1 The European Directive on the Energy performance of Buildings

1.1 Introduction

Most European countries have their own building regulations in place for quite some time. Most were inspired by the first oil crisis of the decade 1970, only concerning the reduction of winter heating needs. Requirements vary from country to country or from region to region, but most consist of requiring varying degrees of insulation according to the severity of the local climate. Most consider and promote the positive contribution of passive solar gains, some also set requirements in terms of building air-tightness, quality of thermal bridges, and other details affecting building performance during winter (Visier, 2004).

Most countries update their regulations regularly, others, maybe too many, have not updated them for quite some time, as energy prices have been reasonably low during the last decade of the twentieth century and early twenty first. A significant change took place in 2004, but there was not yet enough time for countries to react to this new "oil crisis".

Then, in the 1970s, 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 mostly 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: they even have a name: Sick-Building Syndrome, or Sick Buildings.

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 et al, 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 ENPER 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 no requirements for the thermal quality of their buildings during Summer up to 2005.

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 et al, 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 (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 are 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 dif-
ficulty 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 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. 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 was mostly ignored.

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 defined, in general terms, by the EPBD itself. The details and the implications of this Directive will be presented and discussed in the next sections.

1.2 The EPBD

The EPBD establishes five main requirements for EU Member States:

- harmonisation of building calculation methodologies;
- establishment of minimum requirements for new buildings and for major renovations;
- mandatory certification of buildings;
- regular inspections of heating and cooling systems;
- accreditation of experts carrying out the work of certification and inspections of boilers and air-conditioners.

Around the year 2000, there is a wide variation of requirements between the different Member States in terms of their National Building Regulations and construction practices. The European Commission wishes a certain degree of
convergence. During the negotiations of the Directive, the Commission always wanted convergence and the Member States always fought for liberty and freedom, that is, each country wishes to be able to choose how to reach the main objectives of energy efficiency in the building sector. So, the EPBD is a compromise: Convergence, yes, but keeping the freedom of each Member State to go its own way.

The Directive was published in 4 January 2003 and the Member States have three years to implement it. So, after the 4th of January 2006, everything must be in place. The requirements relating to certification and inspection of boilers and air conditioners can be delayed up to three more years because they need a lot of trained and certified experts and inspectors. That is however subject to Commission approval. The Member States must ask and prove that they cannot certify enough trained experts by the 4th of January 2006 deadline.

1.3 Specific requirements

1.3.1 Setting up minimum requirements for new buildings and for major renovations

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 the following items:

a) thermal characteristics of the building (shell and internal partitions, etc.). These characteristics may also include air tightness
b) heating installation and hot water supply, including their insulation characteristics
c) air-conditioning installation
d) ventilation
e) built-in lighting installation (mainly the non-residential sector)
f) position and orientation of buildings, including outdoor climate
g) passive solar systems and solar protection
h) natural ventilation
i) indoor climatic conditions, including the designed indoor climate.

The positive influence of the following aspects shall, where relevant in this calculation, be taken into account:
a) active solar systems and other heating and electricity systems based on renewable energy sources
b) electricity produced by CHP
c) district or block heating and cooling systems
d) natural lighting.

The energy performance of a building shall be expressed in a transparent manner and may include a CO₂ emission indicator.

This methodology is to be prepared on the basis of a series of new CEN standards (Fig. 1). They are available for publics enquiry during the first half of 2005, and should become EN standards by 2007. As noted in the previous list, cooling issues and air-conditioning systems must be accounted for. This will require most countries to make an important revision to their national regulations.
Fig. 1 The new CEN standards for supporting the implementation of the EPBD

The new revised version of EN ISO 13790 includes cooling and lighting calculations. In its new version, the standard allows three alternative methods for calculating energy needs for heating and cooling:

a) A default monthly method;

b) A simpler seasonal method, based on the same principle;

c) 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, ventilation, 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.
Then, in article 4, the Directive requires that "Member States shall take the necessary measures to ensure that minimum energy performance requirements for buildings are set, based on the methodology referred to in Article 3."

Member States may differentiate requirements between new (article 5) and existing (article 6) buildings and different categories of buildings:

a) single family houses of different types
b) apartment blocks
c) offices
d) education buildings
e) hospitals
f) hotels and restaurants
g) sports facilities
h) wholesale and retail trade services buildings
i) other types of energy-consuming buildings.

A few exceptions are allowed, though:

• buildings and monuments officially protected as part of a designated environment or because of their special architectural or historic merit, where compliance with the requirements would unacceptably alter their character or appearance,
• buildings used as places of worship and for religious activities,
• temporary buildings with a planned time of use of 2 years or less, industrial sites, workshops and non-residential agricultural buildings with low energy demand and non-residential agricultural buildings which are in use by a sector covered by a national sectoral agreement on energy performance,
• residential buildings which are intended to be used less than 4 months of the year,
• stand-alone buildings with a total useful floor area of less than 50m\(^2\).

To avoid the indoor air quality problems described in the introduction to this chapter, the Directive further states that "these requirements shall take account of general indoor climate conditions, in order to avoid possible negative effects such as inadequate ventilation, as well as local conditions and the designated function and the age of the building."
The Directive finally imposes that these requirements shall be reviewed at regular intervals, not be longer than 5 years and, if necessary, updated in order to reflect technical progress in the building sector.

For new buildings (article 5), the Directive requires that "Member States shall take the necessary measures to ensure that new buildings meet the minimum energy performance requirements", meaning that it is necessary for Member States to ensure that the requirements are really met. It is not enough to simply set the requirements and then not put in place adequate procedures to check compliance with them.

Moreover, for new buildings over 1000 m², EU Member States must ensure that the following issues are addressed prior to issuing the building permit:

- decentralised energy supply systems based on renewable energy
- CHP
- district or block heating or cooling, if available
- heat pumps, under certain conditions

However, in recital 12, these issues can be handled in a simplified way: "the technical, environmental and economic feasibility of alternative energy supply systems should be considered. This can be carried out once, by the Member State, through a study which produces a list of energy conservation measures, for average local market conditions, meeting cost-effectiveness criteria." So, in practice, especially for the smaller buildings, to avoid costly case by case studies, countries can adopt reference, default conditions where particular options can be adopted or not by building designers without any need for further studies, based on typical performance and costs.

For existing buildings with more than 1000 m² of useful floor area undergoing a major renovation, article 6 states that "their energy performance must be upgraded in order to meet minimum requirements in so far as this is technically, functionally and economically feasible." There is a clear concern not to impose any measures that might not be cost-effective. The requirements may be set either for the renovated building as a whole or for the renovated systems or components when these are part of a renovation to be carried out within a limited time period.

Finally, the definition of major renovation must be clearly set. The Member States have two options:

- the cost of the renovation is more than 25% of the cost of the new building, without the cost of the land where they stand, i.e., construction costs alone.
or if there is an intervention on more than 25% of the envelope of the building.

1.3.2 Energy Certification of Buildings

“Energy Certification” is probably the single major new step required by the EPBD. Almost all the EU countries already have energy regulations for buildings, and applied them regularly for quite a few years. Conversely, only Denmark and a few other countries had Certification in place, and for less than 10 years at best. So, it is a novelty for most countries.

Article 7 of the EPBD requires an Energy Certificate for every new building, for every existing building when it is rented or sold (a certificate must be provided by the owner to the buyer or the renter) and, periodically, also for large public buildings over 1000 m². For the public buildings, the certificate must be displayed in a well visible location at the entrance. The buildings exempted from regulations are also exempted from certification, at the discretion of individual countries.

The certificates must be issued by accredited, recognized, independent bodies. The validity of the certificate shall not exceed 10 years, but Member States can define lower periods of validity.

Certification for apartments or units designed for separate use in blocks may be based:

- on a common certification of the whole building for blocks with a common heating system;
- or on the assessment of a representative apartment in the same block.

CEN is also issuing a new EN standard to define minimum requirements and guidelines for the Certificates, namely to comply with the EPBD requirement that “the energy performance certificate for buildings shall include reference values such as current legal standards and benchmarks in order to make it possible for consumers to compare and assess the energy performance of the building”.

Most importantly, “the certificate shall be accompanied by recommendations for the cost-effective improvement of the energy performance.” By providing a list of possible cost-effective improvement measures, it is expected that a significant number of building owners will voluntarily implement at least a significant portion. This will create a large retrofitting market and make large energy savings possible in the existing building stock, a major energy consumer in Europe. The experience in countries where Certification is already in place,
1.3.3 Inspection of Boilers and air-Conditioners

According to Articles 8 and 9, Member States must require regular inspections for boilers and air-conditioners above a certain power threshold. From the inspection, the owner should receive advice on the replacement of boilers, if applicable.

For boilers, requirements are different for different power levels and by fuel type:

- boilers fired by non renewable liquid or solid fuel of an effective rated output of 20 to 100 kW - period to be defined by Member States. A new EN standard under discussion recommends a default, indicative, non-binding period of 3 years.
- Boilers of an effective rated output of more than 100 kW shall be inspected at least every 2 years. For gas boilers, this period may be extended to 4 years.

It should be noted that gas boilers below 100 kW are not required to have regular inspections.

Heating systems with more than 15 kW, when they become fifteen years old, must be inspected once. On the basis of this inspection, which shall include an assessment of the boiler efficiency and the boiler sizing compared to the heating requirements of the building, the experts shall provide advice to the users on the replacement of the boilers, other modifications to the heating system and on alternative solutions.

Article 9 of the EPBD, requires inspections of air-conditioning systems over 12 kW. This inspection shall include an assessment of the air-conditioning efficiency and the sizing compared to the cooling requirements of the building. Appropriate advice shall be provided to the users on possible improvement or replacement of the air-conditioning system and on alternative solutions.

However, the text of the Directive 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 Figs. 2 and 3. This would be the worst possible option that countries can make for implementing article 9.

Fig. 2 Two views of the air-conditioning system in a hotel central courtyard – the outdoor units of individual split systems for each room.
Building regulations should 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 be inspected 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.

### 1.3.4 Accreditation of Experts and Inspectors

According to article 10 of the EPBD, "Member States shall ensure that the certification of buildings, the drafting of the accompanying recommendations and the inspection of boilers and air-conditioning systems are carried out in an independent manner by qualified and/or accredited experts, whether operating as sole traders or employed by public or private-enterprise bodies."

Studies by Member States indicate a need for thousands of experts and inspectors once all the certification and inspection activities are in place. This aspect is probably the most difficult issue that MS must face to implement the Directive.

### 2 Conclusions
Each country (or region) is free to implement the EPBD in its own way, as long as it complies with its basic requirements. So, a relatively large range of solutions will surely be adopted throughout the EU.

The EPBD, among many other useful consequences, will no doubt also result in more stringent insulation requirements for reducing heating needs in the new building regulations. These will also have to 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 (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 however 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 heating and 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 these issues.

Certification of buildings will play a major role in informing the market (building users and owners) about the quality of new and existing buildings. There will be a strong pressure from market forces to produce higher class buildings (e.g., A type) as a premium in terms of better market price. This measure, just by itself, will become the major driver for improved quality of buildings, more than the new improved regulations that MS must put in place and update on a regular basis after the beginning of 2006.

3 Further reading


