TOWARDS A STRATEGY TO ZERO ENERGY BUILDINGS (ZEB) CONCEPT

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Abstract: *The energy consumption in buildings and the need for its reduction has been since the late 60's and 70´s a main question among professionals (designer, architects, and engineers), legislators and users around the word. Reduction in energy demand for heating for instance was implemented in the so called Solar Buildings (with reduction of 70 to 80% in the heating demand).*
The building regulation start putting targets, in the overall annual energy consumption xx kWh/m2 year, and some achieve the level of standards, imposing very low values, such as Passivhaus standard which fundamentally consists of an energy limit (net useful energy demand for heating of 15 kWh/m²/year and a total primary energy consumption of 120 kWh/m²/year).
Now we are dealing for a new concept, in which those values approach zero (ZEB) or even minus, which correspond to building which produce more than what they spend (ENERGY PLUS BUILDINGS).
This paper discusses some of the main issues regarding the strategy to achieve some of these goals in the future.

Keywords*: Energy Efficiency in Buildings, Passive Buildings, Zero Energy Buildings.*

INTRODUCTION

Buildings are one of the most important sectors in world economy; cities are growing very fast and during this year (2008) more than half of the word population (3200 millions) will live in urban areas. In Europe this figure represent 75% of the population. Many of these cities are becoming "*Mega cities*" (MC) with population more than 10 Millions, in 1950 there was two MC (New York and Tokyo) in 2008 there are 20. This increase occurs special in Asia, where it is expected to have an increase of number of new cities, some of then (250) with population up to 5 Millions (The Worldwatch Institute – Sate of the World 2007).

This situation leads us with major problems worldwide, namely;

- Increase of Energy Consumption in Buildings (and the increase of energy prices);
- Climate Change (global and micro-urban heat island)

Which correspond to major challenges for which, important answers are needed world wild, in the following technical areas;

1. Urban Planning
2. Building Design
3. Energy Efficiency
4. Integration of Renewable Energies in the Buildings

If these problems and challenges are global, if we look for different parts of the word, they assume different levels of importance and different answers also. The problems in a poor country for instance Peru - South America, are totally different in a rich country in Europe or US, so different approaches and answers are needed.
Having in mind all these issues, the main focus in this discussion paper will be at the Building level (Design strategy and approach), Energy Efficiency and Integration of Renewable. Nevertheless there are important maters, such us social and economic, user's behaviour, which are key elements in the implementation of some of the technical answers, not to speak in the regulatory measures that a little bit everywhere is trying to push "*sustainable solutions*" for some of these questions.

Energy in Buildings

How do we spend energy in our buildings?

In Europe energy consumption in buildings represents around 41% (2005) of the total energy consumption, which represents for countries and citizens an important part of the annual expenses, mainly in countries where heating needs are mandatory for the well being of communities.

Different realities according to climate, from north to south the heating degree day can varies from 7000 HDD to 600 HDD and the Cooling Degree Days from 1000 CDD to zero.

According these conditions and culture heritage the buildings were built and adapted to the severity of the climate in the pass. In the last century, there was a change in this process mainly because energy was largely available and cheap and the requirements for comfort increase very much. So the user behaviour start change as also the designer and the building construction in order to use without any particular restrictions, the available sources of energy, consequently there was an increase of energy consumption in buildings.

Only after the first “energy crises” in the 70’s, this behaviour starts changing all over, not only the users start being more conscious about this issues, but also building designers and regulators. Many countries draw the first building codes or guidelines, and many architects and engineers start new approaches and innovation in building design.

In terms of final consumption, space heating is the most important end use of households, with 57%, followed by water heating (25%), electric appliances (11%) and cooking (7%). These figures are much different in each country, as general the countries
from north and central Europe spend much more in heating and the south countries in cooling.

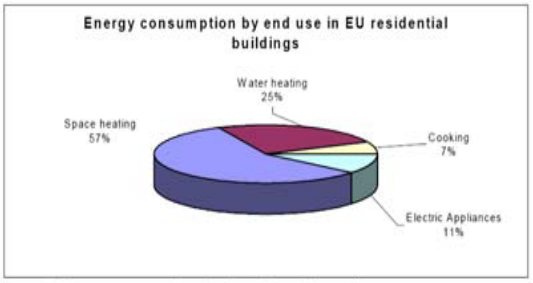

Figure 1: Energy consumption in the residential sector[3]

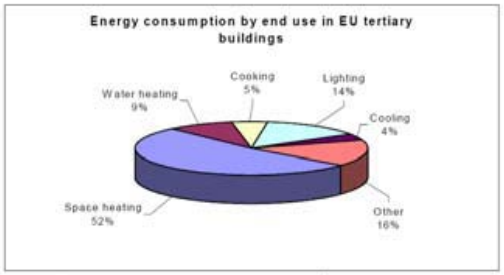

Figure 2: Energy consumption in the tertiary sector[4].

[Ref. Green Paper: Towards a European strategy for the security of energy supply]

How much energy is spend in our buildings?

It depends very much, from country, from type of building and type of user. Several studies carried out thought out the year present different type of figures, which goes from 15kWh/m2 year until 100kWh/m2 year or more.

In the last years, a great effort was done in order to reduce this figures in the Building Regulation in must part of the countries in Europe, mainly after the publication of the Directive 2002/91/EC on the energy performance of buildings.

This Directive has been since the publication a very important driver in changing National Building Codes, increasing the building envelope quality (Uvalues) and promoting the use of Renewable in buildings. The goal is to reach not only the new buildings but also the existent building.

This kind of instruments could be very important because in some cases it impose some minimum requirement in specific components (insulation levels, shading devices) of the building but they can also impose energy targets in term of maximum heating/cooling loads.

Building Design and Strategies

Solar Buildings, Passive Buildings
These buildings which have been built all over the world since the late 60´s, have several designations; *Solar Buildings* is the most common, but we find the *Passive Solar Buildings*, or just *Passive Buildings* probably those which include more than “Solar”.

There was some needs to quantify the “performance” (solar fraction or SLR-Solar load ratio) or just the “energy consumption” (kWh/m2) in total or for heating or cooling or hot water. Then classifications, like “*Low Energy Buildings*” or “*Passive and Low Energy Buildings*” became “normal”, and a kind of benchmarking start to classify and identify these buildings.

At the same time through the eighties and nineties, the building regulation and the standards start to put figures and requirements using these values of demand in the buildings.

So there was an effort, from building designer to explore new concepts of integration of those “passive systems” in the building in order to reduce those figures aiming to the possibility of having very low energy buildings (< 15 kWh/m²/year).

Then the concept was extended to the sustainability concept, were other issues were taking into account, not only energy issues, but life cycle analysis, water consumption and then a new denomination appear, “*Sustainable Buildings*”, and “*Green Buildings*” are now common in most newspapers around the world.

Fig 2. Passive Solar Buildings in Portugal

The Strategy and Technology

The common strategy used all over take in attention the following items;

1. Better building envelope (Minimise the heat losses)
2. Use Solar Gains

- Passive Heating (Direct gains, Trombe Walls, Greenhouses)
- Passive Cooling (Ground Cooling, Convective and Evaporative)
- Active Systems (Solar Panels for Hot Water or to heat the air)

3. Natural Ventilation
4. Natural Lighting
5. More efficient systems (for heating, cooling, lighting, domestic appliances)

Using in a very appropriate way these 6 items, it is possible to achieve the so called "*Low Energy Building"* with energy consumptions lower than 15kWh/m2.

More recently the production of energy on site, using Photovoltaic or small wind Turbines, became a reality in many parts of the word and the building start to produce "part" of its consumption. And it is this relation between energy needs and energy production which derive the "*zero or net zero*" energy consumption and consequently the ZEB concept.

The goal; Energy Efficiency and Renewable Integration towards a ZEB concept

This concept, in our view "**must"** be part of a more general approach in which an overall strategy that include two main steps;

I) Reducing the building energy demand:
This is a very important phase, where the main decisions regarding the building layout, materials, fenestration areas and orientation, glazing, and integration of passive solutions are taken by the designers (Architects and Engineers) and will definitely drive the thermal behaviour of the future building. The following issues must be taken in consideration very carefully in a conscious project;

1. Building site and urban integration (climatic and microclimate conditions)
2. Thermal optimization of building envelope (reducing heat losses)
3. Optimization of solar gains (winter and summer)
4. Use of passive strategies or systems
5. Use of day lighting strategies
6. Use of natural ventilation strategies
7. Use of efficient systems (domestic appliances and equipment)

A designer following these main steps in the building project, can accomplish the goal of a "high energy efficiency building" this in our view a "must" before the second step

Fig 3. Passive Solar Building XXI with PV integration

II) Produce (Generate) energy on building site (Integration):

The most common uses in buildings, is the production of heat (solar thermal) and electricity (PV systems or wind turbines):

1. Thermal Solar (for hot water or air)
2. Photovoltaic
3. Small wind turbines

Depending, the size of the systems and consequently the expected production, it is possible to go forward the so call ZEB concept (when the production is equal with the demand). So all the discussion regarding ZEB is about these two main issues; demand versus production.

How much can be done on the DEMAND side and how much is possible to “go” on the PRODUCTION side. The pros and cons must be discussed, with some sort of rationality and realism in the real world, nevertheless in this “exercise” all the imagination is possible.

Fig 4. Passive Solar Building XXI with small wind prototypes (test)

Question to the near future;

There are some important questions to be raised , studied and discussed in the near future, namely;

1. How to reach this concept in practice?
2. Improve building envelope quality (Passive solutions)
3. Efficiency in the Systems
    i. Lighting
    ii. Domestic Hot Water
    iii. Heating and Cooling
4. Integration of Renewable
5. ZEB, Definition,
    i. Zero energy or Net Zero Energy Building
    ii. Zero emission
6. Towards ZEB
    a. Passive Solar Buildings
    b. Low Energy Buildings
7. Urban Integration
8. Grids /Storage
9. Economics -Costs (LCA)
10. Users.