The keep Cool II idea and strategy: from "cooling" to "sustainable summer comfort"

S. M. L. Camelo, H. J. P. Gonçalves
LNEG, Lisboa, Portugal

C. Laia, M. Richard

CEEETA-ECO, Lisboa, Portugal

ABSTRACT: The European Energy Performance of Buildings Directive (EPBD) explicitly refers to a "passive cooling techniques, primarily those that improve indoor climatic conditions and the microclimate around buildings". However, in Europe the demand for air conditioning is rising, especially in office buildings and is expected that the cooled floor area will be four times higher in 2020 when compared with 1990 figures. About 40% of our energy use is consumed in buildings and air conditioning represents a significant part.
To overcome this problem the conventional answer consists on to improve of the energy efficiency of cooling. However, this strategy showed limited results in terms of saving energy and reducing greenhouse gas emissions. In fact, cooling can be avoided (or the need to use energy for cooling) or significantly reduced without risking summer thermal comfort for building occupants, having thus the potential to achieve substantial reductions in energy demand and contributing to the overall objective of reduction CO2 emissions, minimizing the risk of the global warming and of the European climate protection commitments.
This paper presents the conclusions of two surveys undertaken in the frame work of the Keep Cool II Project. One centered on evaluating current practices in cooling design, construction and operation, in order to obtain a feel of how widely good practices are known and used and as a basis for the subsequent study on incentives to remedy a set of key barriers and to reach the notion of summer comfort as a service. Indeed, efficient strategies for cooling have been studied for at least two decades, and several campaigns have already been implemented in the EU member states to disseminate knowledge on summer comfort efficiency since the 1990s.
The other survey was undertaken in order to review the energy efficiency criteria, in the national building codes, concerning summer comfort or mechanical cooling system in order to elaborate recommendations towards a sustainable summer comfort. This survey intended to update, in a regional basis, the information regarding national building regulations, identifying the measures adopted and delineating good practices concerning energy consumption, summer comfort and summer requirements.
Finally, it should be stressed out the key role of the building designer towards sustainable summer comfort. Building codes requirements and design rules needs a proper use by the building designer.

1 INTRODUCTION

There is a growing energy demand for cooling in European that does not contribute to the overall objective of reducing CO2 emissions. As referred, in Europe in 2020, is expected that the cooled floor area will be four times higher when compared with 1990 figures. However, the adoption of passive cooling solutions, renewable energy sources and internal heat gains reduction can contribute to minimize or even to prevent the cooling in buildings, with a substantial potential on the energy demand reduction, without risking the summer thermal comfort.

Although these techniques are already studied and available, it is necessary to have a clear understanding about the rules and practices in building cooling design and operation in order to identify the good and the bad practices. This will also help on how to promote the adoption of those techniques and to encourage a holistic approach to energy efficiency.

The building regulations can also have a major role in controlling and limiting the energy consumption of the building sector. The changes imposed by the EPBD Directive should always be seen as an effective instrument to achieve highly energy efficient buildings. As almost every new modern office or other non-residential building, due to the existence of high internal gains from equipment loads, has an air-conditioning system, the building regulations should require a calculation of the energy needs for cooling and set a high limit for allowable cooling energy (or including it in some kind of other global energy target) for new buildings and major renovations.

This implies a new approach in building design, construction and operation phases, meaning that even if the financial cost is lower, hidden information, training or organizational costs may constitute a barrier to the fast adoption of these efficient practices. The same happens, on a more limited scale, at the level of cooling equipment choice, even when no radical changes in practices are required. Thus, summer comfort in buildings is a prime exponent of the existence of barriers to energy efficiency, which prevent or delay the adoption of the best practices in terms of economic rationality and social utility.

Under the Keep Cool II Project, the participating countries were involved in of two surveys, one centered on evaluating current practices in cooling design, construction and operation, The other survey was undertaken in order to review the energy efficiency criteria, in the national building codes, concerning summer comfort or mechanical cooling system, in order to elaborate recommendations towards a sustainable summer comfort.

2 SUSTAINABLE SUMMER COMFORT AND BARRIERS

The Keep Cool II Project aims to provide practical tools and recommendations to overcome barriers that differ phase to phase against the widespread penetration of sustainable summer comfort solutions.

In the redesign phase of the building process, decisions taken by developers, investors and financing institutions have a fundamental impact in the final result regarding the achievement (or not) of energy efficient solutions. As we will see when we formalize the different types of barriers at work, the investment decisions are affected by a mixture of information failures and misplaced incentives which effectively discourage, or at least do not encourage, the pursuit of energy efficiency.

For the developers, especially in office construction subsector, where most units are built for subsequent rent, decisions are affected by a fundamental bias to minimize the initial capital cost of investment per unit of net marketable floor space. Although net present value calculations are performed, the value of energy efficiency remains largely hidden, as operating costs tend by default to be borne by the tenants, in a typical illustration of the well-known landlord-tenant problem.

However, a more fundamental failure intervenes at an organizational level during the design phase. Building design is an example of a complex process in which many different actors, with different knowledge and objectives are set to work to respond to a common set of goals. The first need is therefore for these goals to be sufficiently well stated from the beginning, which reinforces the necessity for energy efficiency to become a top-of-agenda priority for both developers and prospective tenants.

The second step is to actually put in place the organizational conditions for a good collaboration of the diverse players towards the common goal. Left to him, each actor intervening in the process (architects, electrical engineers, mechanical engineers, air quality experts, etc.) will have a tendency to add safety margins to avoid liabilities. The multiplication of unnecessary safety margins is a typical example of a chain amplification of inefficiency, which is rendered even more intricate when, as is often the case, critical elements of the building load are not known when the building is first designed.

In addition to the complexity of the chronological organization of the design process, optimization requires to overcome another fundamental barrier to information flow, which is that each specialist speaks, in many ways, a “different language”, not only in terms of his or her individual objectives and incentives, but more fundamentally in terms of units (heat, power, space, weight, money), constraints and knowledge base.

3 SURVEY FOR BARRIERS IDENTIFICTION AND MAIN RESULTS

Due to time constraints, several choices had to be made, regarding the target audience, the method (simple questionnaires or deep interviews) and the geographical scope of our survey.

As the Keep Cool II was designed to focus more on designers and practitioners of the summer comfort sector, the choice of deep interviews with key, knowledgeable professionals was made, with the intention of perhaps providing more nuanced views and insight into real practices as opposed to what “should be”. The downside was that the final sample of interviews was more limited and did not permit a statistical treatment or the affirmation of quantitatively provable trends for each country. However, given the extremely subjective nature of some of the issues tackled, it is not certain that a wider sample could have been a guarantee of safety in attempting country-based generalizations.

The results, in terms of quantity and quality of information gained, vary greatly among the interviews, which partly depends on the availability and cooperation of the various interviewees to participate in rather long and detailed interviews. The professionals targeted in these interviews show a superior knowledge of what constitutes good practice, due to the fact that the professionals chosen represent some of the most experiences practitioners in their field. The consequence of this bias is that their own practices cannot be statistically or otherwise extrapolated to the whole population of their profession.

The questionnaire in the first section was divided in three parts, covering respectively practices in (1) design, (2) installation and (3) operation of cooling solutions today, *Richard et al* (2009).

3.1 *Ideal practice and actual practice*

Concerning the ideal practice and actual practice, the main interest of the deep interviews is that they enabled to discern the subtle issue of the difference between what people know is the best practice and what they or other colleagues actually apply in their everyday.

Concerning the actual versus ideal practice gap, the answers are clear: most interviewees admit that common practice is often greatly sub-optimal in the design and construction phases, and this is visible in the organization of the work, the role of the different participants, and the actual quality standards, affecting the efficiency of the final design in very basic but unfortunately powerful ways –often the same which Amory Lovins had identified 15 years ago, and which have been observed ever since.

Regarding the organization of the design process, the inclusion of a cooling system designer/planner and energy experts early in the process is recognized as desirable as but unfortunately less than systematic.

.

3.2 *Rules of thumb*

One of the rare good news of these interviews is that the use of much-maligned rules of thumb to assist in the design process is not widespread within the interviewed sample. These rules of thumb for cooling systems, for instance, used to have a significant negative impact on efficiency, due to their antiquated nature (in a universe of fast-improving technology) or gross approximations amounting to excessive safety margins. It seems that commercial or academic software is now the essential tool used in calculations except for “smaller” projects, all professionals might not take the time to use these software tools).

Some effort may still be done to turn these tools more user-friendly and disseminated, but incentives are needed, be they in the form of pressure from the building owners or fee-based incentives, to push more professionals into performing up-to-date calculations.

Similarly, more incentives are needed to bring design professionals to systematically base calculations of cooling loads on the heat gains released by the actual equipment installed in the office, instead of data taken from reference tables and encouraged them to have a pro-active attitude aiming for the selection of energy-efficient solutions and equipment all through the process.

There is a large range of different perceptions for what would be the most appropriate way to reward HVAC professionals for a sustainable summer comfort design (see figure 1). However, it is possible to distinguish that among the interviewees, there is most common preference for the reward to be linked to energy savings obtained through “good design”.

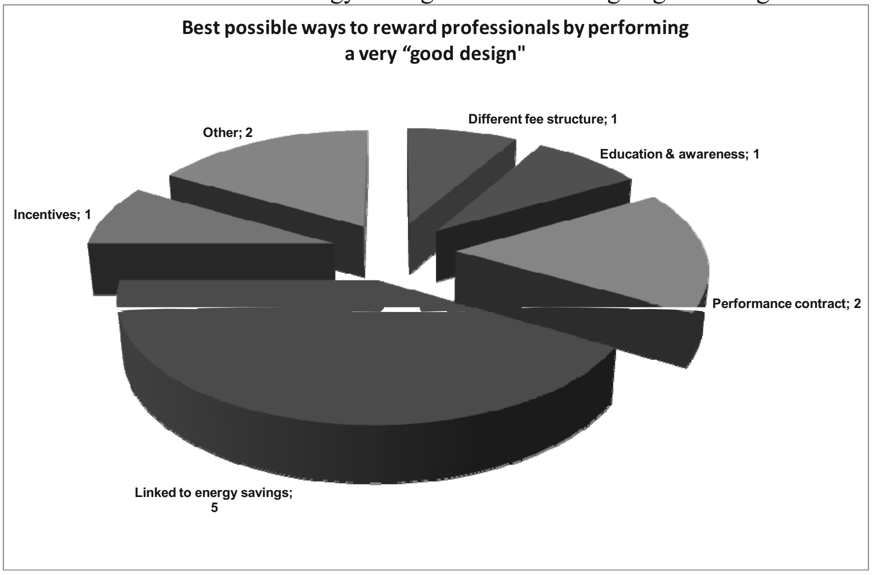

Figure 1. Perception of HVAC planners regarding best possible ways to reward “good design”

3.3 *Operation*

The operating managers of the buildings are a key group to target in future training and information actions, as their impact, for best or worse, may be of a higher order of magnitude than the simple installation of more or less efficient equipment (in buildings which do have active cooling systems).

Building codes and regulations refer to thermal comfort for the calculation of thermal cooling loads or cooling energy needs, but (perhaps understandably) do not set legally binding limits for the operation of the building, which may then well be outside the thermal comfort zone. Adaptive comfort criteria, in particular, shall be systematically promoted to this professional group in order to maximize the buildings’ hybrid operation.

3.4 *Information on regulations*

Regulations, in the form of revised building codes, have recently come into force resulting from the transposition of the EPB Directive. They constitute one of the most powerful instruments to overcome deeply ingrained barriers amounting to bad practice, by effectively outlawing the worst practices and establishing guidelines for construction and renovation.

However, according to the interviewers opinion most of the new building codes are quite complex, and involve important costs in terms of time and effort in order to be fully assimilated. As a result, HVAC professionals are not totally familiar with new dispositions, which are visible in imprecise answers during the interviews, for example on cooling load limits.

The knowledge of the existing regulations is fundamental, and there is scope for improvement here. A review of the national building codes concerning envelope constructive solutions (opaque and transparent), thermal mass, ventilation rates, energy consumption methodology and correspondent values limits has been undertaken for the participating countries of the KeepCool II Project and the main results are presented.

4 SURVEY OF THE ENERGY EFFICIENCY CRITERIA AND NATIONAL BUILDING CODES

The building regulations have a major role in controlling and limiting the energy consumption of the building sector. The goal of this analysis consists on put in evidence the different strategies adopted and try to share and to supply information and experiences in so far as, the energy demand for cooling in Europe, *Gonçalves et al (2009)*.

The evaluation of the questionnaires reveals that the new building regulations were already adopted in all member states, following the Energy Performance Building Directive (EPBD), for new and existing residential and non-residential buildings, differing only on the starting date. The verification of the regulation requirements is usually before and after construction, in France only after construction, prior to sale, rental and/or use, while in Italy only at the planning stage. The role and the entities involved are quite similar: architects and engineers the energy calculations and the technical responsibility, builders the quality of construction works, insulation, installations, respecting materials and specifications of design engineers. Among the good practices, one should stress the need for verification after construction, especially in countries that only recently adopted building thermal and energy regulations, and underline that an entity responsible for the archiving for future statistical analyses.

4.1 *Energy consumption*

The prediction of the energy needs for cooling has already been calculated, in six of the eight countries of the Keep Cool II Project, based on the EN ISO 13790 standard (Ep<Epmax) and even, for Slovenia, when the energy use calculation for cooling can be done by a simplified method, the EN ISO 13790 can also be used as an option. Each country adopted one of the alternatives for the calculation of the cooling needs: monthly or seasonal method or a yearly hourly simulation procedure, with single zone or multizone options, based on simplified RC models for the building.

The survey was extended to other countries in order to a have a clearer perception of the state of the art around Europe. There are some countries in which summer and cooling needs are not a priority like Romania and Bulgaria while others like Norway, although having cold climate conditions are quite concerned with cooling needs inside offices and services and the standard for the energy demand calculation in buildings includes energy for cooling.

4.2 *Recommendations and requirements*

Mandatory U-Values – walls and roofs:

Among all countries of the Keep Cool II Project only Portugal manifests that cooling and heating seasons are both relevant the others the Winter.

The partners have already implemented requirements, differing and reflecting the building tradition and techniques. In all countries there exist requirements on the U-values and on the thermal mass of the building envelope. Six countries reported requirements concerning the U-values on both envelope elements. In Figure 2 are presented the wall and roof U-values requirements for some European countries

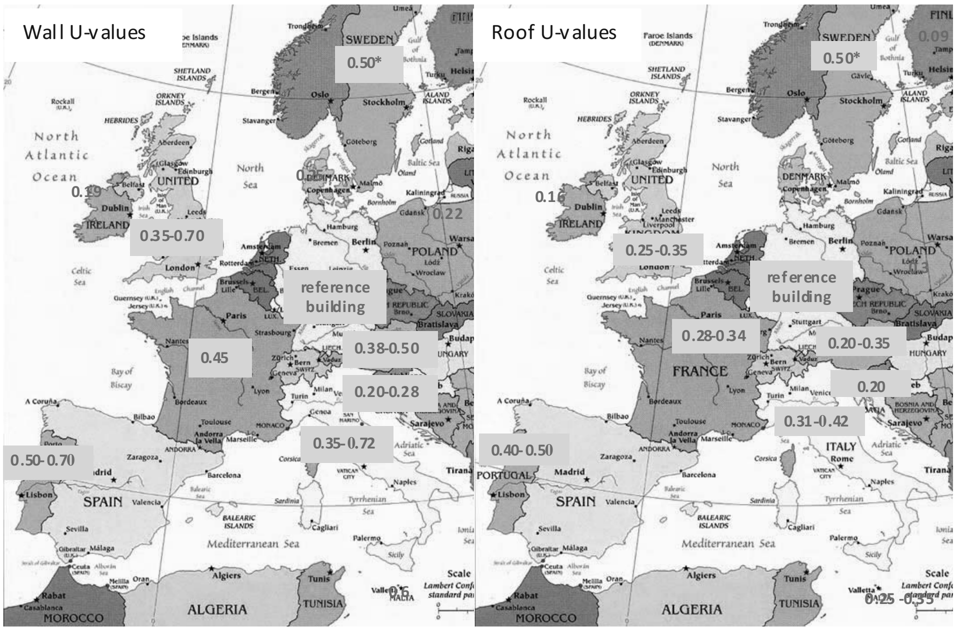

Figure 2. U-values requirements

Concerning the envelope quality each country should analyze if it is necessary to impose more restrictive requirements in terms of U-values of the opaque envelope elements. For instance, in its following revision, Portugal intends to adopt more restrictive U-values.

Requirements on windows, shading and strategies for solar heat dissipation and prevention:
Mandatory measures of shading devices in glazing façades are referred only by Portugal and Slovenia in an explicit manner (excluding only the north oriented windows).

For the solar heat prevention, the countries that don't have any requirements until now in their Building Regulations pointed out that they should implement measures such as: shading devices, glazing area and total area of the façade, glazing area per orientation.

For new buildings the glazing area per façade and orientation is recommendable in particular in combination with shading and that relationship should be included in the calculation methodology. Concerning the glazing areas the use of shading, for new buildings should be external and movable and take in account the external obstructions, and minimum requirements should also be implemented based on the g⊥-values combined with glazing area. So, at least for new buildings it should be recommendable to implement shading factors for shading systems in connection with glazing area/orientation.

The limitation of a totally glazed transparent envelope as a solar heat prevention strategy should be established, for the different countries, based on extensive simulation studies to avoid an increase of the heating energy demands and the penalization of day lighting strategies.

Concerning heat dissipation strategies, for all types of buildings natural ventilation is always mentioned as a measure to be adopted and, whenever natural ventilation is not sufficient, then the integration of a mechanical ventilation system is recommended. Concerning dissipation strategies the only countries that do not refer to any strategy are Slovenia and Sweden. Other countries mention the natural ventilation (night ventilation) and France the earth as cooling source while Germany expressly manifested that is not taken in account.

Regarding the use of passive systems it is necessary to investigate what strategy or strategies should be included in the building regulation according the climate conditions, such as: diurnal thermal amplitudes to evaluate the night ventilation potential cooling; solar radiation intensity to adequate glazing areas and orientation as well as shading strategies without penalizing the natural light and the heating season; use of passive systems, namely the earth, as a cooling source should be investigated and the use of air conditioning systems should be avoided.

Natural ventilation for the new buildings must be always adopted and, if not possible, hybrid solutions should be recommended before opting for mechanical or AC systems but to ensure night ventilation safety demands against storms and burglary are also necessary.

From the answers it is clear that those aspects should be introduced in the building regulations.

4.3 *Summer comfort*

The survey pointed out an enormous consensus for summer comfort to be explicitly introduced in the building regulations for all type of buildings and also that summer comfort calculations should be required. Checking the indoor temperatures and standards should also be explicitly introduced. From the answers, the following comfort calculations can be followed by other countries.

Summer comfort should be introduced in the building regulation for all types of buildings adopting or standards should be explicitly introduced in the building regulation. The EN 15251 – "Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics", the adaptive thermal comfort model should be used for building design to prevent overheating, using solar shading or decreasing window size, increasing thermal capacity of the building or adopting operable windows to promote cross ventilation.

5 FINAL REMARKS

Building regulations should require the adoption of at least the most sensible passive cooling techniques, namely gain avoidance measures such as efficient shading, day lighting optimization, free-cooling whenever possible, etc. Efficient lighting systems should become a major priority.

The adaptation of passive systems must be checked and if realizable, the employment of mechanical cooling systems should always be avoided and only used if it is demonstrated that the passive solar measures (solar heat attenuation and heat dissipation) and the passive cooling systems (ground tubes, natural ventilation devices, etc...) do not guarantee pleasant thermal internal comfort conditions.

Each country should be encouraged to apply mandatory passive requirements for summer but not in a uniform way all over Europe. The requirements on the elements on the building design should be integrated in the building construction according to the climate conditions of each region. In colder areas the mechanical cooling equipments should always be replaced by good design requirements based on architectural solutions. To reduce the cooling consumption further measures can also be adopted selecting efficient electric lighting and equipment and in this way reducing the internal gains. At least for the new buildings cooling energy and summer comfort calculations should be included as well as maximum legal values for primary energy for cooling.

In particular, the energy certification of buildings, generalized in the EU by the EPB Directive, is one of the most powerful axes of action, not only by obliging all actors (developers, financiers, but also commercial appraisers, and of course users) to acknowledge energy efficiency as an objective, but also by constituting a "visible" basis for the internalization of the efficiency value of buildings in their commercial value, i.e. for example in the rents owners will be in a position to demand.

A note is necessary on the issue of renovation, which constitutes a key window of opportunity to increase the efficiency of summer comfort solutions, and which arguably represents a more important target (in terms of sheer market size) than new construction. Practices in renovation are not necessarily similar to those in new construction, if only because the scope of possible options is more reduced, especially for passive summer comfort.

As it is, this specific question deserves to be investigated in more detail in the near future: efficiently refurbishing the existing built residential and office environment is indeed the major and most urgent challenge in stationary (non-transport) energy efficiency policy. It takes particular relevance in relation to cooling, as owners and users of buildings often still choose solutions, when renovating, concentrating excessively on winter comfort, leading to excess cooling needs and insufficient attention to efficient summer comfort solutions.

Informative campaigns on passive cooling, for households and for building managers and users, should be undertaken in order to prevent overheating and to reduce mechanical cooling devices.

The adoption and use of passive systems must always be checked out and their contribution should be incorporated in the building regulation in order to achieve sustainable summer comfort. On the other end, the national building regulations should also have more exigent limit values of the cooling energy demands.

The increase of the use of air conditioning systems in Europe leads to considerable problems at peak load times, increasing the cost of electricity and disrupting the energy balance in the European countries. According to the recommendations of the European Parliament "priority should be given to strategies which enhance the thermal performance of buildings during the summer period. To that end, there should be further development of passive cooling techniques, primarily those that improve indoor climatic conditions and the micro-climate around buildings".

The general conclusion of this limited survey, beyond the obvious need for ever wider information (and particularly knowledge of existing regulations), is that the main failures are organizational and motivation-based: actors may know how to maximize efficiency, but time and complexity constraints end up in sub-optimal practices a significant part of the time

REFERENCES

Gonçalves, H., Camelo, S (2009) Keep Cool II - Work Package 2: Barriers against sustainable summer comfort. Deliverable 2.3 Recommendations on summer energy efficiency on national building codes.

Lovins, A. 1992. Energy-Efficient Buildings: Institutional Barriers and Opportunities. Boulder, CO:ESource, Inc.

Richard, M., Laia, C,, Geißegger, G., Jetzinger, F., Holanek, N., (2009) Keep Cool II - Work Package 2: Barriers against sustainable summer comfort. Deliverable 2.1 Rules and Practices in Building Design and Operation