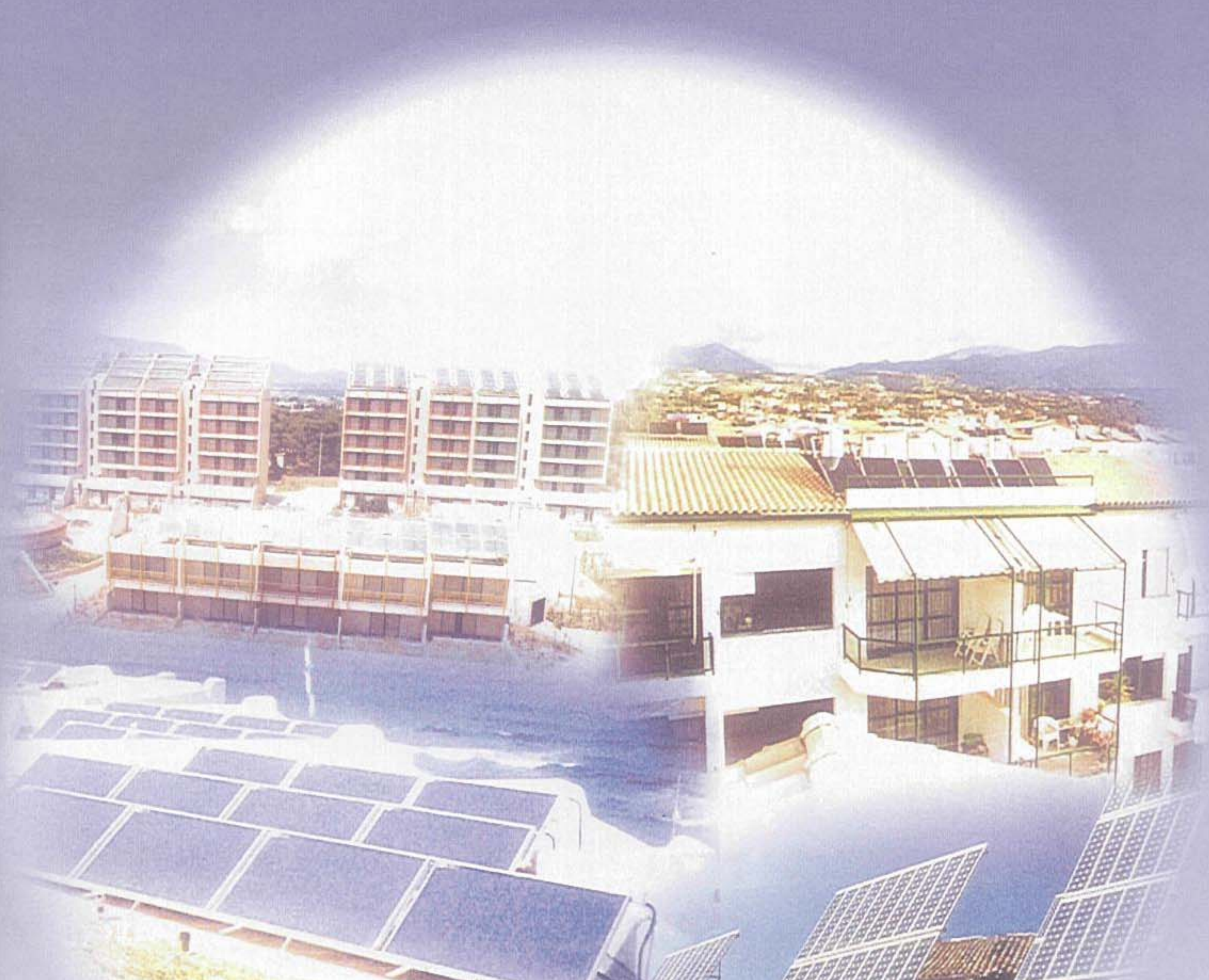
Renewable Energy Sources in Settlements



ΚΑΠΕ
CRES

European Commission
Directorate-General for Energy and Transport

THE PROJECT 'RES DISSEMINATION

This material has been produced with the co-financing DG Energy and Transport (DG TREN) of the European Commission in the framework of the project RES Dissemination (Cluster project 4.1030/C/00/029) of the ALTENER Programme.

The "RES Dissemination" project is a cluster project which was occurred by the clustering of two approved by the EC projects:

1. the project WORES: Educating Women for the Promotion of RES in Communities and

2. the project Clean Energy in Agriculture, Summer courses for engineers.

The "WORES" project concerns the training and information of women on Renewable Energy Sources issues, through professional and social organisations. Participants in the project are the **Greek Women's Engineering Association (EDEM)**, the **Women's Union of Greece (EGE)**, the **Centre for Renewable Energy Sources** from Greece, and from Spain, the **Catalan Institute of Technology (ICT)**. The project comprises two categories of actions: i) the training of women engineers on renewable energy technologies issues, through two seminars of 200 hours and 300 hours organised by EDEM in Athens and ICT in Barcelona respectively, and ii) the information of women who are active society members through 1-day seminars in 6 cities of Greece, and in Barcelona of Spain, aiming at sensitising the local community through the activation of these women. In parallel to these actions and information material is being produced in the form of publications (such as this brochure) and in the form of a CD. The dissemination of the project results will be achieved through the women's and professional organisations in Greece, Spain, and Europe.

The "Clean Energy in Agriculture" project concerns the training of rural engineers on RES application issues in agriculture. Participants in the project are the **University of Thessaly**, the Greek firm **Photovoltaic**, and the German firm **WIP**. The main action in this project is the organising of a 20 day seminar in Volos, Greece, with the participation of engineers from various European countries. The educational structure includes the creation and use of educational material through the Internet. Additionally, two one-day seminars are taking place in Germany, on for university students and one for farmers, aiming at RES dissemination in the area of Munich, in cooperation with the **Munich Polytechnic**.

In the framework of the cluster project RES Dissemination there is information exchange and common information and dissemination activities. The project is coordinated by the Centre for Renewable Energy Sources (CRES).

ACOMMUNITY STRATEGY AND ACTION PLAN FOR RES - ALTENER PROGRAMME AND THE CAMPAIGN FOR TAKE-OFF

European Commission
Directorate-General for Energy and Transport

The ALTENER Programme

ALTENER[1] is the non-technology programme for promoting renewable energy sources (RES) in the European Union. It is a programme issued by the Directorate General for Transport and Energy (DG TREN, ex. DG XVII) that finances actions for the dissemination of alternative energy sources, and in particular renewable energy applications. These actions aim at significantly increasing the contribution of RES in the energy balance of the EU.

Energy for the Future: Renewable Sources of Energy (RES)

The targets of ALTENER are described in the White Paper of the European Commission of 1997[2]. The **White Paper for a Community Strategy and Action Plan: "Energy for the Future: Renewable Sources of Energy**" sets a goal of 12% contribution of RES in the energy consumed by the year 2010 and describes the areas of application.

In order to achieve this goal, the **Campaign for Take-Off**[3] has been issued aiming at raising the interest and the participation of industry, investors, and the public for increased RES applications in all sectors (agriculture, industry, buildings, etc.) The Campaign for Take-Off forms an integral part of the Community Strategy and Action Plan for Renewable Energy Sources by 2010. It is designed to act as a catalyst for the development of key renewable energy sectors.

The Campaign for Take-Off

The Campaign for Take-Off for the development of the areas of RES applications started in 1999 and is focused on promoting the applications of the following RES systems by 2003:

- 1,000,000 photovoltaic systems
- 15,000,000 square meters of solar collectors
- 10,000 MW of wind turbine generators
- 10,000 MW thermal of combined heat and power biomass installations
- 1,000,000 dwellings heated by biomass
- 1,000 MW of biogas installations
- 5,000,000 tonnes of liquid biofuels
- integration of Renewable Energies in 100 communities

The ALTENER programme has significantly contributed to the Campaign for Take-Off by the exclusive financing of actions in the Campaign areas of application during the 1999 call for proposals.

Areas of Action

ALTENER, which has been financing inter-Community projects since 1993, is focused on organizational and legislative measures in order to create and improve the background for renewable technologies application at a European level. These projects are focused on non-technical actions such as information, dissemination, and wide application, placing specific emphasis on the social acceptance and economic viability of the technologies, having as a long term goal sustainable development and environmental protection.

Since 2001 ALTENER includes common actions with the DG TREN programme SAVE, which promotes actions for rational use of energy (RUE) and reduction of the gaseous emissions that cause the world-wide greenhouse effect and climatic change. SAVE is focused on improving energy efficiency in all sectors of energy use (industry, commerce, residential sector, etc.)

In order to achieve the goals towards sustainable development it is most crucial to apply RES and RUE at local level, with the participation of all economic factors of local society (professionals, teachers, simple citizens, local authorities, etc.), as well as at national level (by setting national goals, statutory measures, laws and incentives). The contribution of key actors of local and national economy may be ensured through the involvement of professional associations (industrial, commercial, technical, scientific, educational, etc.).

SOURCES OF INFORMATION

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2. COM (97) 599 final
3. http://www.agores.org/
4. http://www.cordis.lu
5. http://europa.eu.int/comm/dgs/energy_transport/index_en.html

ENVIRONMENTAL IMPACT OF ENERGY CONSUMPTION OF THE RESIDENTIAL SECTOR

Introduction

Torrential rains, extended heat waves and grazing fires are some of the phenomena that occur from the high concentration of greenhouse gases (GG) in the atmosphere. The ever-increasing frequency of extreme weather events due to the greenhouse effect is proof that the planet's climate is changing. Although there is great uncertainty as to how great the changes will be in the future, the assessments predict that if serious measures are not taken the mean surface temperature could increase between 1 and 3,5°C by 2100.

According to the Kyoto Protocol (1997), which hasn't been ratified by every country, the European Union (EU) is bound to decrease GG emissions (CO_2, CH_4, N_2O and halogen compounds) for the period 2008-2012, by 8% compared to 1990 levels.

Greece, based on the fair allocation of burdens and the expected development due to community cohesion, is bound to hold the emissions of the 6 main GGs at +25% compared to 1990 levels.

Climate change and energy

Europe contributes by 14% to the total CO_2 surface emissions, which is much less than Asia (25%) and North America (29%).

CO_2 emissions, the most responsible GG (80%), result from the greater energy sector (primary production). Fossil fuels are regarded as the most responsible for emissions, whereas oil consumption alone, contributes by 50% to the annual CO_2 emissions in the EU. Electricity and steam production are responsible for 30% of CO_2 emissions, while the household sector contributes 14%. The contribution of the other GGs, CH_4, N_2O, is relatively small, 17% and 7% respectively.

In 1998, the total annual CO_2 emissions in Greece, came up to 100,5 Mton, where energy production and the household sector along with the commercial sector contributed 51% and 12% respectively.

For the period 1990-1998 the greatest impact on CO_2 emissions was from fossil fuel burning, with an increase of approximately 19%. Regarding emissions for every sector of the economy, oil products contribute 48%, carbon products, including lignite with 51% and natural gas with 1%.

Energy consumption in the residential sector

In the EU, households and the tertiary sector represent the most important sector in final energy consumption, in absolute figures (40%). It has been noted that building heating is an important part of the total energy consumption (69%), followed by hot water production (15%), electrical appliances and lighting (11%). In the Northern European countries like Finland and Denmark, where severe winters have a long duration, heating of housing comes to 1,5 TOE/residence (1997), whereas in Greece the respective figure is 0,9TOE/residence.

The mean energy consumption/residence for heating has been slightly decreased in the EU since 1990. This is the result of two contradictory trends; larger homes and increased requirements as to comfort on one hand and more energy efficient homes and electrical appliances on the other. The theoretical special consumption of the new residences in the EU is by 22% smaller than that of 1985. This is attributed to the stricter criteria regarding energy efficiency that have been instituted in several countries the last 5 years.

In Greece, a Mediterranean country with far less heating requirements during winter, the residential heating needs have a portion of approximately 70% of the energy consumption, of a typical Greek home. It is worth mentioning that the energy consumption for home appliances, lighting and air-conditioning comes to 18% of the total energy balance (CRES, 1997). In Greece, the homes with central heating systems, which uses oil exclusively, are 35,5% of the total. The other 64% are autonomously heated residences that use 25% oil, 12% electricity and 18% firewood.

The policy of the European Union and Greece

Among the policies that the EU considers competent to fulfill the obligations based on the Kyoto Protocol, is the total utilization of the energy saving potential in buildings, which will allow for the parallel decrease of external energy dependence and CO_2 emissions. Specifically, energy saving in buildings can achieve a decrease of 40% of the energy consumption, regardless of the age or use, based on measures like tax incentives or directives of a regulatory nature that every nation has to develop and implement.

In order for Greece to fulfill its obligations has began the study and planning of policies and measures to decrease the CO_2 emissions in every sector. According to the National Observatory of Athens, a decrease of 17% in relation to the Expected Progress Scenario is anticipated and a 23% increase in relation to the base year 1990. Especially for the household and tertiary sector, a 30% decrease of CO_2 emissions is expected.

Discussion and Proposals

The wide long-term targets that are considered essential and are expected to contribute to the achievement of energy development of the EU via a model of sustainable development, production and energy consumption, rest within the development of a complete range of energy saving technologies and renewable energy sources. This ambitious policy, that will battle "climate change", must be combined with the promotion of innovation (central solar systems) along with the structural changes (liberalization of the energy market) that will lead to a system of more efficient production and improvement of the European Economy's competitiveness.

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2. Ministry of Environment, Public Planning and Public Works, 2000. *Emissions Inventory – National inventory for Greenhouse and other Gases for the years 1990-1998*. National Observatory of Athens, June 2000.
3. EnR, Euroepan Energy Network, 2000. Monitoring tools for energy efficiency in Europe. Published by ADEME and E.C.
4. European Commission (EC), 2001. Green Paper-Towards a European strategy for the security of energy supply. Office for Official Publications of the European Communities.
5. European Environment Agency (EEA), 1999. Environment in the European Union at the turn of the century. Luxemburg: Office for Official Publications of the EC.
6. EC, 2000. Energy in Europe – 1999 Annual Energy Review, Special Issue. Office for Official Publications of the European Communities.

BIOCLIMATIC DESIGN OF BUILDINGS AND PASSIVE SOLAR SYSTEMS

Bioclimatic architecture is aimed at providing thermal and visual comfort conditions in buildings by utilizing solar energy and other environmental sources depending on local climatic conditions. Basic elements of bioclimatic design are the passive systems integrated onto the buildings in order to utilize the environmental sources for heating, cooling and lighting of buildings, but mostly, the building techniques which improve the natural operation and energy performance of the building shell during all seasons.

The exploitation of solar energy and environmental sources in general, via the passive solar systems is achieved through the overall successful operation of the building and the relation of building and environment. The thermal operation of a building is a dynamic condition which:

- depends on the local climatic and environmental parameters (solar radiation, outdoor air temperature, relative humidity, wind, vegetation, shading by other buildings) as well as on the building use (residential, office, health, etc.) and
- is based on the respective energy performance of the building elements and therefore, on the integrated passive solar systems, as well as on the energy profile resulting from the building's operation.

Advantages

The benefits of bioclimatic architecture are multiple with respect to: energy (conservation and thermal/visual comfort), economy (reduction of consumed fuels and of HVAC installation cost), environment (reduction of pollutants), and society (improvement of life quality). Additionally, the application of bioclimatic design in new buildings has minimal or no cost, when simple systems and technologies are applied.

Major technologies

PASSIVE SOLAR SYSTEMS AND TECHNIQUES

Passive solar systems in buildings utilize solar energy for space heating during winter, and for providing daylight.

- The most common passive solar system is the **direct gain** system. Direct gain is the system that utilizes solar energy, which is collected through apertures of appropriate (south) orientation for space heating. Apart from the apertures (windows) the system comprises the required thermal mass (use of materials with high thermal capacity), the appropriate thermal protection (insulation of the building envelope, double glazing, night insulation), and the required solar protection during the summer months.

The other passive solar systems are generally referred to as indirect gain systems and are classified in the following categories:

- **Solar walls**: they consist of walls combined with glazing placed at a distance about 5-15 cm from their exterior side. The wall may be either of high thermal mass and uninsulated (*thermal storage wall*), or insulated (*thermosyphoning air panel*). The glazed surface may have fixed or openable frames with single or double glazing. The solar wall operates as a solar collector, and the heat produced is transferred either through the building mass, or through vents to the adjacent space. A special category of thermal storage wall is the *Trombe-Michel wall* (mass wall with vents), which combines both operations.
- **Sunspaces**: glazed spaces attached to or embodied in a part of the building shell. Solar radiation, passing through the south-facing glazing of the sunspace is converted to thermal energy, part of which is provided directly to space, raising its temperature, while part is stored in the sunspace structure (thermal mass, mostly the floor) and is provided to the space with at time lag. The transfer of thermal energy collected in the sunspace to the interior of the building is achieved by vents or openings on the partition wall.
- **Solar atria** (atria covered by glazing).

The operation of all passive solar systems requires the appropriate thermal mass (depending on the use of each space), so that part of the thermal energy is stored and gradually provided to the spaces, but also the necessary solar control (shading) systems for the summer period (i.e. horizontal overhangs on southern orientations, moveable blinds and louvers, etc.).

NATURAL COOLING TECHNIQUES

The most common and effective passive cooling techniques are:

1. **Solar control** (shading) of the building, which is achieved by various means, such as natural vegetation, geometric elements (projections) of the building volume, permanent, fixed or moveable shading devices, glazing with special coverings or of special treatment (reflective, selective, electrochromic, etc.)
2. **Natural ventilation** through appropriate design and operation of windows and through vents on the top and bottom of internal partition walls, allowing the air movement through the interior spaces.
   - Nocturnal ventilation is very effective, mostly during hot days, during which daytime ventilation is excluded. Night ventilation contributes to the storage of "coolth" in the building thermal mass, resulting in the reduced thermal load of the building the next day.
   - The use of fans, particularly ceiling fans, enhances the natural ventilation effect, with minimal energy consumption. Additionally, it contributes to the achievement of thermal comfort at higher than usual temperature levels (about 2-3^{o}C), as with the air movement created heat it removed from the surface of the human body.
3. The use of **thermal mass** for reducing temperature fluctuations round-the-clock.

Additionally, there are other methods of passive cooling, more complex and less applicable, which, nevertheless, further reduce the buildings' cooling load:

- Thermal protection of the building shell with techniques such as *planted roof, vented roof, reflective surfaces of exterior surfaces, radiant barriers*
- Enhancement of natural ventilation by *wind towers* or *solar chimneys*
- *Evaporative cooling* techniques such as: water surfaces, cooling tower, evaporative cooling units (direct, indirect, combined evaporative cooling). Vegetation, due to the evapotranspiration of plants consists a natural cooling source.
- *Cooling by radiation* (rejection of heat) towards the atmosphere (night sky).
- *Cooling by* heat rejection *to the ground* (*earth-contact cooling*), either by *buried-burmed or semi-burmed buildings*, or by *underground cooling pipes (earth-to-air heat exchangers)*.

DAYLIGHTING SYSTEMS AND TECHNIQUES

Appropriately designed daylighting systems make use of natural light (sunlight). Daylighting systems may be grouped in the following categories:

- Openings on vertical walls
- Roof openings
- Atria
- Light ducts

These systems are combined with specific techniques, so as to provide adequate and evenly in and evenly distributed light inside the spaces. These techniques concern the design of openings, the optical properties of glazings, the photometric characteristics (texture, colour, transmissivity of materials) of all surfaces, and use of reflectors. In particular, the most common daylighting technologies are glazings with particular properties, prismatic light transmitting elements, transparent insulation materials, and reflectors (light shelves or reflective louvers).

(apertures-windows), combined with daylighting techniques such as reflective surfaces, louvers, use of materials with specific optical properties, etc., make use of natural light (sunlight) in order to provide adequate and evenly distributed light inside the spaces.

Key issues

SELECTION OF SYSTEMS AND TECHNIQUES

The largest amount of energy conservation in buildings occurs from the correct and rational design, with respect to building and space layout and orientation, size, orientation and position of apertures, thermal protection of the building envelope (thermal insulation, wind protection, solar control), as well as from the proper operation of the systems.

Generally, the systems of **simple construction and operation**, which combine thermal benefits throughout the year, are the most effective. Most important is the provision of adequate solar control (shading) and natural cooling during the summer. The energy saved through bioclimatic design varies according to the building type, climate of location, and to the technologies applied. In residences built in Greece, the recorded energy conservation in bioclimatic buildings ranges from 15-40%, while the cooling load is nullified.

THE ROLE OF PROPER USE AND CONSTRUCTION

The performance of bioclimatically designed buildings and of the passive systems integrated onto them is significantly affected by their proper construction, maintenance and use. It is characteristic that the energy behaviour of a building may be fully reversed if, for example, the curtains on the south windows remain drawn and the windows open during winter, or if ventilation and shading is inadequate during summer, especially in buildings with passive solar systems.

In buildings of the tertiary sector the effective operation of passive systems often requires the installation of control and automation systems, as the involvement of the building users in the operation of the systems is complex and therefore usually ineffective.

Applications in Greece

In Greece there are at least 180 applications of bioclimatic design, including two housing developments of 340 and 120 residences. Approximately 75% of applications are residential buildings.

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3. J.R. Goulding, J.O. Lewis, T.C. Steemers, Energy in Architecture, The European Passive Solar Handbook, Batsford for the Commission of the European Communities, 1993, ISBN 960 - 239 - 171 - 5
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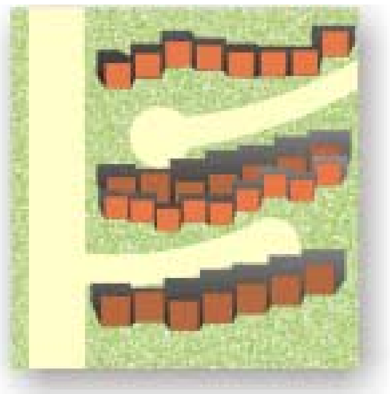
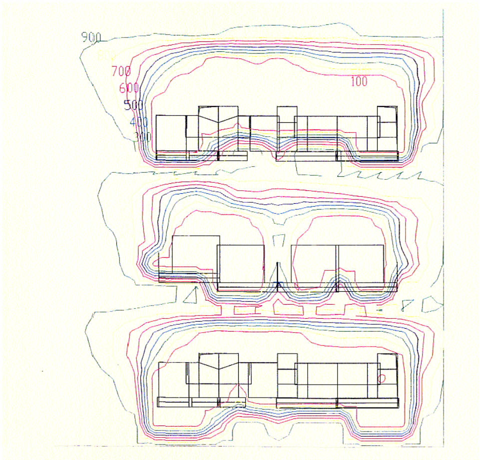
ENERGY DESIGN OF SETTLEMENTS WITH RES INTEGRATION

The energy design of settlements aims at energy conservation, provision of comfort conditions and at the utilisation of locally available Renewable Energy Sources for covering energy demands at building, block, and settlement scale. It includes the bioclimatic design of buildings and their surrounding space, layout of buildings and functions for saving energy, and coverage of thermal, cooling, and electric loads of the settlement by RES.





Advantages

The application of integrated approaches of energy design with incorporation of the most energy efficient technologies in the built environment, is a prerequisite for the full exploitation of the energy potential of each building in each place. This maximum exploitation, via an optimum combination of technologies and systems, results in a significant reduction of the energy needs of a building complex. This reduction in demand, apart from reducing the energy consumption, reduces the required installed capacity of the heating, cooling and lighting electrical and mechanical systems, resulting in their smaller size, reduced installation, operation, and maintenance cost and reduced electricity peak load during the summer, while reducing the environmental impact from the pollutants at building and supply network level.

Furthermore, the utilisation of RES presents nowadays a prerequisite for the improvement of the energy and environmental conditions of a place. By the significant contribution to the abatement of the energy problem without any negative impact on the environment, energy production from RES can contribute with additional technical and economic benefits to sustainable development at settlement (local) scale, as well as at regional and national scale.

The integrated energy design of a settlement based on the local design needs for existing or new population and on the necessity for integrating local renewable energy sources, may attribute to a further social and economic development. Apart form the above advantages, and, depending on the size of the settlement, it may offer employment opportunities in various sectors (i.e. public buildings, energy installations), as well as in the activities related to environmental and energy measurements, further energy design, etc., thus significantly further contributing to regional sustainable development.

Methodology

Aiming at the total coverage of thermal and electric needs of a new settlement, through the exploitation of the local RES potential, the energy design is based on the following methodology:

i. minimisation of the energy demands of the settlement with the appropriate low-energy design,
ii. maximum exploitation of locally available RES with optimisation of the energy systems at design, installation and operation level,
iii. energy management at demand and supply sides.

Basic technique for the minimisation of the energy needs of a settlement is the bioclimatic design:

- at **settlement scale** (urban scale) for the provision of appropriate microclimatic conditions (adequate insolation, ventilation, etc.)
- at the **building scale**, by integrating energy conservation techniques and appropriate passive solar systems, daylighting, ventilation and natural cooling systems, and passive solar techniques

Additionally, systems and techniques of **energy conservation and rational use of energy in buildings** (i.e. installation an rational use of electrical/mechanical systems of low energy consumption and energy management systems), significantly contribute to the reduction of the energy needs for heating, cooling, and lighting, as well as to the increase of RES systems performance.

The **use of RES** respectively is foreseen

- at settlement level (i.e. district heating/cooling with biomass or geothermal energy, electricity supply by photovoltaic, wind, or other RES systems)
- at building level (i.e. passive and active solar systems, geothermal heat pumps, building-integrated photovoltaic systems)

Finally, the **energy management** ensures the maximum performance of the building envelope and installations, and, at settlement scale, the optimum operation of all the energy systems.

At infrastructure level, the energy design concerns the spatial distribution of activities for reducing fuel consumption for transport, the harmonising of the urban space with the natural environment, and the application of elements from the local tradition, as well as the overall exploitation and management of environmental resources at local level.

Bioclimatic design of settlements

The bioclimatic design of settlements (bioclimatic design at urban level) includes the optimum utilisation of environmental-energy parameters at a yearly basis, and in particular:

A. During winter:

❖ Insolation of buildings and outdoor spaces, by the orientation and direction of streets and other axes, orientation of buildings, height of buildings, distances among buildings, plantations, etc.

❖ Wind protection of buildings and outdoor spaces, by the organisation of space in relation to the direction of prevailing winds, thickening of the urban grid and spatial distribution of urban elements, use of dense tree-planting as buffer zones, use of appropriate vegetation in the settlement, etc.

B. During summer:

❖ Solar protection of buildings and outdoor spaces by the use of shading systems (pergolas, overhangs, etc.), use of appropriate vegetation in the settlement and around the buildings (trees, creeper plants, etc.), use of other urban elements (i.e. surfaces shading each other), etc.

❖ Ventilation of buildings and outdoor spaces by the spatial distribution of green spaces of appropriate shape and size (i.e. parks) for redirecting and guiding of winds, correlation of building obstacles and open spaces (provision of adequate non turbulent air flow, avoidance of the Bernoulli effect), appropriate layout of buildings (correlation of height and distance), etc.

❖ Natural cooling and provision of thermal comfort by other techniques such as: provision of unobstructed sky view factor of external building surfaces towards the sky for radiative cooling, spatial arrangement of water bodies of appropriate shape and size for evaporative cooling, etc.

Applications in Greece

In Greece there are a few applications of energy design of settlements, such as:

1. The Solar Village in Pefki, in the area of Athens, where bioclimatic design has been applied, with the integration of passive and active solar systems, including a central active solar system for domestic hot water production.
2. A settlement of 120 bioclimatic residences in Kalamata (http://www.agores.org/Publications/CityRES/English/Kalmata-GR-english.pdf).
3. In Corfu island, the Municipality of Thinalli, in cooperation with 5 other neighbouring municipalities, has promoted a plan for RES integration aiming at 100% coverage of the energy demand of the area by the year 2005. Energy conservation techniques and renewable energy sources are already being applied in buildings of the Municipality of Thinalli, the study for the exploitation of local biomass has been completed, and measurements are being conducted for determining the wind energy potential of the area. (http://www.agores.org/CTO/Catalogue_Summaries/Corfu.pdf).

Additionally, the **integrated design of a new energy autonomous settlement** using Renewable Energy Sources has been produced for the Foundation of Repatriated Greeks, in the Region of Thrace. This settlement comprises 300 dwellings – with the potential of future addition of one more dwelling per lot, as well as a school, a day-care centre-kindergarten, a medical centre, a church, a shopping centre and a guesthouse. The full coverage of the energy demand of the settlement includes the needs of the 83 agricultural greenhouses designed for the professional rehabilitation of the repatriated Greeks. The urban and architectural design was conducted by the architectural firms of A. Spyropoulou-Vei, and A.N. Tombazis, while the overall energy design by CRES with the participation of the Energy Research Group (University College Dublin) and the German firm WIP - Renewable Energies Division.

Studies of integration of Renewable Energy Sources in existing settlements have been conducted by CRES, such as the design of RES integration in the Historic Centre of Corfu and in the Medieval Town of Rhodes.

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BIOCLIMATIC DESIGN OF URBAN SPACES AND THE USE OF VEGETATION

Bioclimatic design of urban spaces includes building scale, block, or even the whole scale of the city. Aim is the creation of urban complexes with favourable microclimate, comfortable exterior spaces, as well as the reduction of energy consumption for heating and cooling of the building sector. Design interventions and regeneration techniques may be applied in various scales and in the outdoor spaces, public or private.

Microclimate and building

The microclimate of an area is affected firstly by the prevailing climatic conditions: temperature, sunshine, wind velocity and direction, and humidity, which present seasonal as well as diurnal variations. The built environment, the orientation and geometry of buildings, the topography, the ground coverage by various types of vegetation, the materials, and the colours, formulate the microclimate of an area, which determines the comfort conditions in spaces and the energy consumption of surrounding buildings.

Microclimatic design of urban scale requires specific orientation and layout of building complexes, as well as the layout and width of streets. The appropriate configuration of the surrounding space and the choice of vegetation depending on season, insolation or solar control is required, along with the wind exposure or wind protection of the urban complexes, is required in order to improve the microclimate of an area.

An important factor to this aim is the use of materials applied in buildings, streets, or sidewalks, which affect the microclimate, the comfort conditions in outdoor spaces, and the energy consumption of surrounding buildings. Properties of materials such as the reflectivity and long wave emissivity, determine, to a great extent, the temperature of exterior surfaces. Light-coloured surfaces absorb a small amount of the incident solar radiation, as they reflect the largest part, and, therefore, the temperatures that occur are lower, contributing to the reduction of overheating in outdoor spaces as well as buildings, a fact that is crucial during the summer period.

VEGETATION

The configuration of the surrounding space and vegetation significantly affects the microclimate of an area. The most important role of vegetation in the built environment is the contribution to the air temperature reduction during the summer period, due to shading of the area and rejection of heat through basic functions of the plants for photosynthesis, transpiration, and evaporation. As the plant transpires, water is evaporated from the leaves and 'traps' thermal energy from the environment, cooling the leaves and the air surrounding them, resulting to the drop of temperature of the surrounding space. Therefore, the air near the ground in tree-planted areas is cooler than in other urban areas.

Various studies and experiments where temperatures were measured at tree-planted areas and in the built environment have taken place, showing that the temperature difference may reach 5 °C, affecting favourably microclimate of an area. Generally, even in the same space the expected temperature difference is about 2 °C in the area affected by vegetation. Equally important is the fact that, due to lower temperature of plants and the ground, the long-wave radiation emitted by these surfaces is reduced compared to the radiation emitted by surfaces exposed to the sun. Therefore, the resulting thermal load on humans is much less, significantly improving the thermal comfort conditions during summer months.

When vegetation is used near buildings for solar protection, the building load may be reduced, while raising systematically the amounts of vegetation in a city, significant energy conservation for cooling may be achieved in the urban environment.

Vegetation affects additionally the field of wind flow of an area, reducing wind velocity. By grouping tufts of trees, the creation of wind brakes is possible, providing protection to nearby buildings, by reducing the wind speed towards this direction. Depending on needs, it is possible to use tree-planting for the redirection of wind and for the creation of currents around a building, aiming at cooling the building.

Other benefits from vegetation concern the reduction of the atmospheric pollution in the cities and in noise reduction. The reduction of noise occurs due to absorption, reflection, and diffraction of noise by the foliage. Plants, depending on their layout, act as an effective sound barrier, with the creation of a buffer zone. The sound barrier may reduce noise up to 10 dBA, it is placed in proximity to the source of noise, while the psychological factor is equally important with the visual separation and possible hiding of the noise source.

Design applications

Integration of vegetation in architectural design may occur at single building level to city scale.

In single buildings it includes trees at a short distance from the building, creeping plants, and pergolas attached to building walls, planted roofs, etc. Depending on the building orientation, different types of greenery are recommended, aiming at improving microclimatic conditions and reducing energy consumption of a building.

At the urban scale, vegetation is integrated in streets, parks, groves, gardens, playgrounds and other recreational spaces, improving the area microclimate and the potential of city ventilation. In public space, shading of whole streets is possible, providing thermal and visual relief. The shaping of the outdoor environment with the appropriate vegetation design, further aids to the redirection of wind and wind protection, depending on the height and density of trees.

Applications in Greece

There are no applications of bioclimatic design at urban scale in Greece to date. The upgrading of urban space, however, is possible with appropriate regeneration plans, taking into account the principles of sustainable development of the urban environment, further improving the quality of life in densely built urban centres.

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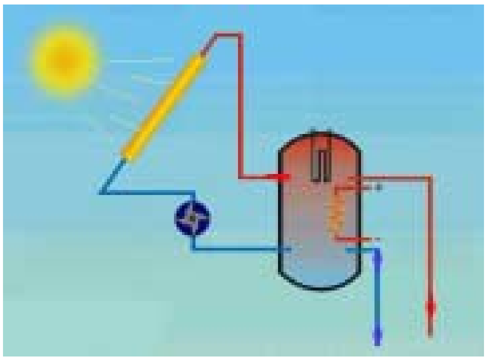
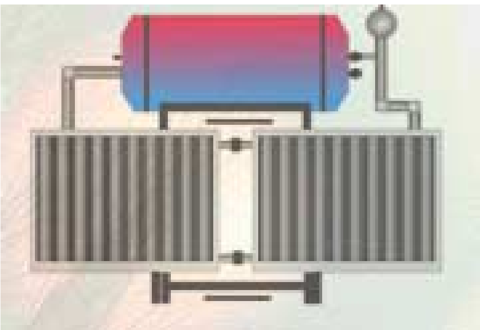
ACTIVE SOLAR (SOLAR THERMAL) SYSTEMS

Solar thermal systems convert solar radiation to heat. Active solar systems operate the collectors and the tank storage as separate components and the energy transfer is attained through a pump system.

A thermal solar system collects, stores and distributes the solar energy with the use of either liquid or air as the fluid for transferring the heat from the collectors. Active solar systems can be used for domestic hot water heating, for space heating and cooling, for desalination, for several industrial and agricultural applications, for pool heating etc.





Categories of Solar Thermal Systems

Active solar systems can be classified in several categories, according to the application that they are designated for, the technology that is in use, their size, the climatic conditions of the area etc. This variety presented by the layout of the systems is mostly due to different ways that these systems are protected from frost.

There are two types of active solar systems: The systems of natural circulation and the systems of forced circulation. The first are separated in two categories:

1. The compact heaters or, as they are also called, the integrated systems of collector-storage, which are constituted from one or more storage tanks and are placed in an insulated jacket with their transparent side facing the sun.
2. The thermosyphoning systems, which are based on natural transfer for the water circulation in the collectors and the tank which is placed on top of the collector. As the water heats up in the solar collector becomes lighter and rises naturally towards the storage tank, while the cooler water of the tank flows via the piping system towards the lower part of the collector generating circulation in the whole system.

The forced circulation systems use electrical pumps, valves and controlling systems in order to circulate the water or the other transfer liquid of the heat inside the collectors. There are two types of such systems:

1. The open loop systems, which use pumps (circulators), in order to circulate the domestic water in the collectors.
2. The closed loop systems, which pump the heat transfer liquid, as for example an antifreeze mixture of glycol and water, inside the collectors. The heat transfer through the heat alternators from the liquid to the water that is stored in the tanks.

The natural circulation systems are in general more reliable, easier to maintain and has possibly longer life span than the forced circulation systems.

Applications

1. Domestic hot water production

Hot water solar heaters of every type can supply a large percentage of the household needs in hot water use, reducing at the same time the domestic energy consumption. The volume of the hot water that solar energy restores depends on the type and the size of the whole system, the climate and the sunshine of the region.

The central solar systems applied in housing complexes are particularly efficient. These systems consist of a central collector system and a central tank, providing hot water in single residences (e.g. apartments), via channel network. With this system, the demand in hot water is evenly distributed diurnally and thus the thermal losses of the stored water for covering the demand of the housing complex are reduced. Such a system has been applied in 'Solar Village' in Pefki of Athens.

2. Space heating and cooling

Space solar heating represents a potentially very large market, even if the possibilities for the wide application of that technology in existing buildings of densely populated urban areas, especially in multi-story buildings, are rather limited. Active solar heating systems are based on components such as roof collectors for the heat collection and distribution. Air or a liquid is used, which is heated inside the solar collectors and afterwards, is transferred by fans or pumps consuming a small amount of energy.

Air solar systems consist of collectors, fans, air-ducts and control systems and can heat up the air of a house without heat exchangers or thermal storage. In large air systems thermal storage is mostly used, for example a dispenser with gravel or small stones. Liquid solar heating systems include the solar collectors, the storage tanks, the pumps, the piping, the heat exchangers (in closed loop systems) and the control systems.

Due to the consequence in the demand for cooling or freezing with the highest available solar radiation, the solar cooling appears as a much promising technology, which may be the start of a fast developing market. The absorption cycle cooling is the first and oldest of the air-conditioning technologies. An absorption cycle air-conditioning does not use an electric compressor in order to mechanically maintain the cooling medium under pressure. Instead of that, a heat source, such a large solar collector is used, in order to evaporate the cooling fluid already under pressure from a mixture of absorber/cooling medium.

3. Desalination

Solar energy can be used for the desalination of sea water with a cost that allows the use of the water in agricultural applications. Considering that most arid areas are close to the sea, the desalinated water can be used for their reformation.

4.Pool Heating

In a swimming pool heat of low temperature is needed in order to maintain the water temperature around 27^{o}C. The small difference between the mean daily temperature of a heated swimming pool and the temperature required for swimming allows the usage of very simple, but simultaneously efficient collectors. In this type of systems the existence of a separate storage tank is not required, since the swimming pool serves as heat storage.

Among the thermal systems utilizing renewable energy sources, the active solar systems are the ones with the larger penetration in the market. The respective manufacturing activity started towards 1970's and since then has been remarkably developed, while results of this development are products of high reliability, competitive prices, and continuously improving quality.

With respect to the various applications, with exception of the uncovered collectors that are used for the water heating in pools, the greatest majority of active solar systems that are produced and sold in Europe are used for hot water supply for domestic use. Large solar collector systems used for water heating or pre-heating in large-scale applications represent a small percentage of the total installed collectors' surface and mostly regard hotel installations, hospitals etc.

Applications in Greece

In Greece there is a very large number of applications of active solar systems. More than 600000 households cover a large amount of their domestic hot water demand by solar water heaters. The sales of domestic solar water heaters are about 50000 yearly. Furthermore, there is a significant number of central solar systems installed in hotels, hospitals, etc. In the Athens area a central solar system for domestic hot water is installed at the Solar Village in Pefki, while there is an installation of 300 square meters of flat solar collectors at the Stadium of Peace and Friendship, covering the needs for hot water used by the people in the Stadium. The efficient operation of the solar systems of the SPF has been proven by measurements conducted by CRES using tele-monitoring for a long period of time.

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PHOTOVOLTAICS IN BUILDINGS

General Information

The use of photovoltaics for electricity production from the sun is a significant alternative energy technology, mainly from an environmental aspect. However, it is not always an economically viable solution. Greece has increased potential for PV development and application, due to the high solar availability (sunshine). The ability to produce adequate amounts of energy remote as well as populated areas without any environmental impact renders the use of photovoltaics in Greece attractive.

Nowadays there are several users, mostly in remote areas with a lack of electricity networks, for whom the photovoltaic systems are the most recommended and economical solution for covering their electricity demand.

Through the photovoltaic technology the energy of solar radiation is utilized. The intensity of solar radiation incident on a surface of 1 m^2 a day with sunshine may reach 1 kW.

The yearly total incident energy on a surface depends on the geographical location and on the orientation of the surface. For the area of Athens, the value of the energy incident on a horizontal surface of 1 m^2 yearly is approximately 1500 kWh. Taking into account the fact that PV frames available in the market transform 11% of solar energy to electricity, one panel 1 m^2 produced about 110 Wp.

Advantages- disadvantages

The main advantage of the PV technology is the electricity production on the spot of use. Other advantages are the following:

- no atmospheric pollution,
- long life span of solar panels (over 25 years)
- silent operation,
- minimal operation and maintenance cost,
- capability of integration on roofs or building facades as main structural elements,
- capability of system expansion depending on energy demands.

The recent years a strong interest has been expressed for PV systems applications on buildings. In these applications PVs are placed on buildings for electricity production, while the PV panels are simultaneously used as structural building elements, covering external building surfaces (i.e. on roofs, on facades, as shading devices, etc. They may also be installed on structures of the broader built environment, as on outdoor parking lots, coverings, sound protection walls, etc.

The benefits of the wide scale application of PV in buildings are multiple. The electricity production from PVs is the only technology that may be applied in an urban environment without producing any pollution. The electricity may be produced during peak load hours, supporting the energy system at periods of high production cost. Due to the distributed production of electricity at the localities of demand, the losses at the transportation and distribution system are minimized.

The cost of PV panels is the main obstacle to the wide application of PV technology. Nevertheless, in many cases, such as in remote areas or in areas where the cost of producing electricity is high, PVs present the most recommended, technically reliable and economically acceptable solution.

Key issues

The main benefit for installing PVs in buildings is the use of the PVs as building elements that replace other materials used on the exterior surface of buildings, and which have often high cost (as in the case of façade coverage). The savings produced by this cost reduction, makes the use of PV systems more economically viable.

The main applications of PV in buildings are:

- covering all or part of the building roof
- use on glazed building facades (i.e. curtain walls)
- use on weather protection devices such as overhangs or shading devices.

Particular care should be given to architectural design so that the PV panels are aesthetically harmonized with the building's architectural form. During the design of the PV system the active participation of the architects in required, in order to combine the technical solution with aesthetically good results.

Integration in buildings

For the installation of PV frames on existing structures ordinary panels with aluminium frames may be used. In this case an additional intermediary structure is required where the PV panels will be placed.

For PV applications in new buildings, 'laminate' type panels without the frame which allow their integration as structural surfaces of the building are preferable. The panels may be supported by specially designed materials or by standard materials used in the market for the support of glazing.

Furthermore, many construction firms may produce PVs by order in specific dimensions or even in various geometrical shapes. For applications of PV panels integrated on buildings panels of various colours and varying transparency levels are available (often at the expense of reduced efficiency). Additionally, manufacturers offer special products, such as PV panels that may replace roof tiles or other conventional materials used for covering roofs.

Orientation

In the case of PV systems placed on the ground, the orientation allowing the maximum utilization of incident solar radiation is given. This is also desirable in the case of PV applications in buildings, but this is usually not possible the existing building surfaces provide a restriction to this. As a result of this the maximum exploitation of solar radiation is not always possible. Nevertheless, the losses from the deviation from the best orientation may not be so important, as are the benefits from the use of panels in substitution of other building elements. What is of importance is the exclusion of shading produced by neighbouring buildings or objects from the surface of PV panels, mainly during the hours of intense solar radiation, because even a minor shading of the PV panels may result in an important reduction of the produced electric power. In the case where solar radiation does not reach evenly all the PV panels, the connection of PV panels in small arrays of even insolation is recommended. In an array of non homogenous insolation or in the case of partial shading, the efficiency of the whole array is defined by the efficiency of the panel with the lowest performance.

Connection to the electricity grid

The output of a PV array is connected via appropriate inverters to the electricity grid. The electric energy produced by the PV system is used for covering part of the building electricity demand, while the remaining loads are covered by the electricity network. Thus the owner benefits from the reduced network electricity consumption. In periods where the PV production is higher than the electricity load of the building, the surplus energy may be sold to the network at a fixed price. For the connection of PV arrays with the electricity network inverters converting the direct current produced by PVs to alternate current. The advanced technology of inverters allows the production of electric power output of high quality, while for network security reasons their operation is stopped in the case where the network supply is cut off.

Applications in Greece

In Greece there is a limited number of installed PV systems, of total installed capacity in the area of 1400 kWp. The applications of PV in buildings are very few, and usually the PVs are not integrated as building elements, but are placed on the building roof. During the recent years, several companies have attempted to expand their activities in this field. Such companies handle the production and trading of aluminium profiles, while one large construction firm is constructing a PV production factory where, among other applications, building roofs with integrated PVs for houses will be produced.

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DISTRICT HEATING WITH BIOMASS

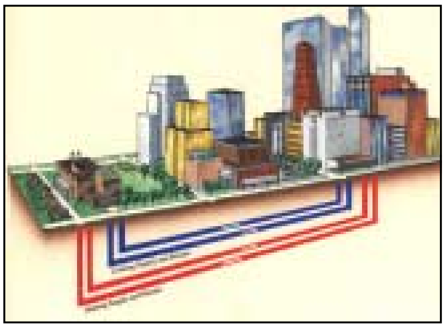
District heating is the provision of space heating and domestic hot water in a building complex, settlement, town or city, through a central heat production plant. The heat is transferred through a network of insulated pipes from the plant to the heated buildings.

A district heating system consists of:

a) The production plant where the central equipment (boilers, fuel supply system, chimney, pumps, etc.) is installed.
b) The distribution network of the heating medium, which is warm or hot water, from the production plant to the heated buildings.
c) The connection substations, through which the connection of internal heating installations with the district heating distribution network is achieved.
d) The internal heating installations of buildings (pipe networks, heating devices, etc.)

Advantages

- Energy conservation by the utilisation of a local energy resource.
- Achievement of higher efficiency level. The usually inadequate maintenance of boilers and burners of conventional central heating systems in residences reduces significantly the efficiency of the system, while in centralized systems the efficiency is high, due to the consistent maintenance, with direct result the conservation of energy.
- Improvement of living standards, as higher quality of heating is achieved, especially compared to cases where there are local heating devices (fireplaces, wood furnaces, etc.), while the consumer ensures his heating putting additional effort (supply of petrol or wood, maintenance of burner, etc.)
- Reduction of the country's dependence from foreign energy sources.
- Conservation of a significant amount of exchange currency due to the reduction of imported fuel.
- Minimisation of environmental pollution, on the one hand due to the use of a central heat production unit, properly maintained, instead of many units dispersed in the buildings, and on the other hand due to the use of biomass as a fuel, instead of petrol. The SO_x emissions are minimal, the NO_x much less than the ones from conventional fuels, while a significant conservation of CO_2 is achieved.



Technologies

The boilers where biomass is burnt and hot water is produced are installed in the production plant. Usually boilers with furnaces of moveable grates are used. Biomass is supplied to the boilers through fully automated supply systems. The exhaust gases are cleaned by special devices such as polycyclones, bag filters, and electrostatic filters and are then directed to the chimney and from there to the atmosphere. The pipes of the distribution network are insulated and consist of an internal steel pipe, polyurethane insulation and an external protective polyethylene covering. The pre-insulated pipes are placed directly on the ground. Wires (usually made of copper) are placed on the polyurethane insulation in order to locate the appearance of humidity along the network, via a special electronic control system. The appearance of humidity may be due either to leakage from the steel pipe, or to humidity entering from the ground to the insulation. The warm water recirculates in the distribution network by the aid of pumps.

Key issues

TECHNICAL

The technology is mature with respect to the production of warm water by burning of biomass in boilers, as well as with regard to the distribution of warm water from the heat production plant to the connected buildings through a network of pre-insulated pipes. Applications of district heating with biomass are in operation internationally for at least 25 years (Denmark, Finland, Austria, etc.)

NON-TECHNICAL

The applications of district heating with biomass are investments of intense capital, due to the high required initial capital.

The fuel cost is an important factor in the expenses created by the district heating systems, therefore the economic viability of such investments are sensitive to its variations.

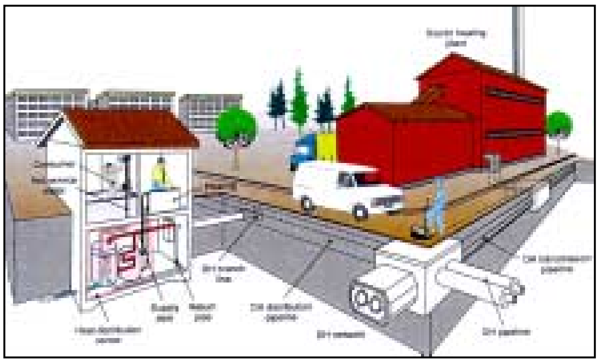
An important problem to be solved before the beginning of a district heating project is the assurance of provision of the required amounts of biomass at agreed rates. This may be achieved by long-term contracts and deals with farmers, forest associations, forest authorities, etc. The ability to utilise an alternative fuel, even for a short period is important, in order to secure the supply of the system with fuel in every case.

An important parameter in the viability of an investment is the number of buildings connected to the system, in order to be heated. Thus, in order to achieve direct connection of the maximum possible number of buildings with the network when the plant is constructed, a complete and extensive informing of the inhabitants of the settlement, that is, potential consumers, before the project is materialised, on the benefits they will have from the installation of district heating system (economic, environmental, quality of life, etc), but also of the possible impacts (i.e from the building of a boiler-room). This action may be achieved through seminars, informative brochures, etc.

The enterprise managing the district heating system should determine with particular care its rating policy. In order to have a competitive value of the thermal energy sold from the enterprise to the consumers, this should be significantly lower than the alternative of utilising local boilers, so that there is a strong motive for consumers to become connected to the grid.

Applications in Greece

In Greece today there is no district heating system operating with biomass. However, there is one application under construction, the district heating using biomass in the Municipality of Megalopolis of the prefecture of Arcadia. Additionally, several studies have been conducted for heating settlements by utilising the available in the area forest and agriculture biomass.



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MUNICIPAL SOLID WASTE (MSW) EXPLOITATION

1. Energy production

The utilization of municipal solid waste (MSW) for energy production occurs through thermal process and anaerobic treatment of organic matter, at large housing estates (that is urban and not small settlements or isolated housing groups). The energy exploitation of MSW, as regards the sustainable operation of cities according to the Local Agenda 21, constitutes one of the most important methods of integrated waste management.

Exploitation of MSW aiming at energy production, has multiple benefits, such as:

1. Promotion of the integrated MSW management at a local urban level, taking into account the 99/31/EC Directive, but also the Local Agenda 21 directions for sustainability
2. Independence from the use of conventional fuels while securing energy supply through the exploitation of a "resource", as MSW are considered to be nowadays
3. Reduction of unregulated emission of gasses such as CH_4, NH_3 and CO_2 which have adverse effects on the environment (greenhouse effect, acid rain, etc.)
4. Reduction of underground water pollution from the landfill leachate
5. Avoidance of fires from disperse landfills, where disposal to rubbish tips on sleep slopes.

The barriers to the energy exploitation of MSW in Greece concerning the non-technological barriers are the following:

1. Managerial insufficiency and lack of planning of the Local Authorities Bodies as well as the State.
2. Structural lagging and indefinite strategy, shortage of expert staff at crucial policy making positions, also lack of co-ordination and reliable records as well as studies.
3. Inadequacy of environmental awareness of civilians in Greece to a point that limits the success of recycling programs at source and of the acceptance of any MSW management plants (NIMBY syndrome).

2. Most important technologies of MSW exploitation

MSW exploitation includes the following material or energy recovery methods:

Recycling: Sorting of re-usable materials (paper, glass, etc.) at source (e.g. houses, offices) in separate buckets or concentration and mechanical shortage at disposal sites of MSW (sanitary landfills).

Combustion: The incineration of the total of domestic waste in industrial plants for the production of energy and steam or the after mechanical treatment of MSW with the production of solid fuels (RDF – Defuse Derived Fuel) which are also used for energy.

Composting: Separation of MSW for the retrieval of the organic matter (food remains, fruits, organic) at source (neighborhood) or at concentration areas for the production of compost as soil conditioner.

Anaerobic digestion: Organic fraction collection is carried out as in composting, where, via anaerobic digestion, either in mesophilic (30^o – 37^oC) or in thermophilic phase (50^o – 60^oC), biogas is produced for the production of energy through internal combustion engines (ICE).

Sanitary Landfill: During MSW landfilling in containment landfills, anaerobic process occurs and results in biogas production, which is pumped and burned in ICE's for energy generation.

Pyrolysis: The organic fraction of MSW is degraded via thermal process in the absence of oxygen and gases (CH_4, H_2, CO_2, CO), liquids (with plenty of trace organic components) and solids (carbonated solid remaining of high calorific value) are produced. Relatively low temperatures are used, 400-800 ^OC and the application is a relatively recent development.

Some combinations of the above methods for the energy exploitation of MSW might be:

1. Recycling materials – Sanitary Landfill – Biogas pumping – Energy production
2. Recycling materials – Anaerobic digestion of organic fraction – Biogas production – Energy Generation + Compost
3. Material separation – RDF production – Energy production + Sanitary Landfilling
4. Material separation – Organic composting – RDF Pyrolysis – Sanitary Landfilling of remaining.

The selection criteria of the most possible combination of MSW treatment methods should take into account the following points:

1. Environmental impact concerning CH_4, NH_3, air-borne ash and VOC's as well as toxic pollutants such as dioxins
2. Cost of processing or of the combination of technologies that will produce the smallest possible investment cost
3. Investment cost, which involves the changing local conditions but also the alternative exploitation shapes
4. Technology implementation duration, keeping in mind the technological developments and the investment risk of the specific application
5. Required land ownership, which assigns the type of technology as well as the combination of methods (urban areas – NIMBY syndrome)
6. Percentage of exploitation with respect to the included synthesis of MSW (humidity, organic fraction and inert materials).

Applications in Greece

Nowadays in Greece, there is unrestricted disposal of a great portion of MSW to landfill sites, while only a small portion which has immediate trading value (newspapers, aluminum cans, etc.) is systematically recycled (i.e. by Associations of Municipalities).

There are no MSW treatment applications of energy exploitation today in Greece. However, the Composting Plant of the Kalamata Minicipality (photo) is in operation, while the Mechanical Separation Plant in Liosia sanitary landfill has been nearly completed.

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7. Photo, Source: ENVITEC, S.A.

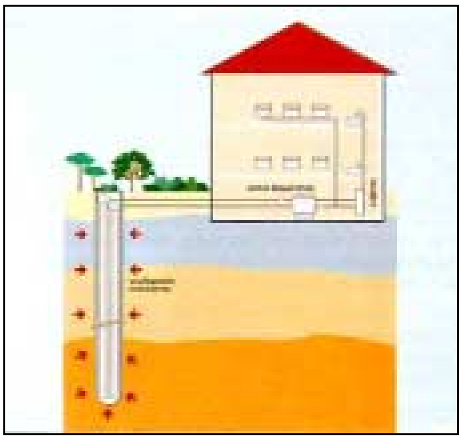
GEOTHERMAL ENERGY

Geothermal energy is a renewable energy source that can cover a variety of energy demands using current technology.

Geothermal energy is the energy enclosed inside the earth and may be exploited through the geothermal fluids. The most important parameter in its utilization is the temperature of the geothermal fluids, which determines the type of application of geothermal energy.

In Greece the most common application is the heating of agricultural greenhouses. Other applications include district heating of buildings, combination with heat pumps in buildings, pisciculture, drying of agricultural products, desalination of water (sea or geothermal water), and others.

Main areas of geothermal interest in Greece



Geothermal system for house heating and cooling with water heat pump and geothermal heat exchanger

Advantages

Geothermal energy is a clean energy, when the final geothermal waste products (if any) are handled appropriately. The relevant technology for the protection of the environment has been developed and is currently available.

The benefit is obvious taking into account the reduction of CO_2, SO_2, NO_x and other emissions, which occurs due to the energy conserved when using geothermal energy. Specifically, in cases where the characteristics of the geothermal fluids make it necessary, the fluids return to their bank, through a second drill (re-entry drill). This solution has the additional benefit of the replenishment of the geothermal fluids, as well as raising the life span and the exploitation potential of the geothermal field.

The drills and the pump facilities have a minimal aesthetic impact on the environment, as they are constructions of small volume.

Technologies

Geothermal energy, depending on the temperature of the fluids, is classified in three categories:

- low enthalpy (25-100° C)
- medium enthalpy (100-150° C)
- high enthalpy (> 150° C)

High enthalpy geothermal energy is used mostly for electricity production. The installed capacity of the geothermal electricity production units around the world is around 8.250 MW_e (1999). The technology required for the exploitation of geothermal fluids of this category is highly developed and widely known. It is based mostly on the use of heat exchangers or, in some cases, on the direct use of geothermal fluids.

Applications in the building sector

The applications of geothermal energy in buildings vary depending on the temperature of the available fluid. For temperatures higher than 90ºC the applications include:

1. electricity production
2. cooling and air-conditioning with absorption heat pumps,
3. space heating with space radiators,
4. hot water production in boilers,
5. desalination of sea water for use in hotels, etc.

In the case of temperatures lower than 90ºC applications include space heating with water air-heaters or floor heating systems, the production or pre-heating of water via heat exchanger and the hot baths. When water temperatures are below 40ºC, heat pumps for heating and cooling are applied. If no underground water is available, heat pumps may be combined with earth heat exchangers.

Applications in Greece

As is seen in the map, there are several areas with a significant geothermal potential, where there are hot or warm baths.

Apart from baths, geothermal applications in Greece include a) greenhouse heating (mostly for horticulture and rose production) in Nigrita, Sidirocastro, Langadas, Nymfopetra, N. Apollonia, N. Triglia, N. Lesvos (Polychnitos), and in Melos, b) ground heating for ripening of asparagus in N. Erasmio and Nigrita, and c) production of drinking water in Kimolos island.

Applications in buildings:

Geothermal applications in buildings in Greece include (1) geothermal floor heating systems applied in an office in New Erasmio, (2) floor heating of the hotel of Traianoupolis Baths in Alexandroupolis, (3) heating and air conditioning with geothermal heat pumps and/or exchangers of five buildings: (3ı) the building of Mineralogists of the National Technical University (3ii) the buildings of the European Centre of Public Law in Legraina, Attica, (3iii) the new building of CRES in Pikermi, Attica, (3iv) the building of Petaloudes Municipality in Rhodes, and (3v) the Papageorgakis residence in Lagonisi, Attica. Two more are under construction: (3vi) the district heating and cooling of schools, health centre, and county house, and a hotel in Langadas in the Thessaloniki region, with the transfer of water of 20-40ºC at a distance of about 2 km from the Hot Baths to the city of Langadas which uses also water cooled heat pumps, designed mostly by CRES, and (3vii) the heating and cooling of the new building of the Municipality of Pylaia in Thessaloniki, financed by CRES.

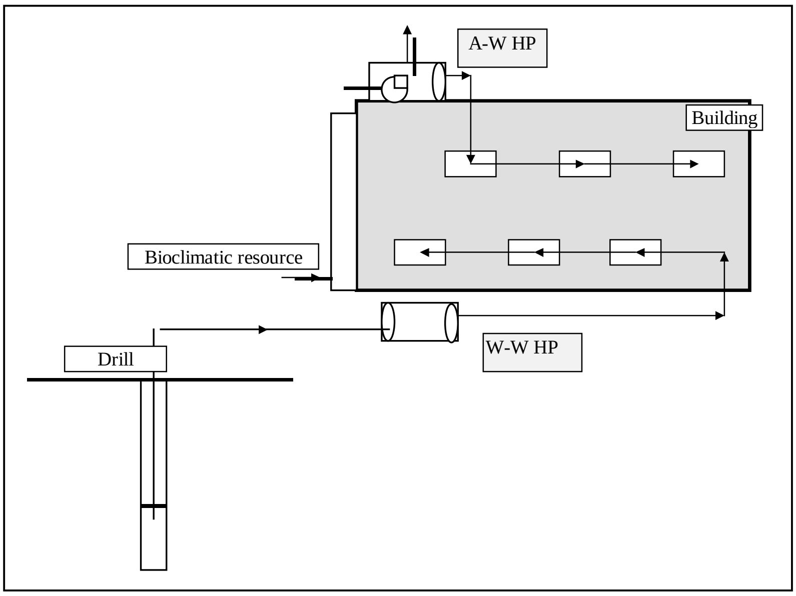
Geothermal application in CRES office building

In the new office building of CRES, constructed in 2001, a geothermal heat pump water-to-water unit is being applied. The building has two storeys and an area of 220 m^2.

As seen in the graph below, the water of the drill during winter passes through the evaporator of the geothermal water-to-water heat pump and offers its heat to the cooling cycle (the design temperatures for the well water are 18/12 ^oC). Simultaneously, the compressor of the heat pump heats the separate water circuit of the fan coils network of the ground floor and offers to it is temperature, thus raising the temperature that dropped form the building losses (the design temperatures for the water are 40/45 ^oC). The heat pump has a cooling power of 16 kW and a heating power of 17,5 kW.

The unit uses the well water of the existing drill at a distance of 10 m from the building. The average temperature of the drill water is estimated around 18 ^oC, while its supply has been measured to be 1,2 m^3/h.

Due to the fact that the supply of the drill is not sufficient for covering the total building load, but only for the ground floor, a second, solar-assisted air-to-water heat pump unit has been installed, at the evaporator side, with a capacity of 18 kW, covering the load of the upper floor.



Schematic representation of the operation of the geothermal heating/cooling system of the new building of CRES, with the application of a heat pump (ground floor) and the solar-assisted heat pump (upper floor).

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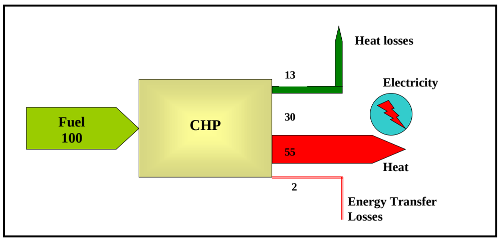
COGENERATION OF HEAT AND POWER

General Information

Cogeneration is the consecutive (simultaneous) production and exploitation of two energy sources, electrical (or mechanical) and thermal, from a system of the same fuel.

With cogeneration more rational utilising of the fuel energy is made and proportional reduction of the pollutants is achieved. It is applied in the industry and buildings where there is simultaneous demand of electricity and heat and, usually, when the annual hours of operation surpass 4000.

In a standard electric power station (thermal, hydro-electric, nuclear etc) the average efficiency is 37%. The losses due to electricity transfer to the consumers are almost 8%. Efficiency is reduced to 34%. In Greece the efficiency is much lower mainly due to lignite. The total efficiency of CHP stations is 85%.



Cogeneration Advantages

The successful installation of CHP leads to reduced consumption of fuel of almost 25%. The reduction of atmospheric pollution is proportional. Also with the use of natural gas the emissions are reduced to zero SO_2, and smoke.

The user benefits are purely economic, because the energy cost is reduced in comparison to the “traditional” units. In succesful installations of CHP the price reduction is 20-30%.

The reliability of the energy supply is increased. The CHP station connected to the electric network, where it provides or absorbs electricity guarantees uninterrupted operation of the unit, in case of interruption of the station’s operation or electricity supply from the network. On country level, it reduces the need of installation of large electric power stations and increases the stability of the electric network of the country.

Cogeneration Technology

The basic part of a CHP installation is the machine that produces electricity and heat. The basic technologies are:

1) **Gas turbine** (Brayton cycle). Known from its use in airplanes. Air is constantly pressurized up to the combustion chamber and then it is released.

2) **Steam turbine** (Rankine cycle). It uses high enthalpy steam to produce mechanical work and also steam of lower enthalpy.

3) **Combined cycle**. Combination of the above, with heat recovery boiler between them.

4) **Internal combustion reciprocating engine** (Diesel or Otto cycle). Known from use in vehicles. Diesel engines of large vehicles or petrol engines (gas engines) of smaller cars.

5) **Fuel Cells.** Basic principal of these systems is the production of heat and electricity without combustion. With electrochemical reactions the fuel (mainly natural gas) is broken down and as a result of the chemical reactions, heat and electricity is produced (in the form of ions).

Machines 1-4 produce energy by connecting a generator to their axis. The heat is produced by recovery boilers with or without additional combustion. Refrigeration is produced absorption and recovered heat.

Choosing the System

The first stage in the decision of installing the CHP system is determining the energy demands of the unit. The choice of the system will be made after all energy saving measures have been taken. The fuel and hot water or steam consumed in the previous 2-3 years must be carefully registered. Daily curves give the potential use of the unit. Predictions for future consumption and use are being made. From the above the factor heat/electricity is calculated which is one of the main criteria by which the machine is chosen.

Financial Analysis

The economic analysis is the one that will prove if cogeneration is acceptable and which technology will be implemented.

The CHP system is connected to the national electric network. To the network this CHP station will:

1) Provide (sell) electric power surplus

2) Absorb (buy) needed electric power

The cost of an installation consists of:

Investment cost. Is the sum of the basic machinery of heat and power production, of the fuel storage units, of the possible filters of combustion gasses, labor, building installations, pipes, cabling, control systems and finally all engineering overviews and studies.

Operation and maintenance Costs. The fuel cost of the main CHP engine consists the main operational cost. Revenue from the electricity sales to the network is added and expenses of electricity purchase from the network is deducted. The labor and spare parts cost is evaluated for the periodic maintenance of the CHP system and the operating costs are added.

Based on the above the economic rates are calculated from which we can decide whether cogeneration is a financially beneficial solution or not. Sensitivity analysis follows.

Legal frame- Funding

The primary law which defines the applications of CHP is 2244/94. The initial evaluation is made by the Regulatory Administration Authority (RAA) then the Ministry of Development and the Ministry of Physical Planning and Public Works.

The installation of a CHP unit requires large capital investments in the beginning stages. This capital can be obtained by bank loans or monitory enterprises with the “Third Party Financing” method.

Current situation

In Greece today roughly 20 CHP units exist mainly in industrial installations, with 2% participation in the national share of electrical power. The installation of new units is under way.

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ELECTRICITY SUPPLY OF SETTLEMENTS WITH RENWABLE ENERGY SOURCES

With the evolution of technology in the area of Renewable Energy Sources (RES) as well as in the static power converters' sector, it is possible to produce reliable solutions of electrification of settlements exclusively by RES. Principal sources are solar and wind energy, hydraulic energy (small hydro), and additionally biomass and geothermal energy. By combining various sources with power converters and appropriate control, the quality in the produced electricity power is ensured.

Apart from providing autonomous electricity supply to settlements, RES can and should be used in combination with existing and conventional systems of electricity production in local or national grid-connected networks for supplying part or all of the electric energy required.

A key issue is the ability to apply energy conservation measures and overall energy management at the settlements' scale, in order to ensure the maximum, most rational, and most economic coverage of the energy needs by RES.

Advantages

The main advantages of RES exploitation systems for electricity supply of settlements are the energy independence and the production near the spot of use. Additionally, there is a minimal or no impact to the atmosphere, in most cases no noise, low maintenance cost and potential for expansion according to local energy needs. It is the most economically viable solution in the case of remote settlements, not connected to the national grid.

The use of RES for electricity production is particularly attractive when combined with heat production (CHP systems).

Technologies

The systems of electricity production for settlements utilise the energy from RES, convert it to useful electric energy and supply the settlement network.

The RES systems use conventional units for converting energy such as photovoltaic generators, wind generators, etc. In Greece and in many other countries solar and wind energy are the most commonly used sources. Wind energy is variable at places and its application is subject to urban and environmental restrictions. On the contrary, solar energy is almost constant and with minimum constraints. Therefore solar energy is a primary component in RES systems for electricity supply of most settlements.

Due to the fact that solar radiation, as well as wind velocity are variable on a daily and seasonal basis, the storage of energy is necessary. The storage is usually in the form of electric energy in batteries.

For the conversion of parameters of electric power to parameters compatible with the users' appliances and for the control of the batteries, special power converters are used. The overall control of the energy flow of the system is provided by a special unit. For increased reliability, the system may be complemented by an electricity generating couple (oil generator).

There are two topologies of systems:

In the first topology (diagram 1), all the sources are connected with the batteries by charge controllers, and consecutively, one or more power converters convert the continuous voltage to alternating with appropriate parameters (230/400 V , 50 Hz) and provide power to the settlement network.

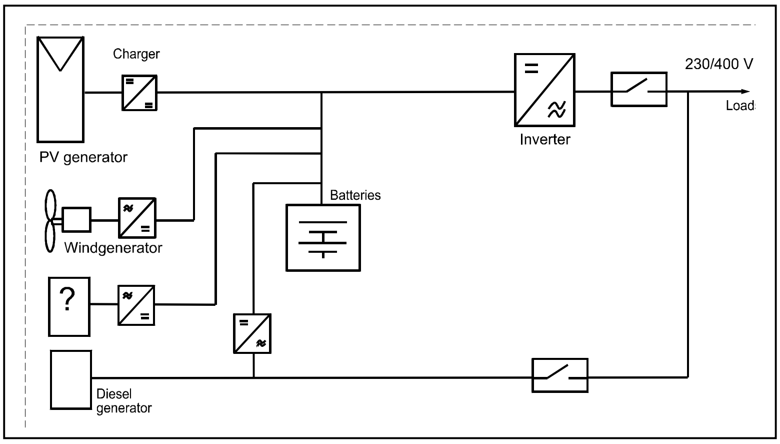

Diagram 1: Topology with continuous voltage line.

In the second topology (diagram 2), each unit is connected and provides the power produced, through an appropriate inverter, to the network of the settlement, for which the power parameters are provided by the converter that simultaneously controls the load of the batteries.

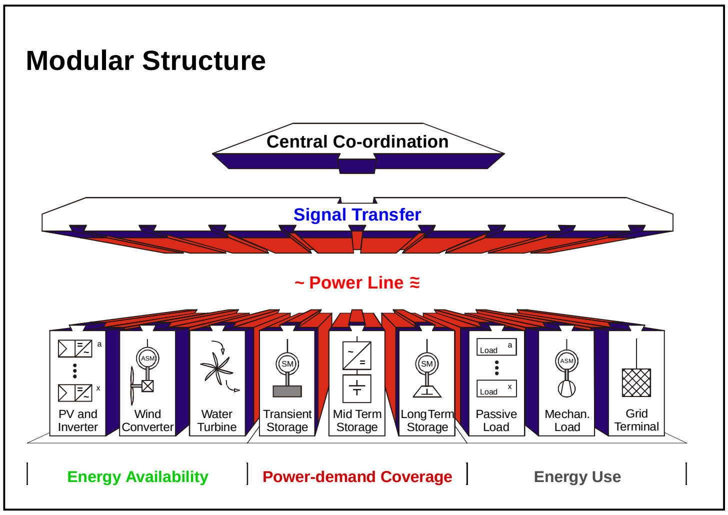

Diagram 1: Topology with alternating voltage line.

The energy management is achieved by the control unit of the system, which is programmed in order to achieve the optimal exploitation of energy from RES, the quality of the power and the system reliability.

Technology selection

The choice of system and technology is based on the conditions of the place of application and on the demand on quality of power and on reliability. In Greece the most probable renewable energy sources to be used are solar and wind, due to the large solar availability and strong winds prevailing in the country, without exempting the use of other energy sources such as geothermy, biomass and small hydro, where this is possible. In the case of utilisation of biomass or geothermal energy for electricity production, the exploitation of the produced thermal energy during the conversion (combined heat and power production) is a significant economic advantage.

As far as the selection of topology is concerned, the second topology has advantages compared to the first, but it still is in the development stage. Soon it will be fully developed and units that may be incorporated to the system with minor interventions will be available in the market. The first topology is widely used, but is expensive due to the high costs of components of continuous voltage and current.

The storage of electric energy in batteries is the weakest point of the system (poor efficiency, maintenance and replacement). An alternative solution is the construction of a pumping hydroelectric plant, the operation of which is based on water pumping, in the cases of low loads, from one tank to a second which is placed higher, and in the output of energy, when this is recommended.

Important element in the design of the system is the control unit. The optimum means for energy management results to, among others, the best exploitation of RES, the quality of the power provided and the increase of life of the system.

The photovoltaic Park of the Public Power Corporation in the island of Kythnos

<u>Applications in Greece</u>

Greece presents remarkable conditions for the development of electricity systems by RES for the following reasons:

- high levels of sunlight and high wind potential in many areas
- existence of many island or other remote areas characterised by the lack of electricity network, or characterised as environmentally sensitive areas (archaeological sites, etc.)
- to-date use of conventional electricity production methods (oil generators) in island areas with high cost of maintenance and pollution of the environment
- increase of the electricity production by RES (particularly with photovoltaic systems) during the highest peak period (summer).

In Greece nowadays there are applications supplying electricity to settlements with RES, such as in the case of the island Gavdos. There is also a significant amount of autonomous systems for electricity supply of isolated houses or other buildings utilising similar technology.

For the small islands of Greece, which are, in their majority, not connected to the national grid, the use of RES is a viable alternative for their electricity supply.

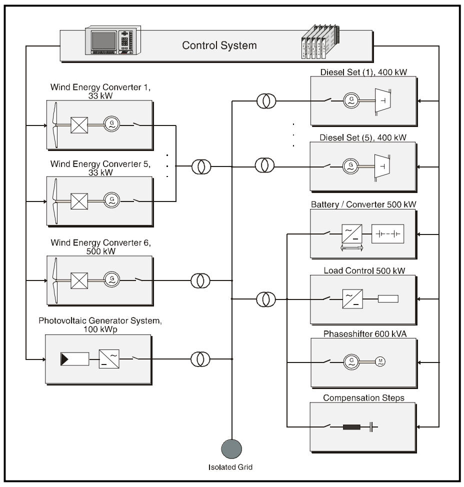

Diagram 3. the network of the hybrid electricity production system of Kythnos. [Source: ISET]

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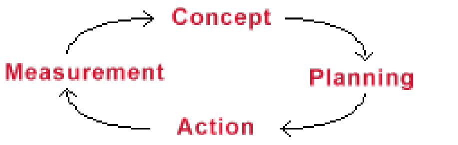
ENERGY MANAGEMENT IN BUILDINGS

The use of energy results in an important part of the operational costs in buildings and / or industries and constitutes a primary factor in the achievement of the inhabitants' levels of comfort. The energy management aims at providing such conditions and services, so that building inhabitants feel comfortable while the least possible energy is consumed. This is based on the prudent use of energy equipment and could be achieved through:

- The optimization of the equipment operation starts / stops.
- Shut down of the equipment during the low demand periods, which therefore are low efficiency periods.
- The gradual start up of the equipment in order for picks to be avoided.
- The definition of setting points according to other data as time tables, external ambient temperature, usages etc.
- The decrease of consumption peaks with discretionary shut down of systems during high demand periods

The energy management procedure consists of four contingent stages, more specifically the concept, planning, implementation and monitoring stages. The energy management basic tools consist of energy audits, energy monitoring, adequate maintenance of equipment and implementation of energy saving measures.



Concept: Define your aims and targets, the achievements that need to be fulfilled, the methods that you will follow and the way of the evaluation.

Planning: Plan the activities, use the sources (existing and new) and the employer skills (through training and incentives) in order to achieve the desired targets.

Action: Implement your plan in the easiest and most effective potential way.

Measurement: Define what must be counted and plan the measurements in a way to evaluate the performance level that needs to be changed, in the frame of a continuous search for ways of efficiency improvement.

Energy Audit

Energy audit is a study targeting the specific determination of energy flows in the installation and answering the next four questions:

- How much of each available fuel is being used and how much does it cost?
- What is this energy used for?
- What other choices exist (and how much do they cost), in order to decrease energy consumption?
- What are the most economic effective energy saving measures?

There are two kinds of energy audits: the walkthrough, and the extensive audit. The walkthrough audit is based on existing data, such as electric or fuel purchase bills, the type and the size of the building, the energy systems available data, etc. This type of audit is based on calculations and not on any kind of local control. On the other hand, the extensive audit is based on local checks and accurate recording of conditions and energy consumptions.

Energy Monitoring

The observation of the operation of the buildings energy systems is an important procedure for the effective use of energy. With energy monitoring, the energy use is organized, logged and examined in the whole building, dividing the energy data according to the usage and the source of energy. It also enables the continuous control of the amounts of energy consumption and use, and helps the energy manager to be updated for the condition of building / plant energy systems. For this purpose various indexes are been used, as is the rate of building energy consumption to the building volume or area. Besides energy monitoring that index is also used for energy labeling of the building.

Maintenance

The energy systems that are not maintained properly, consume higher energy amounts to achieve the same comfort levels. Prevention maintenance preserves low operation cost; simultaneously it preserves the service standards, as the systems perform better and the breaks down hours are decreased. For example the inadequate maintenance of a boiler can decrease its efficiency more than 10%. The periodic maintenance of equipment must be implemented according to a schedule. So instead of a necessary repair an inefficient operation can be prevented. The maker's instructions must be followed, as it is very common for the maintenance needs between different systems to be significantly different

Energy Saving

There are different levels of energy savings that can be achieved according to the existing facilities and the available investments. The need of a complete economic evaluation can be considered before the implementation of a project.

Low or zero costs measures:

- Energy sources shut down (heating lighting) when they are not needed
- Inhabitants activation for the effective use of energy (training may be needed for the improvement of their awareness level)

Measures that embrace a level of initial investment:

- Control systems implementation – central heating systems, central energy management system.
- Building or planning of a new building related topics improvements
- Lighting improvements
- Use of combined heat and power systems
- Air conditioning / ventilation improvements.
- Introduction of solar systems.

When these kinds of measures are considered the following factors should be taken into account.

- The benefits that will be achieved
- The capital investment that is needed and the depreciation time
- The aggravation level that will be originally incurred and the maintenance issues.
- The requisite technical knowledge level

Action plan

When the possible energy saving prospects has been defined, a proper action plan should be formed and introduced. That enables better action organization and ensures that some actions will not be forgotten along the way, while it helps the ex post facto estimation of energy benefits that have been accomplished due to each action separately. A typical energy management action plan includes the following:

- Energy audit is needed for the estimation of current building condition.
- Simple saving measures and correct maintenance should be accomplished firstly. With that a large amount of most costly actions can be eliminated.
- Before their implementation, the higher cost measures should be estimated to see if they are economically viable. Otherwise, the capital can be diverted in other more beneficial direction.
- The whole system replacement is a more costly action and should be avoided (except in the case that it is strictly inevitable), as, apart from the consequent cost, other problems may occur.

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ALTERNATIVE ENERGY AND ENERGY CONSERVATION IN TRANSPORT

General Information

Energy consumption in the sector of transportation equals the 39% of the total energy consumption or in other words, the 59% of the liquid fuel consumption. The pace of increase in the consumption in the sector of transportation is achieved more quickly than in the other sectors of national economy, such as the industrial, the commercial and the household ones.

The consequences in CO_2 emissions are also relevant. It is therefore easily understood that the sector of transportation needs special attention in the attempt of undertaking energy saving measures and constraining the emission of CO_2 (stabilization or decrease). Road transportation has the biggest participation (88%) in CO_2 emissions, while as far as the network categories are concerned, the percentage of the urban transportation network in the total emissions of road transportation is 42%, of the provincial network 26% and of the interurban 32%.

These figures are mentioned in order to prioritize the intervention areas so that the expected benefits are optimized. In any case, though, the suggested measures must take into consideration the cooperation and the coordinated actions of many agents. Agents such as the constructors, the purchasing public, the users of the public means of transportation, the organizations with vehicle fleets, the responsible ministries and the local authorities.

Energy Saving Measures in the Sector of Transportation

The attempts (the measures), which have been made to date aiming at energy saving in transportations, focus on:

✓ Limitation of passenger cars in urban centers

- Banning traffic in the center
- Alternate traffic of passenger cars whose plates end in even- odd numbers
- Cars in the center with at least 2 passengers.
- Optional passing of cars of low or zero emissions (electric cars)

✓ Increase in the use of Mass Media Transportation (MMT)

- Modernization of the fleet (efficient vehicles, alternative fuels)
- Introduction of management systems of traffic flow (telematic systems)
- Improvement of transportation and traffic infrastructures (roads, traffic lights, electronic information)

✓ Production of vehicles of low consumption and limited emissions.

✓ Use of alternative fuels (natural gas, liquid gas, electric cars, bio-fuels)

In the framework of incorporating the environmental dimension into the energy planning of transportations with the aim of sustainable development, ways of limiting the use of passenger cars and the minimization of negative consequences in the quality of life and the environment are sought. The implementation of any planning must lay the conditions for the shaping of a legal, institutional and financial framework.

Strong Action Areas

The actions mentioned below aim at the decrease in CO_2 emissions and energy saving in connection with the improvement of vehicle efficiency, road behaviour and alternative forms of fuels.

1. Implementation of the European directive 1999/94 for the implementation of the Fuel Saving Label on Passenger Cars.
Objective: The existence of a label for fuel saving for all new passenger cars exhibited at sale points with information about fuel consumption and CO_2 emissions.
Aim- Benefit: Introducing the energy- environment parameter in the choice criteria for the purchase of new car. Encouraging of manufacturers to produce more energy efficient cars with low CO_2 emissions.
Responsible agent for the harmonization of the above directive is the Directorate of Control of Air Pollution and Noise of the Ministry for the Environment, Planning and Public Works. The plan of the Ministerial Decision has already been formed and is on the stage of signing by the co-responsible Ministries.

2. Introduction of using alternative fuels in vehicle fleets.

Objective: Bringing into traffic mass media transportation of alternative fuels in big urban centers with environmental problems. 295 buses using natural gas as fuel have already been added to the bus fleet of the Organization of Urban Transportation of Athens. As far as bio-fuels are concerned, research is still being carried out in order to overcome various technological, financial and legal obstacles before they are widely used. Moreover, the electric vehicles meet very specific needs of the transportation demand, mainly the ones related to moving around the city. However, the lack of infrastructure, the high purchasing price of electric cars and their limited autonomy hinder their introduction in the market and help it only in very specific uses, such as the formation of a specific fleet comprising mini electric buses in order to serve selective electric routes in the historic center of Athens.
Aim- Benefit: Improvement of energy and environmental efficiency of transportation means. Improvement of traffic and quality of life in aggravated areas.

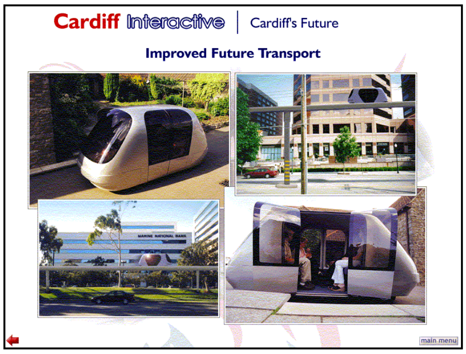
3. Improvement of the management system of mass media transportation

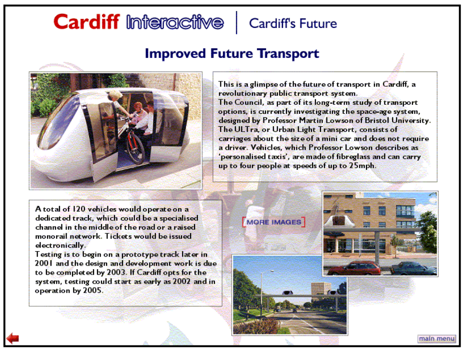
Objective: Methodology development based on the philosophy of the written system of environmental management for its implementation in companies providing transport services.
Various systems of environmental management (EMAS, ISO 14001, BS 7750) for the control of performance procedures aiming at the continuous improvement of their environmental performance can be applied with extremely satisfactory results. A guide has already been developed in Finland for the implementation of the environmental management system ISO 14001 in the administrative procedures of the Ministry of Transportation and Communication and the supervised organizations and companies. The measures to be undertaken up to 2020 in the sector of transportation aiming at sustainable development (development with the conservation of natural and human generated environment) are included in the guide.

Aim - Benefit: The improvement of energy and environmental performance of transportation companies.

4. Introduction of economical driving techniques into vehicle drivers

Aim -Benefit: The decrease in fuel consumption, the decrease in emissions, the decrease in accidents, the decrease in maintenance cost, the increase in road safety and the improvement of transport conditions for drivers and passengers.
In many European countries, such as Germany, Switzerland, Netherlands, France, the principles of economical driving are pilotically applied with very good results. There are already organizations in these countries with specialized instructors for the implementation of economical driving seminars for professional drivers and drivers of passenger cars.
The Center of Renewable Energy Resources will implement such a pilot action for bus drivers of the Organization of Urban Transportation of Athens (OASA, ETHEL [Thermo-Bus Company]) in the framework of the European Programme SAVE.





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SUSTAINABLE CITIES

Sustainable Development and Agenda 21

In June 1992, the United Nations' Environment and Sustainable Development Summit took place in Rio de Janeiro, Brazil. Leaders of the nations agreed to act collectively in the 21st century in order to protect the environment and improve quality of life of mankind. The result of the Summit was an action plan named "Agenda 21".

Agenda 21 aims at sustainable development, which is:

«...the development that satisfies today's' needs, without undermining the ability of future generations to satisfy their own...» (Brundtland Commission, 1987).

According to Agenda 21, mankind is obligated to:

- Decrease the use of fossil fuels, the exploitation of natural resources, waste production and emissions.
- Protect sensitive ecosystems and to conserve landscape diversity.
- Distribute wealth, opportunities and responsibilities for the future fairly among nations and social groups of every nation, while emphasizing on the needs and rights of those groups less fortunate and minority groups.

These targets can be realized with conscientious work at all levels, from the local to the international. Furthermore, every citizen must get involved in decision-making and every social group must co-operate, with sustainability being the common target.

Local Agenda 21 and the European Sustainable Cities & Towns Campaign

In the 28th Chapter of Agenda 21, the importance of Local Authorities in every country is recognized and roles and responsibilities are attributed:

«...As Local Authorities are the level of governance closest to the people, they play a vital role in educating, mobilizing and responding to the public to promote sustainable development. That is why by 1996, most local authorities in each country should have undertaken a consultative process with their populations and achieved a consensus on a "local Agenda 21" for the community. Each local authority should enter into a dialogue with its citizens, local organizations and private enterprises and adopt "a local Agenda 21" ».

The European Union embraced the idea of Local Agenda 21 with enthusiasm and on 24-27 May of 1994, at the 1st European Sustainable Cities & Towns Conference in Aalborg, Denmark, the European Sustainable Cities & Towns Campaign begun.

Initially 80 Local Authorities signed the Aalborg Charter and up until today more than 1300 agencies from 38 countries have signed it. By signing the Charter, they are obligated to get involved into the process of development and accomplishment of social consensus of local societies in a long-term action plan for sustainability.

The second phase of the Campaign begun with the Lisbon Conference in October 1996 and focused on the realization of the Charters principles, on the initiation process and engagement of a Local Agenda 21 programme, and on the realization of a local plan for sustainability, to create the Lisbon Action Plan.

The 3rd European Conference on Sustainable Cities & Towns took place in Hanover, Germany, on 9-12 February 2000. During the conference, 62 European local and municipal authorities signed the Aalborg Charter. The next phase strategy and a draft proposal for a Decision of the European Parliament and Council on a Community Framework for Co-operation to promote sustainable urban development COM (99) 557 were also presented.

Embodying Local Agenda 21 in the City of Today

The realization of Local Agenda 21 can include the following measures and proposals, when taking into consideration every environmental domain:

- Energy Management: Use of Renewable Energy Sources for energy production (photovoltaics), heat and warm water (solar panels, geothermal pumps). Development of energy saving applications like low energy consuming appliances and central energy management systems. Creation of properly staffed Energy Management Service at a municipal level.
- Waste Management: Recycling, Materials Reuse-Regain.
- Urban environment and Building: Building without alteration of the local characteristics of each area (traditional settlements) and degradation of the natural landscape.
- Transport: Electrical/Hybrid vehicles, use of bio-fuels, traffic measures, promotion of public transportation.
- Green-Parks-Gardens: Increase of green grounds.
- Environmental Education: Organization of seminars, conferences, for the involvement and information of the public, accession of environmental education in schools.
- Local Market: Promotion of environmentally friendly products.

Greek applications of the Local Agenda 21

In Greece, various Municipalities have adopted Local Agenda 21.

In 1996, the Municipalities of Maroussi and Chalandri began the first programme, where part of their activities are natural gas networks and municipal electrical cars.

Additonally, the town of Lavrio was the first to formulate the Environmental Charter and secured financing for land restoration and creation of a Technological and Cultural Park for Sustainable Development.

The area of Plaka is another area that was upgraded and the historical, traditional and housing character was restored.

Other areas in Greece where Local Agenda 21 is applied are Ksanthi and the Municipality of Kallithea on the island of Rhodes.

Sustainability, Energy and Buildings

A very important factor for achieving sustainability is the functional and friendly to the environment, energy design of buildings.

Low energy consumption building design, can be achieved through bio-climatic architecture and low cost use (e.g. double windows) and high tech choices (e.g. solar district heating, passive solar systems, centralized solar systems).

The use of recycled materials, certified for their environmental friendliness (Eco-label) and recognized for their minimized impact after usage, contributes to sustainability.

Of equally great importance is the harmonious incorporation of buildings into the natural environment.

Finally, another important factor is the citizen's role, where with their active involvement and them being informed they can contribute to the functional operation and performance of buildings.

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