Baseline designs - environmental services strategy

The industry is moving away from compliance checks at the design stage to checks of Performance in Use (PIU) to ensure an efficient and comfortable building.

Compliance with design criteria does not necessarily ensure good PIU. This is also a way to ensure that design criteria are realistic and achievable.

PIU criteria follow through from design to facilities management (FM) requirements and key performance indicators (KPIs) and on to Post Occupancy Evaluation (POE).

Failures of PIU are penalised in the PFI payment mechanism through service and area availability deductions.

Examples of PIU criteria being introduced in the PSBP OS are:

1. Indoor air quality; maximum carbon dioxide concentrations in occupied teaching rooms of less than 1500 parts per million.
2. Minimum and maximum internal illuminances: lux levels on the working plane; ceiling luminance, cylindrical illuminance.
3. Minimum room temperatures to be achieved under winter design conditions.
4. Heating room control thermostats to be within 3^oC of actual air temperatures.
5. Operational background noise levels in teaching and learning spaces: unoccupied operational noise level not more than 5dB above unoccupied indoor ambient noise level.
6. Maximum summertime temperatures: internal air temperature does not exceed outdoor air temperature by more than 5^oC.
7. Maximum thermal energy consumption of 60 kWh/m^2/year and maximum electrical consumption of 50 kWh/m^2/year with a carbon rating of less than 40 $KgCO_2/m^2$/year to give a Display Energy Certificate rating of C or better.
8. Water consumption of less than $2.8m^3$ per person per year for schools without a pool.
9. Monitoring separate energy loads and reporting quarterly to School Management Team including:
   - External lighting - power to be metered and reported.
   - Server rooms - Power Utilisation Efficiency (power into the room /power used by ICT equipment) should be less than 1.5; room temperatures maintained between 15 and 27^oC.
   - Internal lighting - energy efficiency of internal lighting to be monitored against the end use target for lighting.
   - Hot water system efficiency ≥45% on an annual basis.

Maximum Summertime Temperatures

The baseline designs use thermal mass in ceilings with night ventilation and external shading to reduce the possibility of overheating.

The CIBSE Overheating Task Force have proposed new criteria to assess overheating in free-running buildings, based on the adaptive thermal comfort model, to replace the existing criteria given in Guide A (2006) “Environmental Design”. The requirements set out in the PSBP FOS are based on these new criteria. Free-running buildings are defined as those that are not mechanically cooled.

The adaptive thermal comfort approach used follows the methodology and recommendations of European Standard EN 15251 to determine whether a building is overheated, or in the case of an existing building whether it can be classed as overheating. The new criteria are based on a variable (adaptive) temperature threshold that is generated from the outside running-mean dry-bulb temperature. The running mean takes into account the temperatures over the preceding period of about a week.

The graph below shows how the new criteria relate to the fixed maximum temperature previously used.

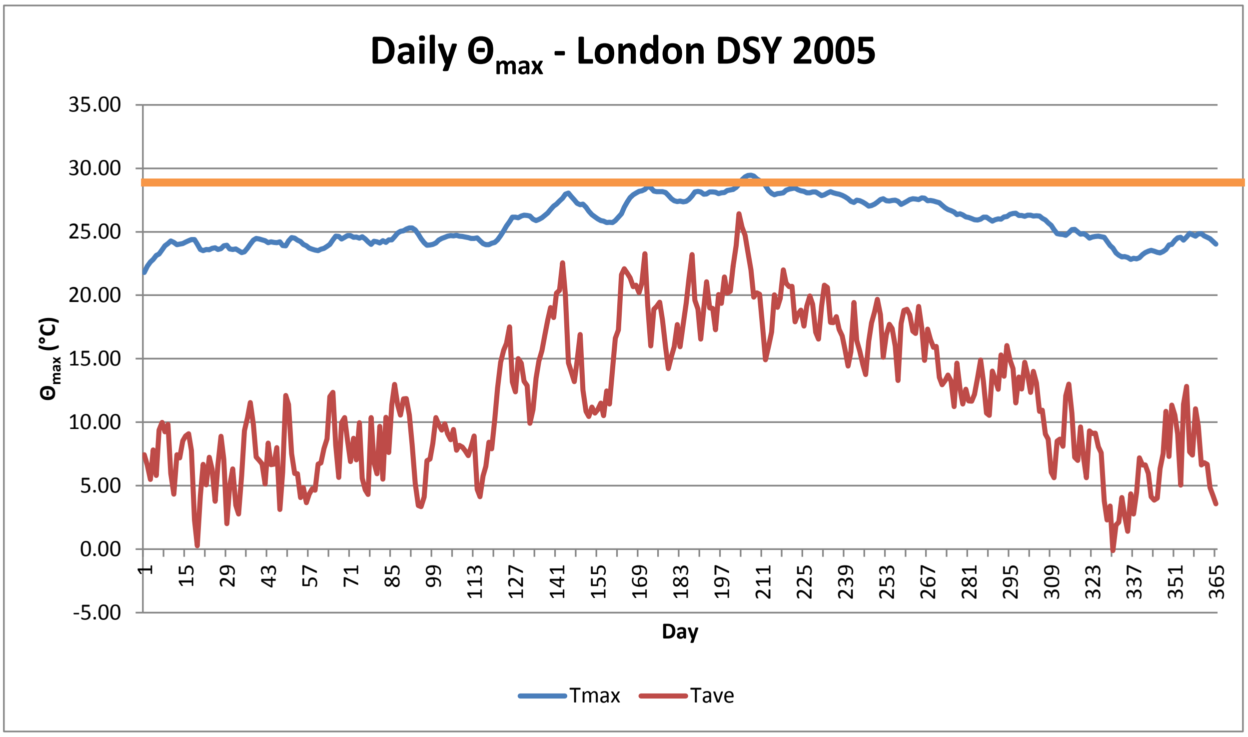
- The dark red line indicates the daily mean outdoor air temperature.

- The bright orange line indicates the old BB101 threshold for a fixed maximum internal air temperature (rather than operative) of 28^{o}C. This threshold has been shown by post occupancy field study research to be too high.

- The blue line indicates the maximum allowable indoor operative temperature Θ_{max} calculated from the running mean of the outdoor air temperature.

In summertime a lower temperature is now required by the FOS than was previously required using the BB101 criteria. However using the adaptive thermal comfort critieria is much better than using a lower fixed temperature as the body can adapt over time when external temperatures are high outside. This means that schools can have fewer artificial cooling systems.

.



It can be seen from the graph that Θ_{max} follows the overall trend of the mean outdoor air temperature, but as it is calculated from the running mean of the air temperature, outlying peaks and troughs are smoothed to form a more uniform temperature target over the course of the year.

The new maximum indoor temperature criterion Θ_{max} described above was used to assess the risk of overheating in the baseline schools for the period of 1^{st} May – 30 September.

Daylight

Climate Based Daylight Modelling

The teaching spaces were now required to be assessed using climate based daylight modelling (CBDM) in place of daylight factors. CBDM uses real world weather data and therefore measures the contribution from sunlight and overcast light. CBDM provides a measure of daylight autonomy (DA), the calculated time the electric lighting will not be required and Useful Daylight Index (UDI), the amount of time the room will be provided with light that is not a glare source nor too low to be useful.

Balanced Ambient Light

The preference is to deliver daylight into the teaching spaces from two sides of the room. This increases the daylight ambient lighting level and ensures when the blinds need to be used to control glare on one side, daylight is still delivered into the space from the other side of the room.

Ceiling Height to Room Depth

The classrooms in the secondary schools baseline designs have 3.3m ceiling heights and a maximum room depth of 7.8m which ensures sunlight and daylight is distributed throughout the teaching space.

Window Dimensions
The secondary school baseline designs provide a minimum of 30% glass to wall ratio with the window heads up to the ceiling level of 3.3m to aid distribution of light throughout the room. Where external obstructions reduce the availability of daylight on the building facades then the glazing percentage to each room affected would need to be increased.

Building Orientation
The assumed orientation for the baseline designs is North/South, allowing a higher quality of sunlight and daylight within the teaching spaces. Higher angle south sunlight is easier to control with respect to glare than East or West lower angle sunlight.

Ventilation

All teaching rooms are designed for stack or cross ventilation in summer and mechanical or fan-assisted ventilation with heat recovery in winter. The ventilation systems with heat recovery in winter are designed to avoid cold drafts and to reduce energy consumption in order to meet the space heating and thermal energy targets for the baseline schools.

Primary Schools
Teaching spaces are 3m high and 7.2m deep with exposed concrete soffits. Night purge ventilation is achieved through stacks on the corridor side of the classrooms; these are controlled by actuators. Windows are not needed for night purge.

Secondary Schools
Teaching spaces are 3.3m high and 7.8m deep with only a few exceptions being 9m deep; all have exposed concrete soffits. The windows are fixed and ventilation is provided by a separate set of insulated ventilated louvres adjacent to the windows. The window blinds can therefore be deployed without obstructing the airflow.

Night purge ventilation is provided through the louvres at high level. This reduces the security risk and the need for restrictors is removed.

At the back of the ground and first floor classrooms are attenuated ventilation openings which connect the rooms with the circulation space behind.

Energy consumption targets
The environmental design is supported by our approach to energy efficiency. This will be delivered through:

- achieving the energy consumption operational targets for the whole building and it’s separate major energy end uses, eg the internal lighting energy;
- the provision of sensible sub metering to monitor total energy consumption and energy end uses;

- using a methodology such as CIBSE TM22 2012 to determine how the design strategy will meet the operational targets, which will also be used to reconcile the in-use energy performance;

- a strategy to determine discrepancies between the predicted and the actual loads.

The strategy has been developed following feedback, evidence and the post occupancy evaluation (POE) of new school buildings constructed during and after 2006, where operational (actual) energy use typically exceeded the expected (design) energy consumption.

The energy efficiency strategy has been developed:

- so that new build schools operational annual energy use performs in line with good practice expectations;

- to periodically evaluate the operational energy performance of the school and make adjustments where appropriate;

- so that the school's energy end uses are managed by those responsible with varying levels of information presented so that it is easily understood and readily available(electronically and on-line);

- to manage the allocation of energy costs, eg, for payment by third party community users of the premises.

Our ethos is based on an interactive approach for those responsible for regulating the energy use of the school, moving away from a reliance wholly on building service controls to manage energy use.

We believe that a combination of a well-designed building and its services in conjunction with an engaged management approach will ensure that a schools energy costs and its environmental impact are minimised. As such, our strategy:

- includes the use of web based platforms, to disseminate information anonymously;

- ensures continual engagement with those responsible for the schools energy use;

- provides a breakdown of in use energy consumption by the main energy end uses of the school;

- provides awareness and the basic understanding of how the buildings should be used, to operators, occupants and all other relevant stakeholders.

The schools have been designed so that they can achieve the following carbon emissions and energy consumption operational targets:

- a total fossil fuel energy consumption of less than 60 kWh/m^2 .
- a total electricity consumption of less than 50 kWh/m^2;
- providing a total energy consumption of 110 kWh/m^2;

- a carbon rating for the School's total energy consumption of less than 40 $KgCO_2/m^2$ and
- a total electricity consumption, in the case of an all-electric school, of less than 90 kWh/m^2 equating to a carbon emission of 46$KgCO_2/m^2$

The above figures are based on an extensive benchmarking exercise of the energy use in existing schools.