Building Energy Efficient Schools in Leicester

Background

At the start of the Building Schools for the Future (BSF) Programme, schools in Leicester accounted for approximately 40% of carbon emissions within the Local Authority's building estate. Secondary schools generate approximately half of those school emissions. This, in part, was because of the inefficiency of a large number of older schools but also indicates the size of the school estate in the overall portfolio of Leicester, and, indeed, most local authorities. Government projections indicate that the current rise in pupil numbers will continue until at least 2023. Therefore, the size and number of schools within Leicester is set to continue to rise over the next few years. Whether under direct local authority control or as academies, the fact will remain that energy used and carbon generated by schools is on an upward trajectory which the Leicester City Council generally and this project specifically has sought to halt and reverse.

The BSF Programme in Leicester, with funding of £350 million, was the City's largest ever single investment in public buildings and part of the national BSF Programme. It consisted of a rebuild and refurbishment programme covering each secondary and special needs school in the City. A key driver from the outset for both the Local Authority and the schools was maximisation of energy efficiency and therefore a reduction in carbon emissions through this programme.

A further significant factor during the time of the BSF programme was the advent of the deepest and longest recession for many years. This led, as we are aware, to a change in government whose austerity measures included an immediate and significant scaling back of the BSF Programme. Leicester fared better than many local authorities. In 2010 Leicester City Council secured funding to complete its programme of redevelopment and refurbishment in exchange for offering up to £30miliion in savings. Consequently, schools in the later phases of the Leicester Programme were constructed within the context of significantly tightened budgets – exemplar new build designs were reduced to smaller schemes and elements of new build were halted, requiring the retention of a greater amount of the existing school estate.

It is also important to note that school energy budgets are not ring-fenced and every pound spent on energy over and above that which is budgeted for has to be taken from the education budget, directly impacting on the learning opportunities of the children and young people of Leicester. Conversely, every pound saved on energy can be added to the education budget.

Despite these budgetary constraints Leicester held, and still does hold, high expectations in reducing its carbon footprint as evidenced by the City's carbon action plan. https://www.leicester.gov.uk/media/179267/climate-change-programme-of-action-2014.pdf This aspiration created added pressure on the BSF Programme to ensure that greater energy efficiency was achieved for less money and prompted a search for a more proactive and creative approach to carbon reduction within the Programme.

Consequently, an innovative Knowledge Partnership between Leicester City Council and De Montfort University was established in 2010 to assist in embedding knowledge and identifying opportunities for carbon and energy reduction in the BSF Programme.

The aim of the Knowledge Partnership is to achieve a two-way process where partner's and organisations share learning, ideas and experiences, generating, in this case, a shared understanding between the academic and the commercial. As part of this Programme, funding was secured for an associate post to work in collaboration with staff from DMU's Institute for Energy and Sustainable Development (IESD) and the Council's BSF Strategy Team.

The knowledge Partnership has worked hard and effectively to keep the focus on key areas of energy efficiency within the design, construction and operation phases. Through applying its expertise, the partnership has helped to identify practical methods of achieving carbon reduction. These areas are identified in this case study as good practice and, it is hoped, will be useful as a guide to aid the development of better, more energy efficient, schools wherever they are built.

The Knowledge Partnership was also able to develop and support initiatives in response to specific issues as they arose throughout the BSF process. One such initiative was the development of Building End User Guides for some of the schools. These bespoke documents are intended to crystalise the extensive building user manuals into a form which provides the essential knowledge to school staff in a way that is succinct, clear and visually strong. The guides have two sections, the first is the more detailed and is for the premises management team to help them understand and manage the whole school premises. The second section has a lighter feel and is for the teaching staff and students, to help them manage their own teaching and learning environments.

A second initiative supported by the Knowledge Partnership is the use of Dynamat Lite. This system, to which most schools in Leicester now have access, enables them to see their electricity, gas and water usage; their carbon emissions and the cost of their consumption, comparing usage over time. The system is connected to the more sophisticated Data Bird system. Data Bird enables the City Council to collect and analyse individual school data and also to receive alerts when, for example, a spike in water usage suggests a leak may have occurred. The Knowledge Partnership has provided training to schools to help them maximise the benefit of this useful tool.

Throughout the following discussion an over-riding message permeates – early thought will generate the best solutions.

Building Orientation and Façade

Appropriate orientation, wherever the site allows, plays a significant and very cost efficient role in regulating the temperature of a school. This is the first and potentially most significant decision in any new design. Wherever possible, new schools are oriented with their larger glazed facades facing north and south, as east and west facades are comparatively difficult and more expensive to shade from the rising and setting sun.

With the benefit of a new, level and unrestricted site, the orientation and design of the building has a great degree of flexibility. However, this can be restricted by a number of factors such as the size and topography of the site, and whether or not there is any retained estate which new buildings will be either joined to or built in the context of. Even if the old school is to be demolished, this usually happens following the construction of the new build and can therefore constrain the orientation and design of the new.

The Leicester school estate includes a wide range of scenarios. For example, Moat College is built on a very restricted site with little space to extend and no opportunity to dictate its orientation. In contrast Crown Hills School is built on a spacious site, offering a greater opportunity to re-orientate the school. Ellesmere College, a special needs school, is on a steeply sloping site which required the school to be built into the bank. This topography dictated its orientation and necessitated a deeper plan design. In consequence, parts of the building are susceptible to excessive glare (from sunlight) and solar gain (the heating effect of sunlight) whilst other areas experience lack of natural light. These factors create design challenges which, if carefully addressed can be overcome.

For example, where possible, rooms with higher heat demand (space heating), such as standard classrooms, face south and those with lower heat demand, such as ICT suites, cookery classrooms and sports halls face north. This has been achieved to good effect at Crown Hills on their unrestricted site but at Ellesmere College, their south facing, sloping site largely precludes north facing classrooms.

Building Form & Shape

Where possible, Leicester's school buildings have been designed with a shallow plan, so that no internal space is very far from natural ventilation and light. The depth of classrooms is usually limited to 7 meters and the depth of the room is not more than 2.5 times its height. In addition to creating an attractive comfortable learning space, this specification can create very significant reductions in the need to use both artificial lighting and air conditioning.

The disadvantage of a shallow plan is a greater surface area exposed to the outside. This necessitates high levels of thermal insulation and airtightness to reduce the potential heat loss. This can certainly be achieved but the design and construction standard required is an exacting one and must be ensured across each surface and, especially, at each joint in the construction.
On sites where a shallow plan is not an option, such as the sloping site at Ellesmere, deep plan buildings offer a compact form with a lower surface area to volume ratio. Consequently, whilst there is less potential for heat loss, deep-plan buildings present a greater challenge in terms of natural ventilation and daylight.

Whatever the shape of a school building, it is essential that rooms are positioned carefully in relation to the available natural light and ventilation. Historically, for example, larders were placed on the coolest part of a building and sun rooms naturally tend to face south. Following the advent of refrigerators, central heating and air conditioning, the importance of the relationship between a building and its environment was considered to be diminished. However, the sustainability agenda is beginning to restore that relationship. The interaction between the building and its environment is an important part of Leicester's school designs and contributes significantly to their effectiveness as places for learning, their comfort and their energy efficiency.

Even in deep plan schools such as Ellesmere, by locating classrooms and offices on the external facades, most occupied spaces do have access to daylight and natural ventilation. Some occupied spaces must, of course, be situated away from the external façade, so communal spaces such as the sports hall or assembly hall are often positioned at the heart of the building because these large, double height spaces can be naturally lit and ventilated more easily from above. Also, computer suites, plant rooms and kitchens can be situated where solar gain is minimal. For example, the designers of West Gate Special School, have located small sensory rooms where they have no external façade enabling them to be completely enclosed so that bespoke therapeutic environments can be created for the pupils using them.

Light

The quality of daylight has a direct impact on learning performance, so optimally lit learning spaces are illuminated for educational success! Driving sustainability into design decisions for our newly built BSF schools has ensured that almost 80% of every new building is illuminated by natural light.

Where site restrictions have necessitated a 'deep plan' building, the difficulty in providing natural light can be overcome, in part, by the use of skylights to allow daylight into the areas poorly served by light from side windows. Natural light brought into a space from above, such as a skylight, enables up to 40% more light to enter the space than an equivalent wall mounted window. Of course, a drawback of lighting from above is that it does not offer a view to occupants of the world outside the room; however, the quantity and quality of light can be beneficial. Skylights may also be subject to direct sunlight which can be overcome by angling the glazing towards the north, as has been done at Ellesmere, or by providing automated blinds.
Sun pipes, which draw light through mirrored tubes, offer soft lighting along otherwise unlit corridors at Ellesmere. Whilst they don't offer a huge amount of light, a corridor space does not require the same level of illumination as a classroom so this form of natural lighting can replace or at least reduce the need for electric lighting in corridors and other spaces with limited or no natural light.

Double height, naturally lit central atrium areas are used to maintain optimum light levels in some schools. For example, the 'strawberry' shaped learning zones at Crown Hills have central double height learning plazas surrounded by classrooms on each floor. These plazas are designed to enable light to flood in from roof lights or windows at the top of the high walls. Internal windows from the plaza draws borrowed light into the surrounding rooms, creating an even lighting with no significant risk of glare.

Lighting in each school is either manually operated by room occupants or light sensitive – switching off when a room has adequate amount of good daylight, or occupant sensing – switching off lights when rooms remain empty. Classroom lights closest to windows are programmable to switch off as daylight increases, independently of those deeper into the naturally darker parts of the room. This ensures that the room remains more evenly lit throughout the learning day.

Motion sensitive lights are more typical is spaces such as toilets and store rooms. These are spaces where infrequent use enables lights to be turned off for periods of time and the use of sensors ensures that this happens automatically. There have inevitably been teething troubles with some of these systems as, for example, the length of time that lights remain on have needed to be adjusted, but the principal of efficient lighting is firmly in place in all of the new BSF schools and is entirely achievable in all new schools.

Ventilation

New schools are designed to be much more airtight, in order to promote heat retention. Appropriate ventilation design is therefore crucial to ensure that adequate fresh air levels are achieved to prevent the build-up of airborne toxins and of carbon dioxide (CO2) in occupied spaces.

Over recent years, mechanical ventilation has become the norm in many buildings, often contributing significantly to energy consumption. Leicester's BSF schools have been designed to reverse this trend and to place emphasis on natural ventilation wherever practical.
Classrooms, and most other areas, are designed to be entirely naturally ventilated for most of the year. A mechanical extractor assists only on days when additional fresh air is essential because of high temperatures or low air quality.

Classroom windows are specified to have a minimum of two levels of opening, as far apart from each other as possible and at least a fifth or each window unit capable of being opened. This enables a good rate of circulation within each window unit. Additionally, each window has a trickle vent so that, when windows are closed, some ventilation remains possible.

Trickle vents also enable the mechanical ventilation system to be effective when required. The extractors, located in each classroom, draw air from the room; this air needs to be replaced, which can only be provided through openings in the envelope of the room. In the well-sealed and insulated rooms of our new schools, natural openings such as gaps beneath doors and around window frames have been minimised. Consequently, the use of trickle vents and opening windows is essential. It is of note that the excellent Business Manager at Crown Hills has only praise for the fabric of his school but habitually opens his office window each morning, whatever the weather, to facilitate air flow and to ensure that there is fresh air in his work-space at the start of each working day.

Our later schools have CO2 sensors in all classrooms, which use a traffic-light system that guides staff members when to open windows and turn extractors on. When needed, the mechanical extractors can be locally controlled by teaching staff. Where such systems are used it is important to ensure that the traffic-light system changes at appropriate concentrations and that staff are informed about their operation and the corresponding actions to take.
Throughout our new schools, the natural action of warm air rising (buoyancy) is utilised to create natural ventilation. For example, the double height atria are used at Crown Hills to allow warm air from lower floors to rise and reach the roof space where it can be vented from the building through the same mechanically operated windows which flood the centre of the building with light.

Heating and Zoning

The heating in the schools is typically either through wall mounted radiators or ceiling radiant panels. Space heating is provided by a combination of gas fired boilers, biofuel boilers and in some cases by biofuel combined heat and power units (CHP), which generate electricity whilst also heating the water in the sealed central heating system. In some cases, mechanical ventilation units have a heat exchange unit, which ensures that heat is recovered from the extracted air before it leaves the building and the heat is used to heat the incoming air.

Additionally, some schools, such as English Martyrs have had photovoltaic solar panels (PVs) fitted to their roof, which contributes significantly to meeting their electrical energy demands. Babington, a later school built on a very tight budget, did not have PVs specified but have invested in them subsequently, aiming ultimately for this form of power generation to meet the basic power needs of the school. West Gate are still considering whether to invest in PVs but have the infrastructure in place to enable them to take the decision when ready. The funding landscape for renewable energy is constantly shifting as the unit and installation costs fall. However, the opportunity to build in the physical space and electrical capacity for PVs exists at the design stage and should be actively considered.

The zoning of Leicester's later schools is hugely significant in creating an efficiently managed building. For example, schools, such as Babington, remain open for extended school activities and community use up to 10pm most days. However, not all areas in the school are in use. Consequently, significant energy savings can be made by heating only those areas which are occupied. Creating zoned areas makes this possible. It is quite remarkable to think that this has not been a standard design feature of schools for years, but it certainly should be in years to come.
All spaces accessible to the community are usually placed together with independent access and are zoned independently for heat, light and energy. Adequate care is taken to ensure that access to community spaces does not require any other section of the building to be heated, unless that too is in use.

Sports facilities, for example, may be in full use whilst an unused computer suite is using no power or lighting and requires heating only to a minimum level. This allows for operational efficiency in conserving energy and also allows the school staff to easily manage their building through real time or programmed control. Sub-metering of each zone is possible, to establish how efficiently each area is being managed, which offers opportunity for further support and training of occupants if required. At Crown Hills, for example, a competition between occupants of each zone is planned to see who can operate their environment in the most energy efficient way.

Metering is essential so that users can gain feedback on their usage, fine tune heat, light and power systems, address anything which might indicate technical or behavioural issues. Some of the schools, such as Babington and Crown Hills, have a computerised control panel, enabling frequent and fine adjustments throughout the day whilst other schools, such as Ellesmere, are seriously considering acquiring this enhanced level of management which, though expensive, will have a short payback period if used in the active pursuit of greater energy efficiency.

The Dynamat Lite system has also been adopted by our BSF schools. This enables schools to monitor and record their energy and water consumption hour by hour, day by day all the way through to year by year. This information enables comparison which can bring about incremental improvement in carbon reduction. It is also available to Leicester City Council which enables their energy team to provide support where issues are identified. It may also offer, in the future, the opportunity for schools to compare their energy performance with each other.

Within the zones, individual rooms can be controlled to suit occupancy as well as the movement and intensity of the sun. This gives autonomy to teachers and students in their learning environments. In order to ensure that teaching staff fully understand how to manage their rooms, premises staff have been thorough in their support. Additionally, the knowledge Partnership has created, for five schools, a Building End-User Guide which provides premises staff, teachers and students with a simple, visual guide to their building. Schools such as English Martyrs, Crown Hills and Babington have used this information to great effect. Feedback repeatedly heard is that students are leading the way in managing their learning spaces effectively, frequently helping teachers to make the most efficient use of the in classroom heat, light and ventilation controls.

Building Fabric

The quality and thermal efficiency of materials used in the construction of the schools it critical to the retention of the heat generated within it. As important is a high quality of workmanship in assembling the different materials – the point at which materials and elements of the building meet, for example where a window meets a wall, are the most likely places for heat loss.

The most significant transfer of heat between the inside of a building and the surrounding environment is by conduction through the fabric of the building. Heat flow as a result of differences in air temperature, or the heating effect of solar radiation for example, can be minimised through the use of high levels of thermal insulation. Economies of scale, afforded by such a big building programme, have enabled levels of insulation above the already significantly high standard requirements to be exceeded.

Thermal bridging increases conductivity considerably and all efforts have to be made to minimise and eliminate the presence of high conductivity material bridging the gap between the inside and the outside of the building. Therefore, any structural element such as steel beams, traveling from inside to outside of the building should be insulated with low conductivity materials. The same is true for window frames, which also should be carefully insulated against drafts. This level of detailing and workmanship has been present in Leicester's BSF schools all of which have achieved higher energy standards than building regulations.

School Case Studies

Babington

Babington is one of the later generation of BSF schools directly benefiting from the intervention of the Knowledge Partnership programme. On a lower, post-recession budget, the school has built into its design a range of extremely energy efficient features which it is learning to use increasingly effectively to reduce energy consumption.

Ray Allsop, Business Manager and champion of the school's environmental excellence says," from the day I arrived at Babington, 15 years ago, my aim has been to minimise school running costs whilst maintaining the quality of service provision – enabling maximum funding to be transferred into the education budget for the benefit of the students at Babington". And now Ray has a building to support his aspirations.

The School budget for heat and light is approximately £100,000 a year, so each 1% saving represents £1000 which can be spent on education rather than power.

Of the data collected on 11 Leicester BSF schools (for which data was available at time of writing) for electricity and for gas usage Babington is second lowest.

This has been achieved despite significant new pressures on power usage. For example, there are now 500 ICT units being powered in the school on a daily basis. Also, during school holiday, except the summer, there are daily revision classes and other activities which, in addition to term time, require the school to be heated, ventilated and lit for approximately 45 weeks a year.

Even so, energy use in the new school building is almost exactly half of energy used, compared to the consumption of the old school building. This performance also exceeds that predicted by the dynamic simulation models, used when the school was at the design stage.

Babington has adopted a whole school approach to managing the behaviour of users of the building to minimise energy usage. For example, the building management support team has been set targets to reduce power usage by 10% over the coming year. This is also the target for ICT. This will be achieved largely by basic housekeeping such as turning computers off when they are not in use at evenings and weekends and not using auto start up so that computers are not automatically turned on in ICT lessons until they are actually required. Cleaning staff too are required to carry out a routine of checking lights, equipment and windows when leaving each of the rooms that they are cleaning – a series of small interventions which can have a large combined impact.

Local controls have been provided within individual classrooms. These can have both positive and negative consequences. The ability of teaching staff to change settings and control their own environment has had a positive impact on attitudes. And there are fewer complaints as the staff themselves are in control. The loss of overall control means that the premises team has a higher level of management responsibility in ensuring that the individual classrooms are being managed efficiently. However, with increasing knowledge and commitment to energy efficiency, there have been very few instances of classroom environments being managed inefficiently.

Likened to learning to drive a car, but with a manual stretching to several volumes instead of driving instructor, learning and managing the energy usage of the school has been a tough challenge. It has also been one that the Business Manager and his team have relished and done to a high standard. For the first six months they struggled to get used to the highly technical nature of the energy system and it is only since then, with a full understanding of the systems, they have started to make the changes that will bring real efficiencies.

Babington was quick to take up the opportunity to be a part of the Building End User Guide project, developed by the Knowledge Partnership. The project offered a readily understandable summary of the school's new energy systems, created by the Knowledge Partnership with additional help from De Montfort University architecture students.

Prior to the production of Building End User Guide document, staff complained about issues to do with heat, light and air quality in their classrooms. Following the guides production, the information has been displayed in each classroom, this has reduced the level of issues to a minimum.

A key part of this process has been the purchase by the school of the interface software that links the Building Management System to a desktop computer. This enables the school to be managed in detail throughout the day, responding to usage, the path of the sun and the weather conditions. The high initial cost of the purchase, when used in this way, will be fully met by energy savings over time.

The school also has the benefit of the Dynamat Lite system which allows the use of gas and electricity, and their associated carbon emissions, and cost of usage to be monitored and evaluated by premises staff - and by teaching staff and students as a part of their lessons.

The school has seven separate zones which are key to its control and efficiency. Each zone can be isolated from the rest of the school; heated, ventilated and lit when independently. Throughout the working day, each zone is managed separately to maximise efficiency.

The school has three heat recovery units to minimise the loss of heat through ventilation.

The Premises Team quickly learnt to manage the buildings warmth by changing the feed in temperatures, based on the warmth of the air that is extracted from the building, rather than the temperature of the air that is pumped in.

A school which is full of staff and students can become 2o to 3° warmer than the empty school. This is the case even allowing for doors opening and closing throughout the day. Consequently, it is important to adjust and regulate heating, by thermostat or active management, throughout the day to maximise both comfort and energy savings.

Babington has leased a 141.78 KwP array of solar photovoltaics (PVs) in time to take advantage of the government's higher rate feed in tariff. The array has generated 68 MW of electricity over its first seven months. The aim, over the period of a year, is to generate sufficient solar power to equate

to the cost of running the school at shutdown – the base level of energy required.

There are a number of south east facing classroom which do suffer from excess heat gain during the summer, (temperatures of over 30o have been experienced). Additionally, these classrooms experience glare during the winter, when the sun's trajectory is lower in the sky. Unfortunately, brise soliel, which were in the initial specification, were removed during value engineering so there is no external feature to mitigate against this. Teachers have therefore been lowering their blinds and turning the lights on. Trees have been planted, as part of the design, to block some sunlight and reduce glare but they have at least a decade of growth ahead of them before they become sufficiently substantial to make any real contribution to alleviating the problem. The school has therefore decided to experiment with anti-glare film for the windows.

This summer, with the tools currently available, the school will try further solutions to problems of overheating. For example, circulating cooling air overnight rather than attempting to circulate air during the day, which is often not significantly cooler than the air inside the overheated classrooms.

Careful and accurate monitoring of this issue is also important to ensure that ongoing discussions with the developer are factually and evidentially based.

Despite, or because of, their considerable commitment to energy efficiency, Babington still felt that they could do more. So they decided to participate in Leicester's Ashden Less CO2 Programme for schools. This national programme is designed to help schools understand their energy usage and wastage and to provide the catalyst for positive behavioural change.

Being part of the Ashden reduce CO2 project has confirmed to Ray and his team that Babington is on the right track and, more importantly, Ashden has greatly enhanced their and other schools' abilities to share knowledge, to work together and drive sustainability as a "shared responsibility". The school's next focus will be on the sports hall, which is on a separate site: changing all the lights to LEDs, purchasing a new, energy efficient boiler and fitting solar panels so that the building runs on zero net electricity.

It is evident that Ray has a particular interest in the energy efficiency of his school and is prepared to commit time and considerable effort to developing his skills and understanding. He works hard to share his knowledge and enthusiasm with his premises team and all others utilising the building. This commitment has undoubtedly enabled the school to achieve Ray's target of enabling funds which may have been spent on energy to be spent on education.

Crown Hills

Crown Hills is a PFI school. This means that for the first 25 years of the life of the building, the school is leased and, in consequence, the process of its management involves an ongoing dialogue between the school and the facilities managing organisation, G4S, who are responsible for its day to day running.

The relationship between the school and G4S is therefore of great significance in all aspects of its physical management, including the energy used to heat, light and power the school. This is something that the Crown Hills Business Manager is acutely aware of and is working very hard to cultivate for the good of the school and its students.

Design and build schools such as Babington have direct influence over the maintenance of the building and, therefore, directly benefit from savings made. At the PFI schools there is no direct control and currently no financial benefit to the school in making additional savings. However, the school is very committed to environmental issues and is pursuing these savings to minimise its carbon emissions.

The school pays a significant annual sum to be in the building. Within this cost is an agreed amount of energy for heat, light and power. Any usage over and above this amount will cost the school additional money and, with no contingency, would need to be taken from their education budget, directly impacting on the learning opportunities of the students.

Consequently, Crown Hills joined the Ashden CO2 project, primarily to inform and educate their Business Manager so that he can disseminate best practice throughout the school. As part of the evolving relationship with the school, G4S has now agreed to use the best practice from the Ashden project as the basis for their formal energy management strategy.

Crown Hills has the same interface software for their Building Management System that Babington has. However, unlike at Babington, where adjustments are made by the school throughout the day, there is no such direct control for Crown Hills, and adjustments are subject to a process of negotiation with G4S.

The school has recently paid for software to enable the Leicester City Council energy management team to see and review real time energy usage. It is hoped that this will sharpen the focus on energy usage and provide the evidence that will bring about greater efficiency.

Crown Hills has fully embraced the ethos of BSF – they have sought to transform teaching and learning and have designed the school around their learners. From the start of its design process, energy efficiency has been a vital element of the development process. Early discussions between the design team, the school's BSF Team and developers have, for example, enabled the orientation and design features of the building to be considered in relation to the sun's path in both summer and winter.

The school has been orientated so that most of its classrooms face either north or south. The south façade has large over-sailing roofs providing shade to the upper level classrooms and brise soleil to shade the lower windows from harsh sunlight in the summer. Windows are also recessed to cut out some additional sunlight.

On the north façade the windows are set flush with the brickwork to maximise the available amount of light entering the building and the roof overhang is replaced by a parapet. East and west also feature deeply recessed windows to cut out some of the angled sun; there is also shade created in places by the profile of the building. The west façade, subject to the greatest risk of glare, also features vertical fins to block direct sunlight.

Crown Hills consists of four zones, three of which feature a 'strawberry' shape with classrooms around the perimeter. These zones offer addition levels of control and energy saving. For example, zones containing community facilities are separately powered to enable them to be heated and lit whilst the rest of the school continues to operate with minimal energy consumption. Extra controls too are provided in close proximity to glazing where there is the potential for greater heat and light fluctuation. Also, shading is brought about by interaction of the four zones and their proximity to one another. Each learning plaza is a double height space with high-level windows providing natural light to the plazas below.

"We have a regular group learning projects in the teaching Plazas. It is wonderful to see these beautiful spaces working so well for the education of the children and young people." Says Dean Barnett, Crown Hills Business Manager

A daylight linked lighting control system minimises the use of artificial lighting by measuring available daylight and supplementing it with just the precise amount of artificial light required to maintain optimum illumination levels in all learning areas. The bright central areas are lit by large roof lights. Some of the adjoining rooms have internal windows into these spaces, drawing large amounts of light from the plaza with no incidence of glare.

The double height learning plazas also enable excess heat to rise and be naturally vented through the high level window vents. Windows open automatically whenever the plazas get too hot in the summer. The building is naturally ventilated in the temperate months with mechanical systems that support the ventilation during very hot or cold periods. Automatic opening of the windows can also be triggered when high levels of carbon dioxide are detected, which, if excessive, can reduce attentiveness and impact on educational performance.

A biofuel Combined Heat and Power boiler, (70kWe and 107kWt) provides up to 49% of the school's annual heating and electricity demands. This renewable heat and power reduces the reliance on the national grid, building significant efficiency into the building service design.

During peak times a conventional gas fired boiler meets the additional heating need. The existence of two boilers utilising different fuel systems also provides a system backup in the event of failure of either.

The building fabric is designed to standards that are substantially better than current building

regulations and features super insulation. The building is made air-tight to prevent unnecessary heat loss. This is achieved by attention to the detailing throughout but especially at junctions and openings (windows and doors) where, at little or no additional cost, the specification ensures high levels of airtightness.

However, it is evident that from this airtightness emanates a range of issues relating to air quality. For example, there have been complaints from staff and students of dry skin, listlessness and migraines. Some staff are in the habit of opening windows at the start of the working day to increase air quality – potentially reducing the building temperature.

The School Business Manager has taken a very proactive approach and recently carried out a voluntary staff survey about their experience of the building. It covered heat, light and ventilation and also questions about colours, classrooms and equipment. Out of 180 staff, there were 75 responses, providing invaluable feedback. The biggest concern revealed by the survey was ventilation. It identified two areas in the school which are not believed to be ventilating properly and external surveys have now been commissioned. It is in these areas that individuals have been experiencing health issues.

More than 80% of the building has good access to natural light. The classroom windows are designed to maximize quantities of natural light and views – maximizing the glass element, while minimizing the frames. Classrooms are less than 7 meters deep as standard, ensuring that light is sufficient even in the areas furthest from the windows.

However, the behaviour of those utilising the building significantly impacts on the efficacy of the design features. For example, there is evidence of classrooms being heated to over 5 degrees above a comfortable level and the sports hall being heated to levels suitable for sedentary activities; thermostats in classrooms have been turned to maximum when a lower level would suffice; despite little incidence of excess light or glare in classrooms, some staff habitually begin their lessons by drawing the blinds and turning on the lights.

The school has begun to implement a series of "common sense" energy saving measures. For example, they have adjusted the length of time that lights on sensors stay on in corridors and they also have made better use of zoning in the building, shutting off areas not in use.

The bulbs in the corridors produce more light than is required, however this prevents G4S incurring penalties for not changing failed bulbs sufficiently quickly as, when a bulb fails, there is still a sufficient level of light in that space. However, the school is currently exploring with G4S the removal of some of the bulbs in order to save energy whilst maintaining an adequate level of light.

On the first Christmas Day that the school was open, there was no difference in fuel usage than on a term time day when the school is fully operational. So, last Christmas holiday a baseload test was carried out when the building was effectively put into hibernation – testing how much energy was required for "life-support".

There is now a policy in place to minimise fuel usage during times when the school is empty. So, for example, between the end of July and the middle of August the school is seldom used and the power is effectively turned off. The building is also effectively shut down between ten in the evening and six in the morning. For example, hot water machines are no longer left on overnight and unused computers are powered off.

There is a tendency for staff to turn up thermostats in classrooms, so discussion is taking place about removing the ability to change temperature remotely, ensuring classroom temperatures are controlled centrally.

The 8 court school sports hall is designed to accommodate the school's cricket specialism. Cricket requires all lights in the sports hall to be on, whereas, for other sports, only half are required and the excess lights tend not to get turned off after cricket has taken place. This too is a process of education and the development of good habits.

Crown Hills was one of the schools which benefitted from the Knowledge Partnership Building End User Guide project. The school feels that this has significantly helped them to develop knowledge and good habits. However, the notices created by this project which have been placed in each classroom at other design and build schools and which have proved so helpful, have not yet been fixed to the walls at Crown Hills as, in PFI schools, even small damage to paintwork on walls has the potential to incur penalty costs.

In some classrooms, staff have complained of health issues which do not appear to be related to ventilation. For example, in Design & Technology, lamps which provide a high level of illumination are used for some of the practical work and this has caused the teacher to experience migraines. Consequently, she was typically turning off the lights until their use became essential. So the school has experimented with the use of daylight bulbs in the area where she usually stands and her migraines have ceased.

In order to gain the dual benefits of positive behavioural change and maximum educational benefit, strong emphasis has been placed on the development of strong visibility and interaction with users – staff and students. Large visual displays showing a breakdown of school energy consumption for each sub-metered zone is controlled and updated via the Building Management System. Carbon reduction is also displayed. The next academic year will start to see the use of school energy information being used within the curriculum. The visual displays are not currently correlating with the computerised information from the Building Management System but work is taking place to overcome this issue.

Crown Hills has just joined the Eco-Schools programme which will bring together a core group of environmentally committed students to lead a process of positive environmental change within the school. There is also an innovative plan to engage the three key school learning zones, expression, exploration, and discovery, in an informal energy saving competition.

The Eco-Schools team will be an invaluable asset to the school in helping to check and monitor

these issues., bringing about small practical changes to common practice in controlling heating, lighting and ventilation, which will have a significant impact on the cost of heating the school.

The Crown Hills Business Manager believes the school is an excellent building. It is what they expected and more and it is now simply a case of learning, over time, to hone their skills and use it to the maximum. He has thoroughly enjoyed the BSF process – interacting with contractors and trying to get the best for the school – and is very interested in helping and supporting other schools in their development process and helping them to achieve their own energy efficient school.

Ellesmere

Ellesmere College is a Special School with a strong ethos of learning together and a specialism in sport.

The new Ellesmere College is a highly attractive building and carefully designed as a place for learning. After years of existence in a very old, inappropriate building, the school now has the environment within which its children and young people can thrive. The sloping site created a series of design issues for the school and its architectural team but, ultimately they have created an aesthetically pleasing and functional building together.

The site constraints shaped the orientation and split-level design of the building. However, the school is well orientated with very little of the school facing the difficult south east direction where solar gain through the morning can cause overheating. Instead the majority of the school is north east and south west, so gets little sun in the morning and the school day is finished before too much is received in the afternoon. So, extensive glazed areas provide good natural light, but the depth of the school, set into the hillside necessitates deep classrooms and rooms with no outfacing walls. Consequently, some creative methods have been adopted to bring natural light into otherwise darker areas of the building: internal stylish skylights brighten some classrooms whilst sun-pipes provide diffused light along corridors deep into the floor plan.

Some areas, such as the food technology room do experience glare and solar gain. Blinds are used by staff to solve glare issues, but this increases lighting costs and blinds do not stop solar gain. The school is currently experimenting with UV film on the windows but it may well benefit from a canopy or brise soliel on the outside of the building. There does seem to be a particular issue with this room – when ventilation is used to reduce temperature, the staff room and offices on the floor above the kitchen experience strong cooking are smells.

From the outset there was a strong desire to maximise the energy efficiency of the building, minimising carbon emissions. In order to achieve the reduction in carbon emissions the school is zoned and has been provided with two sources of heating. The first is the use of bio-fuel fired combined heat and power plant (CHP). A CHP plant produces both thermal energy and electrical energy. The thermal energy is used to meet hot water requirements in the summer term as well as provide the heating requirements during the winter and autumn terms. Whenever the CHP plant operates, it also generates electrical power for use by the school.
A standby gas fired boiler has been provided to meet peak winter time loads as well as provide a standby facility should the CHP fail or be offline for maintenance.
Unfortunately, since the school opened, up to the present time, the CHP plant has not worked. There have been several attempts to overcome this, the school staff, Leicester City Council staff, heating engineers and the manufacturer. Still, at present the issues preventing it from working have not been overcome.

In consequence, the gas boiler is the only heat source for the school and no back up exists for a boiler which is not intended to support the full heat load.

The thermal performance of the school is, of course, crucial to its energy efficiency. The school was modelled using Dynamic Thermal modelling software to ensure the best possible thermal performance. The thermal efficiency is achieved through a combination of the construction materials used, the thermal mass of the hillside into which the school is built and the attention to construction detail in ensuring that joints throughout the building are constructed to prevent drafts and the unwanted escape of warmth air.

In common with many new highly insulated buildings, one of the challenges for Ellesmere is minimising overheating. The requirements specified in Building Bulletin 101 (current building regulations for school construction) require that internal temperatures should not exceed 32oC at any time. Neither should the number of occupied hours above 28oC exceed 120 hours between 01 May and the 30 September. However, these requirements represent limits to extreme temperatures and are not directly related to comfort or the optimisation of learning conditions. The UK Government recommended temperature for classrooms is 18oC; for corridors, sports halls and toilets it's 16oC; for offices where occupants remain for long periods and are quite sedentary then 21oC is more appropriate.

Natural ventilation at Ellesmere is supported by extractor units in the ceilings of each classroom, which can be manually turned on by teachers. However, for this to work well, the windows or the trickle vent built into their frames are required to be open in order to replace the air which has been lost.

Airtightness can have further disadvantages; poor ventilation inevitably results in a build-up of CO_2 in an occupied classroom. The average CO_2 concentration should not exceed 1500ppm (parts per million) during the occupied time and must not exceed 5000ppm at any time, in all teaching spaces. The classrooms at Ellesmere each contain sensors which provide a warning to occupants when the CO_2 concentration reaches unacceptable limits, indicating to the teacher to activate the extractors and open the windows.

The main entrance draught lobby is an important and well-designed feature that performs well, providing a buffer area between the main school building and outside reducing heat loss when people enter or leave the building.

Managing behaviour is a key element of achieving the best energy performance in any school. At Ellesmere there are a couple of important behavioural issues to be addressed before this becomes possible.

The first and possibly most crucial is the need for the key business and premises staff to fully understand the system that they are managing. Other schools have benefitted not only from a member of staff with the determination and aptitude to get fully to grips with the technical complexities but also a Building End User Guide provided by the Knowledge Partnership.

Unfortunately, Ellesmere has not had these benefits and they are consequently finding it more difficult to fully understand their energy systems. They have taken steps to overcome this themselves by joining both the Eco-Schools Programme and the Ashden Less CO_2 Programme. A key benefit of the latter being the opportunity to meet and discuss with other schools, learning from their experience.

Ellesmere has not been supplied with or yet chosen to purchase the part of the Building Management System which enables them to view and easily control the zoned energy system. The consequence of this, for example, is a diminished ability to regulate temperature or energy consumption. Almost inevitably, therefore energy use is higher than it could be. Key staff are fully aware of this and are exploring this expensive, but ultimately, cost saving option.

Secondly, teaching staff are not being fully briefed on the way to manage their classroom environments because the premises staff who should be briefing them are still not fully aware themselves.

So, for example, extractor units are being deployed without opening window vents and radiator valves are being set to maximum even though classrooms are above recommended ambient temperatures.

The need for education and training is urgent and very overdue. Engagement of students through the Eco-Schools programme can then be increased, enabling them to help police and manage light, power and temperature in their outstanding learning environments.

English Martyrs

English Martyrs is a Catholic Secondary School with a very strong tradition in the performing arts. The school exists on a difficult sloping site. There is some retained estate and there was some demolition in order to accommodate the new build part of the school which incorporated sports facilities, an impressive library and an outstanding theatre/auditorium. In spite of the complexity of the development process, the school is rightly proud that there were no lost school days during the build.

One significant issue during this development was that there was a total of 8 Project Managers employed by the developers to lead the process, so there were understandable issues with continuity. It was necessary therefore for the school to be very hands on in order to ensure that the important things for them were delivered. This caused some issues but ultimately ensured a very good school building.

At the core of the school's considerable effort to achieve the best possible design and building is energy efficiency and environmental sustainability.

The school is much better served by natural light than the previous buildings. The librarian spoke enthusiastically about the flood of daylight in her new library which contrasts hugely with artificially lit and poorly designed former library. The beauty of the new, bright space has significantly increased usage. The new sports block also benefits from natural light which has enhanced its popularity too.

Most learning spaces are south facing with few facing east or west, which presents the greatest risk of glare from low angled sunlight. To minimise the incidence of glare brise soliel has been fitted on the sports block and few east facing or west facing classrooms.

There is a significant retained estate at English Martyrs which was tired and could have contrasted considerably in appearance and energy efficiency with the new build. However, the school has worked hard to bring the older parts of the school to a standard which is not out of place with the new. Canopies have been added to minimise glare and new windows with UV protected glazing has ensured learning spaces consistently lit within acceptable illumination levels.

The only place identified in the whole school which occasionally suffers from excessive glare, especially in the wintertime, is the foyer of the auditorium. This presents little or no issue as it is not a learning space and need not be occupied during the occasional times that glare occurs.

The BSF Team at English Martyrs feels that it has benefitted greatly from being one of the last BSF schools to be developed; lessons have been learnt across the programme and therefore not replicated at English Martyrs.

However, the bills have gone up for both gas and electricity since the moving into the new school. The Business Manager predicted this as she is aware that the old school was cold and many classrooms were based in temporary buildings, heated by Calor Gas and, therefore, not directly comparable.

The school now has to two gas boilers, designed to supplement the bio diesel boiler. However, as is also the case with nearby Ellesmere College, this has never worked despite repeated and concerted attempts by the school to encourage the manufacturer to resolve the issue. The gas boilers are therefore exceeding their anticipated workload quite considerably.

Some problems, evident when the school was handed over by the developers, remain and the school continues to attempts to resolve them. For example, the auditorium temperature is often too high when it is in full use – it appears that there is a ventilation problem. In consequence, some paying customers have said that they will not return until the temperature issue is resolved. In order to diagnose the origin of the problem, the school has installed data loggers to capture any pattern which may point to the problem. Presently, no solution has been found and the problem remains to the detriment of those using the auditorium and to the school in lost revenue as local and professional groups refuse to use it.

The heat, light and power systems for the new school are complex. Manuals stretch to volumes and the training support received by the school from developers and manufacturers was minimal. Consequently, the school leap at the opportunity to become part of the project to develop abbreviated Building User Guides delivered by the Knowledge Partnership. This has proved to be an invaluable resource for English Martyrs. Prior to this being provided, the premises staff at the school were experiencing a very steep learning curve in order to understand the technology of their school's energy systems.

The first part of this guide is the more detailed and is for the premises management team to help them understand and manage the whole school premises. For this group of people, suddenly there was a possibility of picking up information clearly and quickly – providing the right level of detail whilst eliminating the complexity of the technical manuals. The second section, with a lighter touch, is for the teaching staff and students, to help them manage their own teaching and learning environments. This second section has been copied and pinned to a noticeboard in each classroom. The Premises Manager feels that this has empowered teachers and learners to, not only express their concerns if the environment feels to warm, cold or stuffy, but to do something about it. It has become evident that students tend to know more about how the systems work and are regulated than the teaching staff!

The fundamental level of understanding, created by the Building End User Guide, is an essential basis from which is being developed the working practices that will maximise the energy efficiency of the school.

The school also makes good use of the information provided by Dynamat Lite , enabling them to see their electricity, gas and water usage; their carbon emissions and the cost of their consumption. Earlier in the life of the new English Martyrs school building there were some issues which were not picked up by the Dynamat Lite system, revealing that it was working incorrectly. These issues have since been resolved and the Premises Manager believes that this is a very useful tool in his drive to understand and manage his building as efficiently as possible.

Work continues to increase energy efficiency. The school has recently bought some new software which automatically turns off all of the school's 500+ computers at night but enables manual turn on only when each device is needed in the morning.

Students too are very much involved in the energy efficiency of the school. As part of the Eco-Schools programme, the active student group, Eco-Martyrs has worked creatively and well to develop a series of initiatives. For example, they worked with graphic artist Inner Smile to create a bright piece of environmental art for an uninspiring courtyard area. The school is increasingly using the building is a curriculum tool. For example, Dr Paul Cropper of DeMontfort University worked with Eco-Martyrs students as part of a STEM project to compare the old and new building temperatures, carbon emissions and ventilation.

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