THE EUROPEAN
GREENBUILDING PROGRAMME

Technical Module on Sustainable Summer Comfort

Contents

Summary

Sustainable summer comfort can be defined as achieving good summer comfort conditions with no or limited use of conventional energy (fossil and nuclear) and through the use of environmentally non-harmful materials.

It can be achieved if the following ten steps are considered when planning, constructing and operating a building:

1. Define the thermal comfort objectives explicitly, using the Adaptive Comfort model where possible;
2. Intervene on the site layout and features of the surroundings of the building which can affect summer comfort;
3. Control and reduce heat gains at the external surface of the building envelope;
4. Control and modulate heat transfer through the building envelope;
5. Reduce internal gains;
6. Allow for local and individual adaptation;
7. Use passive means to remove energy from the building;
8. Use active solar assisted cooling plants;
9. If still necessary to reach the stated comfort objectives, use high efficiency conventional active cooling plants;
10. Train building managers and occupants on how to use, monitor performances and adequately operate and maintain the building.

What is sustainable summer comfort?

The average efficiency of electricity generation in Europe is about 36%[1], and other losses are present in the chain from electricity to the final useful service delivered. Hence energy saved at the end-user level has a larger effect on reducing demand of energy resources, investments in the energy chain and of impact on the environment than any other measure. Therefore our logical path to sustainable

---

[1] This is the ratio of electric energy generated to the energy content of the fuel input to the electric power plant. When considering the entire process of extracting the resource from the ground (e.g. crude oil, natural gas, coal), preparing, transporting, converting it in a power plant and finally distributing it the overall efficiency of this chain of processes is considerably lower. Other losses are then present in the chain from electricity to the final useful service delivered

summer comfort will necessarily start from analysing the means to reduce energy demand at the user level.

Sustainable summer comfort can be defined as achieving good summer comfort conditions with no or limited use of conventional energy (fossil and nuclear) and through the use of environmentally non-harmful materials.

Instead of setting maximum energy input or prescribing certain technologies to be used, we propose a logical sequence of steps that should be considered when designing, constructing and operating a building. This approach has the advantage of leaving ample freedom to designers while supporting them in adapting the building to the local situation (climate, culture, locally available materials). In addition, this approach leaves open the possibility to find and implement even better strategies and technologies in the future.

Not all the steps and actions will be available in a specific situation to the owner/designer (e.g. urban planning is outside their competences, but in certain cases the design of a relatively large area with a number of buildings and open spaces might be possible), but our recommendation is to follow the path starting from step 1 and closely analyse what are the possibilities for action in a given situation for each step. If action at a certain step is considered not feasible in a given situation, one should explicitly state and document why, before proceeding to the next step.

10 steps to achieve sustainable summer comfort

Define the thermal comfort objectives explicitly, using the Adaptive Comfort model is possible.

Eliminato: where

Mostly, regulations require keeping upright a constant indoor temperature, regardless of the outdoor conditions. These prescriptions come sometimes from a unduly rigid interpretation of the underlying comfort model (Fanger model), derived from a series of climate chamber experiments. However, recent field studies with a large population sample all over the world show that people in real buildings, when they have some direct control on local conditions (e.g. in naturally ventilated buildings), spontaneously adapt their comfort requirements to the prevailing outside temperatures. This means that the indoor temperature at which occupants of a building report comfort, varies with the location, type of climate, weather and season. In addition, the field studies show that a wider range of temperatures are considered comfortable than prescribed by the commonly used regulatory and design practices. Based upon these results, scientists created a new comfort model, the Adaptive Comfort Model, which has been included in ASHRAE building norms and is in the process of being included in CEN norms. Using, where possible, this model in building regulations, design and control will remove some of the present incentives to construct highly serviced, over-heated and over-cooled buildings that use more energy and provide less comfort than they should.

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

A compact urban layout may be useful 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 solar absorbivity of urban surfaces (streets, parking spaces,…) can strongly influence surface and air temperatures in open spaces surrounding the buildings.

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

Heat enters through the external surface or boundary of the building because of solar radiation and of the difference between outside air temperature and inside air temperature.

A high reduction of the amount of heat going through the external surface (or boundary) can be achieved by means of solar protections designed to shade windows when required (and possibly also walls and roofs), by surface finishing with adequate values of reflectivity and emissivity, and by means of limiting air exchanges when outside air is at higher temperature than inside air.

Eliminato: finishings

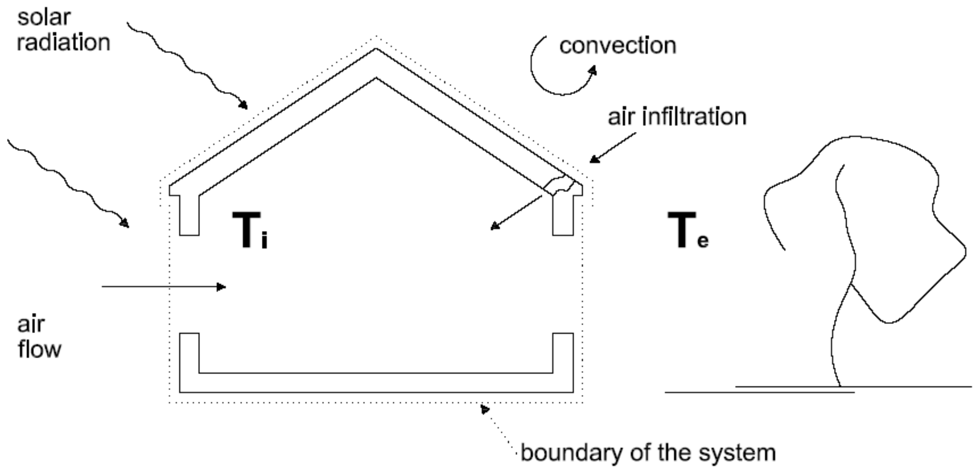

Figure 1: Thermal energy flows though the boundary separating the building and its environment because of absorption of solar radiation, convection exchanges with the atmosphere, air infiltration and air flows through cracks and openings.

Control and modulate heat transfer through the building envelope

Once heat has passed through the external surface or boundary, its movement to the interior (via heat conduction and convection) should be limited by appropriate use of insulating materials and the time lag by which it gets to the interior should be controlled by appropriate size and position of thermal mass.

Reduce internal gains

Internal gains should be reduced by using efficient lighting sources and systems (notably the most efficient one, daylight); by direct venting of spot heat sources; by using efficient appliances and equipment.

Allow for local and individual adaptation

Allow 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 up to a few days of "heat wave holidays"[2].

Use passive means to remove energy from the building

Once having reduced external and internal gains and having allowed means to individually adapt, if the desired comfort objectives are still not met, use passive means to remove energy from the building and/or increase comfort (comfort daytime ventilation, night ventilation, use of the ground as a heat sink – directly or via a heat transfer fluid –, radiation of energy to the night sky, direct or indirect evaporative cooling).

An important issue here is the definition of a passive measure. We adopt the definition given by Givoni[3]:

> *"the term passive… does not exclude the use of a fan or a pump when their application might enhance the performance. This term emphasizes the utilization of natural cooling sources, or heat sinks, for the rejection of heat from the building and, if some power is needed to operate the system, that the heat transfer system is low cost and simple and that the ratio of power consumption to the resulting cooling energy is rather low …"*

---

[2] In the same way as schools and offices may be closed in winter as a consequence of a snowfall

[3] Givoni, B. (1991). Performance and applicability of passive and low-energy cooling systems. *Energy and Buildings, 17*, 177-199

Use active solar assisted cooling plants

If passive means are not sufficient to achieve the thermal comfort conditions assumed as an objective at step number 1 for a sufficient fraction of time, then remove the excess thermal energy from the building via active solar assisted cooling (e.g. absorption and adsorption cycles driven by heat from solar collectors).

Use high efficiency active conventional cooling plants

If, and only if, steps 1-8 are still not sufficient to achieve the desired thermal conditions, use conventional active cooling plants with high efficiency. Design this active system always in combination with steps 1-8 so that they are only responsible to remove peak loads in extreme hot times or in special parts of the building, and the major drive towards summer comfort is provided by the previous steps. In case of existing buildings with existing HVAC systems, try to use steps 1-8 to reduce cooling loads and improve the efficiency of the existing plant using the same approach, i.e. starting from as close as possible to demand. This means intervening first at the level of the diffusion of cold air to the internal environment, going then upward to the distribution system (air or water), reducing pressure drops in the ducts (straight ducts layout, choice of low friction elements) and leakages, increasing the efficiency of heat exchangers, shading the condensers from the sun, using efficient fans, pumps and motors with variable speed regulation. Intervening in these ways to reduce losses in the chain allows finally for the use of a smaller size vapour compression cycle.

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

Having followed the previous steps, the entire building (rather than the active plants) is the means for reaching comfort conditions. 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 building and its systems/plants when present.

For new buildings, a monitoring plan should be prepared to asses whether the performance (comfort, consumption) of the building matches the design objectives and the persistence of good performance over time.

A maintenance plan should be followed (ordinary planned maintenance and extraordinary maintenance when decay of performance is detected)[4].

---

[4] It should be noted that point 10 is not a burden which is connected to the choice of passive techniques. On the contrary in the case of the presence of an active cooling plant all the above actions are also necessary, and the technical complexity of the plant requires specific training.

Conclusion

Following the 10 steps of our sustainable summer comfort process means to:

- consider the building as a whole and its multiple interactions with its environment and
- exploit envelope/passive measures (eg. building envelope design, climatic conditions and natural energy sources) to achieve the desired - and explicitly stated - comfort objectives.

This is the contrary of the design process that is often prevailing today. Here, design architects/engineers tend/are forced to delegate the achievement of comfort conditions to HVAC engineers, which in turn cannot intervene in decisions about building envelope, lighting systems, and not even the building layout which affects the placement of mechanical equipment and ducts. In this way, internal comfort is achieved primarily through active measures, i.e. cooling and ventilation based on importing fossil energy into the building. The result of this lack of integration is a large number of buildings which are less pleasant to inhabitate, more costly to build and several times more costly to keep comfortable in summer than they should be.