TOWARDS SUSTAINABLE SUMMER COMFORT

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Abstract: There is a growing energy demand for cooling in European buildings. It is expected that the cooled floor area will be four times higher in 2020 when compared with 1990 figures. Cooling is already the energy use in the building sector with the highest increase rate. This evidence is not contributing to the overall objective of reduction CO_2 emissions.
The conventional answer to this problem is 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.
However, avoidance or even major reduction of cooling implies a new approach in building design, construction and operation phases. Different scientific and technological advances shall coherently be used and be offered to building promoters or building owners as a new service. The new adaptive comfort theory, the possibility for local adaptation for building users and facilities, the capability to intervene in the surrounding urban environment, the use of mature passive cooling solutions, of renewable energy sources and high efficiency lighting (reducing internal heat gains) are some examples of the techniques to be integrated in the new approach.
Such a service should integrate different skills and competences as well as different kind of systems and equipments, from architects, building consultants and engineers, from solar shading devices, integrators of passive solutions and suppliers of very efficient lighting and office equipment.

Keywords: Cooling of Buildings, Energy Efficiency, Sustainable Summer Comfort

INTRODUCTION

Space cooling is becoming a considerable target of energy use in the European Union. The rise in living standards primarily, and other factors such the “heat island” effect, are pushing up a historically low demand for artificial cooling in Europe.

The total cooled area is expected to rise in one decade from 1200 Million m² in the year 2000 to around 2200 Million m² in 2010, corresponding to the rise in cooled area per capita from 3 to 5 square meters. Just commercial areas and offices may account for about 70% of the stock by 2020. This leads to an electricity consumption of around 51 TWh for air conditioning in 2000 (18 $MtCO_2$) reaching 95 TWh in 2010 (33 $MtCO_2$). See EECCAC study [1].

There are differences in cooling demand depending on the country. The growth of air conditioning is partly related to the differences in climatic conditions but also to the development of the tertiary sector, especially offices. In fact, some central European countries like Belgium, Germany, etc., have shown larger rates of growth in air conditioning than some more Southern countries such as Portugal or France. Today just two countries, Spain and Italy, account for more than 50% of the entire EU cooling market.

However, Southern European countries will continue to see their energy consumption for cooling increase significantly. Projections made in 2004 under PNAC (Portuguese Climate Change Programme) [2] studies, show a trend corresponding to a huge growth of energy demand for cooling, both in the residential and tertiary sectors: see figure 1.

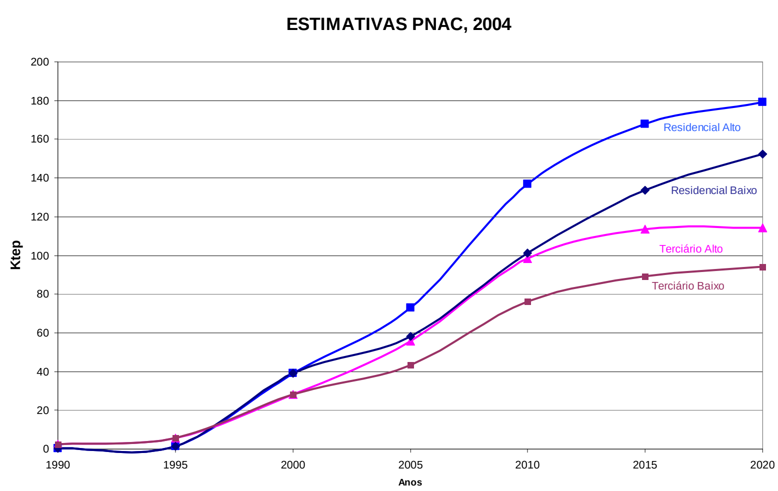

Figure 1

Another important aspect concerns national electricity system peaks in European countries. They have traditionally occurred in winter but simulations show a possible transfer of the annual extreme peak hours to summer in some countries, which constitutes a particular problem as hydropower resources are usually less abundant in summer. Furthermore, these peaks were determined in a national perspective and would certainly be worse in some regions, particularly in local urban environments. As a consequence, electrical load management will be under strain, which may imply further investment in both electricity generation and grid infrastructures.

STANDARD APPROACH TOWARDS SUMMER COMFORT

Portugal has been a pioneer country in accounting for building energy performance under summer season climatic conditions. In fact, the first building thermal code for Portugal (DL 40/90 [3]), has imposed some conditions to improve energy performance in the winter period, regarding the thermal quality of the building envelope by favouring better heat transfer coefficients for building envelope elements and/ or increasing winter solar gains through glazed surfaces oriented towards the South. At the same time, the building code would not allow inefficient solar shading of those same surfaces in the summer period.

However, with the coming into force of the EPB Directive [4], new building energy codes have been approved. In particular, the existing regulation (RCCTE) has been revised and a new building thermal code has been published [5]. A new building energy certification scheme (together with IAQ rules) has been introduced into Portuguese law and in most other European countries. In addition, the Directive on Energy End-Use Efficiency and Energy Services (EEE-ESD) [6] is setting energy saving targets for the European Union and the Member States, and requires an Energy Efficiency Action Plan (EEAP) as well as energy efficiency criteria in public procurement schemes from each Member State (European Communities, 2006). Both instruments, EPBD and EEE-ESD, allow for the broad implementation of measures that help to reduce energy consumption for cooling, including passive measures, and to make use of the newest standards in the design of cooling equipment.

Despite the availability of passive solutions, the standard way of securing summer comfort is still the application of mechanical air conditioning. It is a fact that mechanical cooling needs to and can be reduced, in some climates even avoided through "passive" measures (such as the use of sun shades, efficient lighting and office equipment). It is also a fact that these measures are not widely used on the market today: The obvious choice for a building owner is still mechanical cooling when addressing summer comfort issues.

NEW APPROACH: SUSTAINABLE SUMMER COMFORT

Sustainable summer comfort can be defined as achieving good summer comfort conditions with limited or no use of conventional energy and through the use of environmentally non-harmful materials. According to this definition, focus is on *summer comfort* and not on *cooling*. People need primarily comfort, not a thermodynamic process. The fundamental need corresponds to a service – summer thermal comfort -, not inevitably to a given equipment or quantity of energy.

This service can be described as a set of activities which start from the conceptual and design phase, to construction, and to the operation and maintenance (O&M) of buildings, aimed at achieving large energy savings or even, in some cases, avoiding altogether the installation of mechanical cooling systems, while obtaining satisfactory levels of summer thermal comfort.

A pathway, *in ten steps*, can be used in order to reduce cooling energy demand in buildings [7]. This approach leaves ample freedom to designers while supporting them in adapting the building to the local situation (climate, culture, locally available materials). Not all steps and actions will be available in a specific situation to the owner/designer, but one should follow this path and closely analyse the possibilities for action in a given situation for each step.

<u>I. Define the thermal comfort objectives explicitly, using the Adaptive Comfort model where possible</u>

Usually, regulations (e.g. ISO 7730) and practical operation in buildings require keeping indoor temperature inside a constant range of values (e.g. 24-26 °C), regardless of the outdoor conditions. These prescriptions come sometimes from an unduly rigid interpretation of the underlying comfort model of Fanger (1970).

However, Nicol and Humphreys (1972) proposed as an alternative an Adaptive Comfort model that states that people in real buildings, naturally ventilated, tend to adapt their comfort requirements to the prevailing outside temperatures. The optimum indoor temperature varies with the outside temperature; in particular, it is correlated with the average external temperature in the last few days.

The Adaptive model of comfort has wide-ranging implications for the application of passive cooling methods and energy use for cooling. As the indoor comfort temperature varies in time in correlation with the average outside temperature, the difference between the two temperatures tends to be lower, and consequently cooling loads tend to be lower than in buildings with fixed temperature set-points. Further, the slightly fluctuating indoor comfort temperature given by the Adaptive Comfort Model is more likely to be achieved by passive cooling methods than the fixed temperature set-point derived from the Fanger model. Hence, the adaptive model does not create an unjustified obstacle to passive architecture, as the Fanger model may.

The European Standard EN 15251 “Indoor environmental input parameters for design and assessment of energy performance of buildings- addressing indoor air quality, thermal environment, lighting and acoustics” seeks to define minimum standards for the internal environment in buildings. EN 15251 makes an allowance for differences in comfort conditions in naturally ventilated (heated in the winter and free-running during the summer) and mechanically cooled buildings, allowing designers to take advantage of occupants’ natural ability to adapt conditions to their liking.

II. Intervene on the site layout and features which can affect summer comfort

A compact urban layout contributes to reduce irradiation on external surfaces in hot dry climates, while an openly spaced layout might be required in humid areas to increase ventilation possibilities; the presence of vegetation and surface water, the choice of materials and finishing with low values of solar absorbance for urban surfaces (streets, parking spaces,…) can strongly influence surface and air temperatures in open spaces surrounding the buildings, and limit the so-called "heat island" effect.

III. Control and reduce heat gains at the external surface of the envelope

In order to reduce the amount of heat going through the external surface (or boundary) one should improve the efficiency of solar protections (and possibly also walls and roofs), by using surface finishings with adequate values of reflectivity and emissivity, and by limiting air exchanges when the outside air is at a higher temperature than the inside.

IV. Control and modulate heat transfer through the building envelope

Building designers can control heat movement towards the interior (via heat conduction and convection) which can be limited by an appropriate use of insulating materials: Also, the time lag by which it gets to the inside should be controlled by the proper dimensioning and positioning of thermal mass.

V. Reduce internal gains

Internal gains should also be reduced by using efficient lighting sources and systems, by direct venting of spot heat sources, by using efficient appliances and office equipment and by ensuring that all systems are turned to stand-by or shut down when not in use. Internal gains due to a high presence of occupants (e.g. in conference rooms etc.) need to be duly taken into account in order to assess the need of active cooling in this case.

VI. Allow for local and individual adaptation

One must not underestimate the capacity for local and individual adaptation via a flexible dressing code, low thermal insulation furniture, use of ceiling fans, and flexible working hours during high temperature periods, such as the system of “heat wave holidays” which is applied for example in German schools.

VII. Use passive means to remove energy from the building

Passive means can be used to remove energy from the building such as comfort daytime ventilation, night ventilation, use of the ground as a "sink" to discharge heat removed from the building, open groundwater or surface water systems, radiation of energy to the night sky, direct or indirect evaporative cooling. The term *passive* in this sense does not exclude the use of a fan or a pump when their application might enhance the performance.

VIII. Use active solar-assisted cooling plants

Active solar-assisted cooling systems, such as absorption and adsorption cycles driven by heat from solar collectors are becoming commercially available and technological more mature. These systems can be used also to remove heat from the building.

IX. Use high efficiency active conventional cooling plants

Finally, active systems can play a residual role: they can be designed to remove only peak loads in extreme hot times or in special parts of the building, while the summer-comfort base load, being reduced to a minimum by the application of steps I-VI, is easily taken care of by passive systems.

X. Train building managers and occupants on how to use, monitor performances and adequately operate and maintain the building.

Clear and exhaustive manuals should be prepared, and an initial training provided, to allow the management staff and the occupants of the building to know how to rationally operate and control the entire building (rather than only the active plants). For new buildings, a monitoring plan should be prepared to assess whether the performance (comfort, consumption) of the building matches the design objectives and verify the persistence of good performance over time.

CONCLUSIONS

The introduction of an energy service in the area of summer thermal comfort in buildings can yield considerable results. This service would gather expertise from professionals in the planning and design phase, to the O&M activities. The steps outlined above show the various levels at which an integrated approach to summer comfort can make a difference. In practice, according to each individual case, the summer comfort service can be provided in different ways, through in-house teams, consulting or outsourcing, but the key point is that recognizing this need as such (and not as a simple matter of air-conditioning equipment dimensioning) and addressing it from a holistic perspective can lead to an effective satisfaction of comfort needs with little or no mechanical cooling support.

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