Design guidelines for the Efficient Integration of Renewable Energy systems and techniques in new-build settlements in Europe

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ABSTRACT

The White Paper on renewable Energy proposes market measures for fair access to the electricity market, fiscal and financing measures, a bio-energy initiative and improved building regulations. The building's sector represents 20 to 45% of the total energy consumption in the various European countries. A project called RESSET has been undertaken with the aim to study and propose global strategies, tools and guidelines that will promote the efficient and cost effective global implementation of Renewable Energy Sources systems and techniques in new-build settlements in Europe. The study moves towards the direction of promoting the use of RES and other energy saving systems and techniques in the building sector. An educational package including global strategies, tools and guidelines on the integration of RES system and techniques in the efficient design of new settlements will be produced.

KEYWORDS
Energy efficiency, renewable energy, efficient building

INTRODUCTION

The White Paper on renewable Energy proposes market measures for fair access to the electricity market, fiscal and financing measures, a bio-energy initiative and improved building regulations. The Community Strategy for action plan, of which ALTENER is an integral part, incorporates a take-off campaign of renewables, one of the aspects of which is the integration of renewables in a larger number of communities. The total energy requirements in the domestic sector could be reduced by 50% in EU until the year 2010, half of which could be accounts for by introducing passive and active solar technologies in buildings.

A project called RESSET has been undertaken with the aim to study and propose global strategies, tools and guidelines that will promote the efficient and cost effective global implementation of Renewable Energy Sources systems and techniques in new-build settlements in Europe. The specific objectives of the study include the combination and adaptation of scientific and technological knowledge with best engineering and architectural practice in order to study, develop, propose and disseminate global actions on the integration of RES systems and techniques in new-build settlements, the development of tools for best practice and economic efficient development and management of new-build settlements, the study of the existing legislative framework on the implementation of advanced RES systems and techniques in settlements, the assessment of five case studies on the global integration of RES in settlements planned to be constructed in Europe, the integration of the results and conclusions into a set of design guidelines for managers and designers of settlements, urban sites and utilities.

1 Energy and Buildings in Europe

Buildings represent the most important energy consuming sector. According to recent estimations the primary world energy consumption of the building sector, is close to 17 Mtoe per day which is almost equal to the daily production of the OPEC countries.

The building's sector represents 20 to 45% of the total energy consumption in the various European countries. The mean energy consumption of buildings in the European Union countries represents almost 40% of the total energy budget. The primary energy use in housing and non-domestic buildings in EEC countries, is made up of 43% fuels for electricity generation, 20% of directly used, 18% gas and 6% of soild fuels directly burned and finally 13% of solar energy.

The mean energy consumption in Europe exhibits a slowly increasing trend. A significant increase has been observed in Southern European countries which is mainly due to the increased living standards and low energy prices. On the contrary, the primary energy consumption of buildings in Northern Europe has been reduced during the last years, as a result of intensive energy consumption measures.

The building industry is one of the biggest economic sectors in Europe representing a annual turnover of the order of 400 Billion Euro. However, the buildings industry is diverse and highly fragmented, does not have significant funding for research while in general, energy efficiency is not a primary design consideration. Intense competition, despite the limited finances, force the industry to run, in general short term and low risk research projects, aiming to improve their particular products. This type of research although limited given the size of the buildings industry, has given valuable products which are available to the market.

2 Reducing the energy consumption of the building sector- the role of passive solar systems and techniques

Reducing energy in the built environment requires examining every aspect of a building and its surroundings, including its materials and structure, operating equipment, landscaping and relationship with its surrounding environment and the behavior of its occupants. Energy consumption plans should aim at reducing the energy requirements of key building elements and harvesting the supply of renewable energy available to the buildings.

The building's envelope together with the building's equipment and the outdoor conditions, control the energy consumption of buildings. Especially the building envelope regulates the mass and heat transfer, thus the energy flow through the building and defines the environmental quality and energy consumption of buildings. Thus, in order to improve the energy performance of the built environment, it is required that proposed interventions have to be applied in all elements mentioned above. During the last decade one main approach for improving the energy performance of a building, is the one taking advantage of renewable energy sources, as the wind and the sun, by selectively allowing or permitting natural ventilation and solar radiation to enter the building for cooling or heating purposes. This approach, combined with interventions modifying the local microclimate of the surrounding environment (vegetation, use of cool materials, use of water, etc.), increasing the efficiency of the building's energy systems (use of advanced HVAC equipment, use of district cooling and heating techniques, use of active solar systems) and enhancing the building's envelope (increase of insulation, use of radiant barriers and reflective materials), can significantly increase a building's overall energy performance.

Where solar and other RES based passive and hybrid techniques are used as alternatives to conventional heating, cooling and lighting systems, various benefits occur:

- Direct and indirect environmental benefits, associated with reduction of CFCs due to the reduced use of air conditioning equipment and reduction of CO2 emissions caused by electricity production and use of fossil fuels
- Improvement of indoor quality, due to the increase of thermal comfort, visual comfort and indoor air quality.
- Cost savings including savings in capital, maintenance and running costs.
- Energy savings in primary energy which, depending on the case, can be considerable
- Reduced strain on national grids and utilities due to the decrease of the peak electric demand.
- Simplicity and ease of operation on of the used systems, less dependence upon mechanical systems and more opportunities for personal control of the building's environment
- An efficient long-term investment with less dependency on supplies of delivered energy

The penetration of passive solar design in Europe is not negligible. There are some 10000 to 20000 passive solar dwellings in the EU, but there are probably no more than a few hundred other buildings which incorporate such features. However, passive solar supplies EU countries with the equivalent of 96 Mtoe pf primary energy per year, which represents 13% of the total annual building's consumption. In USA during the 80's, there were almost 150000 passive solar homes and 10000 non-residential buildings, while it is estimated that some thousands of buildings being added each year. It was estimated that passive solar constituted as much as 5 to 15% of masonry material sales.

Rapid penetration of solar energy technologies is directly related to the replacement rate of buildings. The current housing replacement rate averages around 1-2% per annum in Europe, while non-domestic building as are replaced more rapidly. The slow replacement rate of buildings increases the potential for passive solar retrofitting of existing buildings. In the frame of older research projects evaluating the energy efficient refurbishment of various types of buildings (office, multiuse, residential), it was clearly derived that proper building retrofitting using energy conservation and passive solar techniques can significantly reduce their energy consumption, even up to % of their energy requirements when conventional design is used.

Based on the above discussion, it can be easily derived that the integration of solar and other RES-based systems and techniques in the built environment of an existing settlement, will potentially have a high potential of applicability, as a global integrated approach can be followed investigating the potential of using such energy-efficient systems in all sectors of the settlement, including architectural characteristics of buildings, energy systems and modification of surrounding environment. Since the design of a settlement is global, it is easier for the designer to design the integration of advanced solar and energy efficient techniques in the rehabilitated settlement's fabric, taking in account the relationship and interaction of the proposed interventions, either when these are applied at building level or at settlement level.

3 Development of guidelines and tools for solar and energy efficient design of buildings

The development of new advanced building materials, components and RES related systems and techniques, as well as of experimental and analytical methodologies evaluating the performance of such energy efficient interventions to the build environment, within the framework of research projects and activities, should be complemented by defining how such information benefits the city planning and building design community. To utilize the knowledge gained from research activities into real world applications, tools are necessary for application and dissemination of this information. With these tools an architect or designer can take advantage of years of solar research to make intelligent design decisions.

In addition these educational tools should include and replicate best practice applied to successful cases of implementing solar and energy efficient interventions around Europe. As, during the last decade, the number of RES applications in the building sector has dramatically increased, a large database of best-practice guidelines tested successfully in the field has been formulated and is expanded everyday. All this technical expertise and know-how should be collected, classified, evaluated and disseminated to the largest possible audience, so that professionals benefit from the acquired best-practice knowledge and be capable of easily replicating integration of solar and energy efficient systems and techniques in the built environment.

Educational actions aiming to integrate all new research findings and acquired best practice into a complete and global approach are necessary, in order to fully exploit our better understanding of the science and engineering behind RES technologies which has resulted from the various research and development actions in this area. This global educational approach should create the necessary links between research results and practitioners, to reach the mainstream of building professionals and to awaken their interest in energy-efficient building design and improved building performance.

The integrated and global implementation of RES-based efficient measures, can benefit the settlement and its inhabitants in many ways. In detail, the benefits due to the application of the proposed global RES strategies include:

- Decrease of energy consumption
- Money saving through decreased maintenance and operational costs
- Improvement of indoor and outdoor living conditions
- Increase of the property's value
- Improvement of the settlement's environmental performance

As it is obvious successful global integration of RES and energy efficient measures in new settlements, requires good knowledge of the available systems and techniques and appropriate expertise on their installation, operation and maintenance. In addition the designer should be familiar with the advantages and disadvantages of each technique, with the cost and potential benefit of each intervention, with the possible restrictions on the use of some techniques under specific climatic or operational standards and generally with the philosophy of the integrated design.

During the last 20 years, numerous research activities have been realized on the efficient integration of RES in buildings or in the built environment, producing educational tools aiming to help professionals and authorities. At the same time a large amount of best practice on the same field has been acquired through the realization of many projects and pilot demonstrations, integrating in practice solar and energy efficient techniques in the built environment. However, never in the past an attempt was made to develop a scheme for the integrated energy efficient use of RES in settlements. The scope of the current study is to combine these sources of information and translate them in practical design guidelines and

decision making tools, that will aim building professionals in the direction of efficient integration of RES systems and techniques in new settlements.

3.1 Objectives

The study moves towards the direction of promoting the use of RES and other energy saving systems and techniques in the building sector, by combining the above presented elements: the need for providing high quality training based on scientific achievements and acquired best practice to related professionals on the use of RES and on the energy efficient integrated building design, the lack of appropriate educational material, tools and guidelines for the global integration of energy efficient techniques in all aspects of new developed settlements (microclimate, buildings, local and district energy systems) and the high potential for energy savings due to RES integrated design and development of settlements in Europe.

The main objective of the project is to study and propose global strategies, tools and guidelines that will promote the efficient and cost effective integrated implementation of Renewable Energy Sources systems and techniques in new-build settlements around Europe.

The specific objectives of the study and of the actions planned to be realized within its framework are:

- the combination and adaptation of scientific and technological knowledge with best engineering and architectural practice in order to study, develop, propose and disseminate global actions on the integration of RES systems and techniques in new-build settlements. The considered techniques will involve actions aiming (i) to improve the local microclimate, (ii) to improve building design and implement the use of passive and active RES systems and techniques in them, (iii) to study the potential of centralized cooling and heating systems operated with the use of RES, (iv) to study the potential and the applicability of specific Demand Side Management actions managing and controlling the energy requirements of the developed settlements.
- to develop tools for best practice and economic efficient development and management of new-build settlements and their environment as well as of the used remote energy systems, integrating the broad use of RES in all levels.
- to study the existing legislative framework on the implementation of advanced RES systems and techniques in settlements, identify possible barriers and contribute to the development of appropriate national and European codes and standards.
- to study a number of real case studies around Europe, applying the proposed design guidelines and tools to settlements actually planned to be constructed, thus evaluating on one hand the efficiency and applicability of the proposed guidelines and on the other hand the potential benefits dye to the use of an integrated RES strategy to new-build settlements.
- to integrate the results and conclusions from above into a set of design guidelines for managers and designers of settlements, urban sites and utilities proposing appropriate interventions, techniques and methodologies for the energy, environmental and economic efficient integration of RES in new-build settlements.

3.2 Direct outcomes, results and products of the proposed action

Training and advice provision are the more efficient and convincing processes to encourage people in applying energy efficient technologies in buildings. An issue of key importance is to continuously educate building professionals and clients to facilitate the implementation of the basic principles and main techniques and systems, by providing them the necessary resources - available information and tools- in a

complete and simple form. It is evident that it is not possible to evaluate exactly the impact of educational material and provision of guidelines to energy conservation and thus to apply cost-benefit analysis that action. However, it is more than sure, that it is a very powerful tool towards a more efficient integrated design of buildings.

The effect of the action will be to provide the following:

1. The new training material will permit to promote energy efficient integrated design of settlements, will increase the efficiency of the education on this topic and thus will contribute in reducing building energy consumption in Europe.
2. The proposed educational material combines and links, all the necessary information on RES integrated settlement design, thus professionals will benefit a complete and combined set of information that will facilitate and improve design of buildings, systems and settlements' environment.
3. Development of the educational material will facilitate training institutes, by minimizing the time to collect primary information, significantly reducing the cost of production of new educational material and improve educational standards and promote efficient courses on the topic.
4. The development of an educational package with specific orientation will avoid or minimize the possibilities to organize educational actions not well fitted with the issue of settlement sustainable development, reducing therefore the risk to spend teaching hours and funds inefficiently.
5. The evaluation of the five case studies of new-build settlements provided by the local partners, will result in the potential use and implementation of active and passive solar systems and other energy-efficient RES techniques in each examined settlement, as it will act as motive and initiative for the application of an energy saving strategy. This can eventually lead to important energy savings, up to 15-20% of the estimated energy consumption required for all functions of the settlements functions (heating, cooling, lighting, ventilation) and consequently to relevant significant money saving and decrease of CO2 emissions. The specific targets that have been set by each involved region are reported n the ANNEX, where information on each proposed case study is presented.

3.3 Project work plan, methodology and approach

In order to fulfill the above mentioned objectives, it is proposed that an educational package including global strategies, tools and guidelines on the integration of RES system and techniques in the efficient design of new settlements will be produced. The process will include:

a) a theoretical part in which acquired scientific knowledge derived from previously made research activities will be combined with high quality expertise and best practice, in order to evaluate the performance of various active and passive energy efficient techniques when are applied to the built environment at settlement and building level and propose specific guidelines in the form of do and don't on the integrated design of new sustainable settlements

b) the evaluation of a number of case studies, so that the derived guidelines and conclusions are applied in real life examples and their efficiency is evaluated in practice. Global scenarios will be derived and applied so that all possible aspect of RES integration n settlements is sufficiently investigated.