Estudio de casos

UPGRADE OPPORTUNITIES FOR BUILDINGS IN CITY CENTERS

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ABSTRACT

The themes of climate change, energy scarcity and energy security motivated an overwhelming interest in new efficient buildings and, in a secondary level, in adapting these emerging goals into the existing stock.

City centers were, are and will (probably) be crossroads of people, information and goods, as well as references for those who live, trade or hearsay about them. In this perspective the economic, physical or quantitative approaches must be intertwined with irregular parameters as uses, local constraints, appropriateness or notions of beauty.

The ongoing case study evolves in the presumption that we can only "upgrade" what we "have and know" to a desired "want and expect", and that the necessary tradeoffs result within these points. In this scenario added-value options like enhancing the ambient comfort levels in city centers can leverage the advantages of the amenities and transports abundance over the limitations of reduced living areas and parking restrictions.

To illustrate this perspective digital monitoring systems are used to identify the existing case study situation, a set of "flows" is used to visualize implications of a given service and to understand how to induce change on users' needs and corresponding expectations, and in a final moment, the same monitoring system will verify the results.

Having in mind that a "standardized comfort" response is impossible in the city centers as we know them, this paper proposes a contribution to substitute the anonymous "conservation-disguised" works that prevail in our city centers by custom-tailored technically supported interventions that reduce fossil fuels consumption while offering comfortable ambient conditions that re-attract people to the heart of the cities.

Keywords: [building "upgrade" or retrofit, actualização de edifícios existentes]

I. INTRODUCTION: THE BUILDINGS EVOLUTION IN THE CITY CENTERS

Most of the cities with an historical legacy have observed and participated in the introduction of more or less intrusive innovations in their buildings. The inclusion of electricity required power reduction buildings within the city, a profusion of cables, allowed electrical street lighting and, inside the buildings, heating and cooling, telephone, radio and TV, with their antennas and parabolic dishes. The inclusion of grid water required storage tanks and supply systems that connected and pierced buildings while creating the need of "bathroom" spaces in the houses and a recollection system for used water, with its ducts or exterior draining pipes converging into treatment areas.

Today´s innovation is to guarantee our energy security and to reduce the human impact on climate, requiring neighborhood energy services, local and regional renewable production and many other solutions that include spending less and better, and added-values like better indoor ambient quality: change must be attractive.

II. CONTEXT OF THE ENERGY SAVINGS IN THE EXISTING BUILDINGS SECTOR

The underlying concept of this case study is that although the solutions might change in each building and in each country due to varied starting points or working parameters, the equation to intertwine energy conservation, efficiency and sources with better ambient quality and use has common issues and flows: the best choice is the "instance" result, a "mass-customized" response to each set of quantitative and qualitative factors.

This case study relies on scenarios such as "A roadmap for moving to a competitive low carbon economy in 2050" (European Commission, 2011) that reaffirms households and services as "effort sharing sectors" to reduce CO_2 emissions, advocating bi-directional grid connections to improve demand-side efficiency and more energy efficient housing stock, solutions where the CO_2 emissions reductions will not "leak" to other countries.

1. Energy savings, energy sources or CO2 reduction?

The way to achieve the 20-20-20 objectives (Barroso, 2008) is highly dependent on the defined objectives and approaches: savings and efficiency, sources and/or CO_2.

The energy savings approach in the buildings is focused on the energy losses reduction, on managing energy gains in the cooling and heating seasons and improving the equipments efficiency. This negative energy approach (negenergy) favors consumption reduction and behavioral changes, meaning less emissions and smaller energy needs.

The energy sources approach faces the energy security issues favoring renewable sources energy harvesting, local production or extraction and exterior dependency reduction, considering the benefits of nuclear and the availability of coal in Europe.

The CO2 approach faces the climate change issues with solutions that reduce the amount of carbon dioxide emitted to the atmosphere, and assuming that further developments of current technologies (fossil fuels+biofuels, coal+carbon sequestration, nuclear fusion+fission, amongst others) can reduce CO2 emissions without significant changes in the contemporary energy scenario, with smaller financial costs.

Although each individual or state may have specific preferences or interests, the global objective will only be achieved if all the alternatives are weighted and tested.

2. Energy saving approaches in buildings and their impact in EC energy reduction

To illustrate the general potential of the buildings in the energy security and climate related issues Table 1 assumes that the current data is acceptable as a starting point in 2020 and that all the reductions from savings, efficiency, renewable sources and CO2 emissions in the other sectors are irrelevant or absorbed by the population and living standards growth until 2050, considering only three building strategies:

a) NZEB: 1% per year of the existing built area will be replaced by Nearly Zero Energy Buildings (NZEB) with savings of 95%, either by new construction or demolition;
b) UPGRADE: 2% per year of the existing buildings area will be upgraded to more efficiency and better comfort, with savings averaging 50%;
c) REHAB: 2% per year of the existing buildings area will be rehabilitated using current technologies with savings averaging 20%.

Assuming that these strategies occur in the existing built area, and that each strategy does not occur twice in the same built area, although superimposition is possible, this simple calculation environment shows their impact in the period from 2020 to 2050:

Table 1.- Potential of energy savings in buildings and overall reduction in 2050

Strategy	Target	Energy savings	Overall reduction in 2050	Positive and negative effects
Nearly Zero Energy Buildings (**NZEB**)*	1% per year	95%	25%	High investment with recognized value, mid-term payback, high material intensity, possible increase in pendularity due to their distance from city centers, or existing buildings demolition required.
UPGRADE or retrofitting	2% per year	50%	23%	Medium to high investment with recognized added-value, mid-term payback, reduced ecological footprint, densification promotes reduction of transportation needs
Rehabilitation	2% per year	25%	9%	Small to medium investment without added market value, low material intensity, reuse of materials, low cost

Although the reduction goals until 2050 can only be achieved with an integrated use of all strategies, Table 1 alerts us to demonstration potential of "Nearly Zero Energy Buildings" (NZEB) and of "Existing Building Upgrade or retrofitting", this one having the advantage of not implying the construction of new cities, or new images of them. Upgrading existing buildings to a high degree of quality and comfort will encompass positive "bounce-back" effects derived from the re-densification of the city centers and collateral gains from transport and infrastructural energy consumption reductions.

Knowing the diversity of every house and user, a global common strategy requires a look to the automobile industry: their purpose is adequately achieved, and the strategies for fossil fuel reduction include the users either by mandatory guidelines either by promoting new use patterns and individual choices.

In this perspective, and remembering Buckminster Fuller (1981), the future of existing buildings is not passive, but rather active like our electric cars.

III. WHAT WE HAVE AND KNOW

This case study is located in the city center of Coimbra, Portugal, in the protection area of Jardim da Manga, a protected national monument and, like many other buildings in this area, it was built and changed throughout several centuries. This example illustrates that intervention on existing buildings imply additional costs in several stages: in the project phase its' physical existence requires measurement, in the construction phase requires adjustment and in the use phase requires compromises. Knowing that a thorough starting point reduces inadequacies and extra costs in the successive stages, this thesis is also an opportunity to investigate solutions towards more interlaced information.

A traditional measuring using a standard horizontal cut (plan) at 1,2m and three vertical cuts for "2,5D" information took about 30 man/hours. The significant distortions on the walls and floors required reference lines that were pierced vertically through the building, and five level measurements (0m; 0,6m; 1,2m; 1,8m; 2,1m) in each floor, taking more than 150 man/hours. To achieve a better detail previous examples (Annex 50, 2006) and the work developed (2011 Mateus et al) suggested a complementary approach using 3D automatic photogrammetric techniques and digital approaches as Photosynth. Although Terrestrial Laser Scanning (TLS) is still expensive, it enabled an accurate and comprehensive survey of the case study, as shown in Figure 2, that resulted from four man/hours in the field and 16 hours of point clouds post-processing.

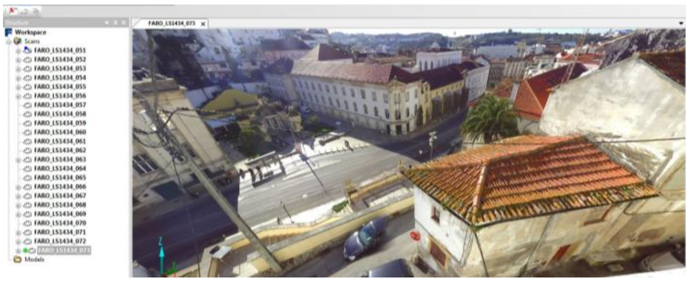

Image 2 – Panoramic image corresponding to Terrestrial Laser Scanning survey.

The thermal behavior of the building was initially measured using a thermographic camera and heat and humidity sensors, describing results that were not coherent with the Portuguese thermal regulation (RCCTE 2006). The readings suggested that the "very high inertia" of the building and its orientation, in conjunction with the circadian cycle and use pattern could be responsible for the measured indoor temperatures that, although inferior to the "desired" standard, were stable in all seasons without acclimatization.

To investigate further a "real-time" measurement system from WSBP (Janus) was installed to measure temperature, relative humidity and CO2 in each level and in the exterior. The comparison of temperature and humidity data between interior and exterior allows a constant control of the thermal envelope, while the CO2 rates reveal user presence and activity, from which internal gains and infiltration rates can be assessed. A better understanding of the wall's mediation dynamics requires the introduction of thermal sensors to characterize the climate and human use influence in this process, and on the overall behavior of the case study. The image 2 shows one of the current output:

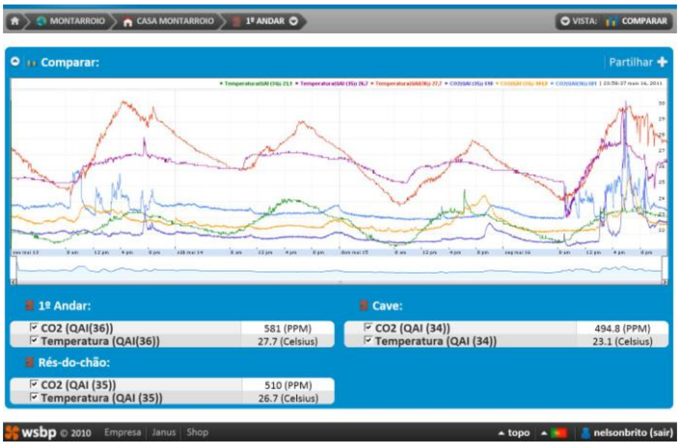

Figure 2 – Data output, to be maintained after upgrade for comparison and optimization

IV. WHAT WE WANT AND EXPECT

An evolution towards the upgrade of existing buildings must be driven by the resulting advantages, guided by regulations and boosted with incentives: the aim of a better comfort with reduced operating costs must be designed/installed by technicians that guarantee the interoperability of the systems and measurability of results, and incentives that balance the initial extra costs. In a recessing economy the existing buildings upgrade can gather the manpower surplus and the existing buildings costs reduction within midterm projects that join universities and private stakeholders.

The International Energy Agency Annex 50 (Annex 50, 2006) demonstrated that evolved methodologies can be used to capture information and assist prefabrication to optimize existing buildings intervention, while Annex 56 (2011) is taking the initial steps to identify the "cost-effectiveness" and "added-value" that supports decisions.

What we want and expect from a building derives from an existing archetype that is progressively updated to incorporate the new needs, consolidating evolutions. But today's challenge to reduce fossil fuels consumption is not as visible as electricity networks and grid water, and even these are unpaired from the notion of quantities: the required measurement systems are, in fact, extended reality sensors.

This case study proposes the expanded use of extended reality solutions to gather information, to acquire knowledge and to induce user behaviors (Sunyoung, Eric 2009). The CO_2, temperature and humidity values can provide information that, if unsatisfactory, can be crossed with external conditions, response scenarios or previous experiences to induce user interaction or automatic response. To organize the multitude of inputs this thesis learns from Bluyssen [2009], intertwining indoor parameters with the human response, and the Energy Service Companies approaches [Limaye & Limaye, 2011], that rely on the measurement, prediction and comparison of "shared savings" to make a profit.

In this perspective the analysis of the qualitative and quantitative flows that influence buildings (Vladykova & Rode, 2011) in varied locations can be focused on <u>their influence on users comfort</u> and on the <u>energetic impact of the available response options</u>, disclosing adequate alternatives to each "instance" and their possible "bounce-back" effects, opening ways towards a configurable active intervention for each existing building.

VI. BUILDING UPGRADE: WEAVING THE FUTURE WITHIN TRADITION

To achieve high efficiency and comfort in existing buildings the needs of the users, the recent evolutions in the electric vehicles and the constant change of scenarios must be intertwined through active mediation capabilities and bidirectional responses. Although many solutions are already available in Ambient Intelligence technologies, the integration of knowledge requires a clear perception of the major flows and future scenarios.

Although this case study presents a high level of difficulty due to its geometrical irregularity, contextual constraints and high efficiency goals, its success can demonstrate that it is possible to upgrade many of the simpler decaying buildings into new realities that, respecting previous tradition and knowledge, are still able to incorporate an active, efficient and comfortable future that re-attracts people to our city centers.

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