSc
Natasha Dourala	Economist, MA	Georgios Theodosiou	Mech. Engineer
Lia Frangou	Biologist, Environm, MSc	Thomas Tsatsarelis	Mech. Engineer
Efrosini Giama	Mech. Engineer, MSc	Georgios Tsegas	Physicist
Anastasios Karamanos	Mech. Engineer	Christos Vlahocostas	Mech. Engineer, MSc
Apostolos Malamakis	Mech. Engineer	Anna Xirogiannopoulou	Mech. Engineer

## Technical Staff and Secretariat

Lazaros Sotiriadis	System Administrator	Dimitra Alexiou	Administrative Support
Ioannis Papaioannou	System Administrator	Georgia Spiridou	Administrative Support
Dimitrios Nerantzis	System Administrator	Sofia Varnava	Administrative Support



## Main Research Topics



### Energy Systems and Technology

- Process analysis and optimisation
- Renewable energy sources
- Rational energy use
- Life Cycle Analysis
- Sustainable production

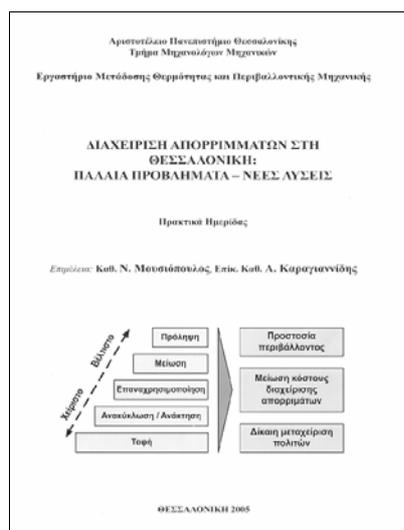
### Air Pollution

- Transport and transformation of pollutants
- Air quality assessment and management
- Environmental impact assessment
- Integrated environmental assessment

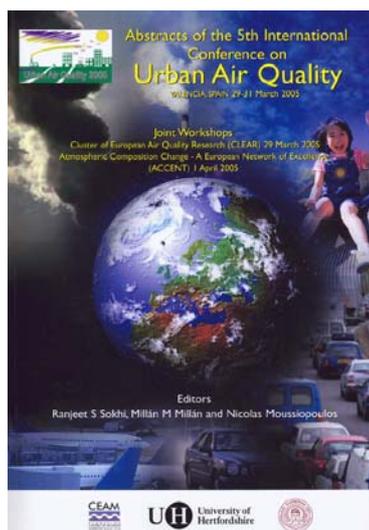
### Waste Management

- Siting, logistics and recultivation issues
- Recycling and energy recovery
- Pricing schemes

## 2005 Proceedings



**Waste management in Thessaloniki: Old Problems-New Solutions**  
(Thessaloniki, 22 February 2005),  
Workshop proceedings  
(Moussiopoulos N. and Karagiannidis A., eds), Aristotle University, 76 pp.



**5<sup>th</sup> Urban Air Quality Conference**  
(Valencia, 29-31 March 2005)  
Abstract book (Sokhi R.S., Millan M.M. and Moussiopoulos N., eds),  
University of Hertfordshire, 294 pp.



**ACCENT Workshop on Atmospheric Transport and Transformation at the Urban and Local Scales**  
(Valencia, 1 April 2005), Workshop report  
(Moussiopoulos N. and Kalognomou E.-A., eds), ACCENT Report 3.2005,  
70 pp.

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