The impacts of the EPBD upon the summer performance of buildings

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ABSTRACT

While most existing EU National regulations only prescribe requirements for reducing heating needs, the new EU Directive on the Energy Performance of Buildings (EPBD) requires them to be updated to also account for cooling needs. In particular, the EPBD stresses the need to effectively promote the use of passive cooling measures. This text concentrates on ways how these requirements can be implemented, in both the residential and in the non-residntial sectors, discussing issues such as shading, thermal mass, ventilation, lighting and internal gains, AC use and AC avoidance techniques, etc., as well as on the practical implications for global building energy efficiency during the Summer months.

1 INTRODUCTION

Once upon a time, thermal building regulations in Europe, inspired by the first oil crisis of the decade 1970, only concerned themselves with the reduction of winter heating needs. Then, air-conditioning was not a major issue. Both residential and nonresidential buildings used mostly old traditional construction methods, well suited for avoiding overheating in most of Europe, and internal gains were modest, as electricity-using equipment and lighting were used in a modest way.

The focus on reducing heating bills in the 1970's was such that some errors were even made, namely an excessive effort to improve air-tightness of the building envelopes to reduce infiltration levels without an accompanying care to provide sufficient ventilation by alternate mechanical means. The resulting serious indoor air quality problems that followed are well known and documented.

New building technologies and international architectural styles, with little distinction anywhere in the World, namely the use and abuse of poorly shaded glazed façades and lighter construction materials, quickly caused a generalized tendency for summer overheating, even in the colder climates where, typically, such problems never took place before then. But building regulations up to the early 1990's mostly continued to ignore the issue and only two countries, France and Portugal (Maldonado and Oliveira, 1993), introduced Summer comfort requirements in building design around 1980.

A more recent survey of European building regulations (Visier, 2004) completed within the EC-supported SAVE project ENPER-TEBUC shows that the situation is much improved now, but still the number of European countries with specific Summer requirements is quite small:

- Seven countries (CH, DE, FR, GR, PT, UK and YU) have specific requirements related to solar protection;
- Four countries (CH, FR, GR and PT) apply specific calculations of thermal inertia, an important parameter influencing the maximum temperature inside the building;
- Only PT imposes specific restrictions for low inertia buildings in terms of the quality of external shading devices;
- Only CH requires a proof by simulation or simplified calculation of the expected internal temperature;
- Seven countries (CH, BE, FR, GR, NL, PT and YU) require a specific calculation procedure for characterising the energy behaviour of buildings in Summer.

From the 18 countries included in the EN-PER study, only three (Ireland, Italy and Sweden) have neither requirements nor even any recommendations whatsoever. These recommendations cover, in many countries, the issues of solar gains, in terms of glazing area, orientation and shading devices, as well as the adoption of natural ventilation as a means to avoid overheating. Strictly speaking, however, recommendations are not mandatory, merely good-practice advice, and, thus, in reality, only a minority of 7 of the 18 countries have some type of mandatory Summer requirements for their new buildings. Notably, even two large Southern European countries with hot summers and well-known high air-conditioning needs, Italy and Spain, have so far no requirements for the thermal quality of their buildings during Summer.

Yet, over these last two decades, air-conditioning has been fast expanding all over Europe. Growth rates have averaged more than 10% per year in most EU-15 countries. E.g., in Italy, the average growth rate between 1996 and 2002 was 14%, in Spain 12%, in the UK 10% and, in France, 8% (Dupont and Adnot, 2005). But industry statistics show that the high growth rates are also present in countries where apparently air-conditioning would be expected not to be so widely needed. Santamouris and Asimakolopoulos (1996) showed that AC sales are closely related to the national PNB, with Germany and the UK, two countries not usually associated with long, warm Summers, especially the UK, as some of the largest users of these technologies in Europe.

This situation is easily understandable, though. Countries with cooler climates worried mainly about reduction of heating needs, through efficient insulation and low-leakage envelopes, together with promoting solar gains through relatively large glazed areas. However, failure to prevent these same solar gains during the warmer days, even in winter and midseason, especially in non-residential environments with reasonably high internal gains, easily results in difficulty to expel those gains towards outside and, thus, in overheating and need for air-conditioning systems. It is quite common to find office buildings in Scandinavian and other countries with similarly colder climates that need air-conditioning throughout most of the year, Winter included. These buildings could certainly benefit from efficient solar shading to lower their air-conditioning loads, and regulations should start to address this issue as quickly as possible. Overinsulating this type of buildings may, in certain cases, even cause an increase in cooling energy needs and overall (heating + cooling) energy needs (Chavtal et al., 2005).

Despite all the alerts since the 1980's (Aranovitch et al., 1990), and the mounting evidence that air-conditioning use was growing faster and faster everywhere, somehow, it seems that most countries simply ignored the dangers of growing AC needs and, despite the significant impacts of the AC loads upon the national electricity grids and energy consumption, little has been done to amend building regulations to try to limit this type of situation. Even in a few countries with warmer Summer climates where one would expect this issue to be important and up-to-date, an apparently clear priority for policy action, the issue has been ignored so far.

Environmental concerns, namely the need to reach the goals established by the Kyoto Protocol, plus a certain number of recent important electricity Summer blackouts, have given an important impetus for changing this situation. The European Union adopted in December 2002 the Directive on the Energy Performance of Buildings (EPBD) that, among other issues, requires EU Member States to review their building energy regulations by 4 January 2006, using a common methodology where cooling needs and AC systems must be accounted for in all types of buildings. The details and the implications of this Directive towards addressing the issue of cooling, and, namely, passive cooling, will be discussed in the next section.

2. COOLING ISSUES IN THE EPBD

The EPBD, in article 3, requires that "Member States shall apply a methodology, at national or regional level, of calculation of the energy performance of buildings on the basis of a general framework…". This common methodology (an annex to the Directive) must include, among other items, the following items that have a direct link to cooling performance and cooling energy needs:

c. air-conditioning installation

d. ventilation
e. built-in lighting installation (mainly the non-residential sector)
g. passive solar systems and solar protection
h. natural ventilation

In article 9, the EPBD states that "With regard to reducing energy consumption and limiting carbon dioxide emissions, Member States shall lay down the necessary measures to establish a regular inspection of air-conditioning systems of an effective rated output of more than 12 kW."

In addition to these two "prescriptive" requirements, in its introductory recitals, the EPBD states a few orienting principles, intentions from the European Commission and requests for action from Member States on specific issues:

11 The Commission intends further to develop standards such as EN 832 and prEN 13790, also including consideration of air conditioning systems and lighting.

(...)

18 Recent years have seen a rise in the number of air-conditioning systems in southern European countries. This creates considerable problems at peak load times, increasing the cost of electricity and disrupting the energy balance in those countries. Priority should be given to strategies which enhance the thermal performance of buildings during the summer period. To this end there should be further development of passive cooling techniques, primarily those that improve indoor climatic conditions and the microclimate around buildings.

19 Regular maintenance of ... air conditioning systems by qualified personnel contributes to maintaining their correct adjustment in accordance with the product specification and in that way will ensure optimal performance from an environmental, safety and energy point of view.

3. THE IMPLEMENTATION OF THE EPBD

Each country (or region) is free to implement the EPBD in its own way, as long as it complies with its basic requirements. Here lies, however, a major difficulty or a major weakness of the EPBD: it specifies a complex and comprehensive methodology for the energy characterization of buildings, but it lacks a legal text, e.g., a standard, that describes that model in all its technical details. The existing standard EN ISO 13790 only deals with heating issues, and even this standard, because it is not specifically mentioned in any of the Directive articles, only in its recitals, is not a mandatory requirement that must be adopted by every country.

Recital 11 of the EPBD indicates the intention to promote the revision of this standard to also include cooling and lighting issues and, indeed, the European Commission issued a legal mandate to CEN to prepare a new revised standard. CEN created a specific task force (CEN-BT-WG173) to coordinate the preparation of the newly revised EN ISO 13790 and many additional standards supporting the implementation of the EPBD, and it produced most of them by early 2005 (CEN, 2004).

The new revised EN ISO 13790 is completed, including cooling and lighting calculations. In its new version, the standard includes three alternative methods for calculating cooling needs:

- A *default monthly method*, similar to the procedure adopted for calculation of useful solar gains in winter (the cooling load corresponds to the overheating portion of the gains that are neglected in winter, though calculated, of course, with a different internal temperature);
- A simpler *seasonal method*, based on the same principle;
- A yearly hourly simulation procedure, with single zone or multizone options, based on simplified RC models for the building, allowing for consideration of more complex use patterns, e.g., free-cooling, intermittent occupancy, etc.

Countries are free to adopt any of the three options, the same option for all types of buildings or different options for different types of buildings.

This new proposed standard will undergo public review during the second part of 2005 (CEN, 2005). However, due to the timings required for approval of any new standard, it cannot be formally published, at the earliest, before the end of 2006, a full year after the deadline for transposition of the EPBD. Thus, many coun-

tries may possibly still opt to apply the existing EN ISO 13790 and continue to ignore cooling issues, or take a more advanced position and informally adopt a building energy model on the basis of the new PrEN standard, yet to receive a number, that eventually will become the expanded 13790 with cooling issues included.

Realizing this situation, the European Commission and the Member States of the EU created a common forum for discussion of these issues, the European Concerted Action for the Transposition of the EPBD, CA-EPBD, (Maldonado, 2005), where, on a totally voluntary basis, ideas towards a certain degree of harmonization in the transposition of the EPBD are being debated by the experts that, at National level, are in charge of the preparation of the technical work for transposition.

So, in the context of this possible legalistic loop-hole, given the excerpts of the Directive reproduced in the previous section, and taking into account the positions that are informally being discussed within the CA-EPBD, the following can be realistically expected for cooling and air-conditioning issues in the European regulations in the near future:

3.1 Residential buildings

In certain countries, where Summers are not warm and there is almost no tradition of using air-conditioning in homes or apartments, there is a certain understandable resistance to introducing summer comfort requirements in their national regulations because that would result in an undesirable increase in complexity with little benefit. Yet, the two simplest options of the new version of EN ISO 13790 require very little additional effort after the winter calculations are performed using the corresponding simplified methodology. For full compliance with the requirements of the EPBD, in theory, cooling needs should be always evaluated for new buildings and major renovations, before licensing. But a pragmatic national approach can probably also be acceptable and expectable if, indeed, air-conditioning in residences is never used.

Anyhow, it would be interesting to always ensure the promotion of at least the simplest of the passive cooling techniques, such as provision of shading, possibility to promote natural free-cooling ventilation and avoidance of excessive solar gains, even if only under the form of recommendations, as well as always requiring more demanding calculations whenever air-conditioning is really installed in any building.

3.2 Non-Residential buildings

Every country that intends to seriously implement the EPBD cannot ignore the fact that almost every new modern office or other non-residential building has an air-conditioning system. Indeed, office buildings are alike everywhere, characterized and dominated by reasonably high internal gains from equipment loads. So, it makes every sense that new 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. Not doing so must not be accepted by the European Commission as a correct transposition of the EPBD.

It also makes sense that building regulations for this type of buildings should require the adoption of at least the most sensible passive cooling techniques, namely gain avoidance measures such as efficient shading, daylighting optimization, free-cooling whenever possible, etc. Efficient lighting systems should become a major priority. This will be done only by the most ambitious regulations. However, aggressive limits of the overall cooling energy can also achieve high-performance goals without any need to specify individual requirements on these passive solar or artificial lighting techniques, as they would be almost mandatory for a building to meet them.

Ideally, the detailed hourly simulation option of the newly proposed version of standard EN ISO 13790 would be the best option for establishing the energy target that, according to the EPBD, each country must establish for the various typologies of non-residential buildings. Should this not be legally possible in some countries because the legal standard is still the present EN ISO 13790, or should this be an undesirably high demanding step for the new 2006 regulations for some country, firm steps should be taken to adopt it in the next revision of the national regulations (the EPBD demands a review at least every 5 years), as the new standard will surely have been already formally adopted by then.

3.3 Air-conditioning systems

Providing efficient, low-energy air-conditioning to buildings requires a good design and a well thought global energy plan for the whole building. The first step is an energy-efficient building envelope, with as much passive solar contribution as possible (i.e., heating, cooling and daylighting). In many non-residential buildings, though, air-conditioning systems will still be needed to provide the remaining load. It is well known that centralized air-conditioning systems, taking advantage of scale to obtain savings, are usually more efficient than multiple small individual units supplying cooling to individual spaces.

Article 9 of the EPBD, by requiring inspections of air-conditioning units over 12 kW, leaves a major interpretation open for EU Member States to implement this requirement:
Should the 12 kW limit be applied to each individual AC unit or to the sum of all the installed AC power in a building?

Some countries are inclined to interpret the requirement as applying the 12 kW limit to individual AC units. Should this be the case, they shall be promoting individual split units over the more efficient central air-conditioning systems. Designers and owners of non-residential buildings in those countries may quickly be tempted to adopt a strategy looking like the two examples shown in Figures 1 and 2. This would be the worst possible option that countries can make for implementing article 9.

Building regulations must adopt the 12 kW level at building scale as a means to encourage efficient lower-energy consuming systems. Small splits have their own special role to play in the conditioning of residences, small spaces or rooms with special requirements that are best handled by individual units.

Sometimes, options that look simpler (in this case, reducing the number of AC units to inspect at a national level) may result in a totally undesirable implicit recommendation for the break-up of large efficient centralized AC systems into a large number of small units that would bypass the EPBD inspection requirements.

Low-energy cooling systems stand no chance when the selected option is the system with the lowest initial cost.

4. CONCLUSIONS

The EPBD, among many other useful consequences, will no doubt also result in new building regulations that will pay a more close attention to summer issues. AC consumption is on the rise everywhere, and it is necessary to design new buildings (and major renovations) in such a way as to reduce cooling needs in both the residential and the non-residential sectors.

It might still be acceptable that, in the residential sector in more Northern European

Figure 1: Two views of the air-conditioning system in a hotel central courtyard – the outdoor units of individual split systems for each room.

Figure 2: View of the main façade of a hotel using individual AC split units for each room.

(cooler) climates, cooling issues may take a more secondary role, but care must always be ensured that excesses do not become more common and AC starts to penetrate even the least likely markets.

Cooling issues must be present in the regulations for non-residential buildings in every country, even in the coldest regions, as most modern office buildings are dominated by internal loads and not by the envelope. Regulations should however also aim at efficient envelopes that do not contribute with excessive additional gains for air-conditioning.

Efficient building regulations should, directly or indirectly, at least promote passive cooling techniques such as gain avoidance or free-cooling ventilation, as well as the more efficient centralized systems rather than individual units.

A new set of standards recently completed by CEN as PrENs will be a powerful aid for the formulation of new national regulations dealing with this issue.

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