Learning

Low Carbon Research Institute: Low Carbon Built Environment

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Preface

This report is published by Design Research Unit Wales and is the second output of the Low Carbon Research Institute's (LCRI) Low Carbon Built Environment programme work package, 'Design of Low/Zero Carbon Buildings'. It focuses on varied procurement processes and construction techniques leading to the realisation of low carbon schools and colleges in the UK and beyond.

The objective of the project is to provide design teams involved in the delivery of low/zero carbon buildings with clear but non-prescriptive design guidance based on current best practice.

The work package aims to examine buildings within the sectors of Housing, Education and Healthcare and this document follows a publication in October 2011 of the report 'Dwelling' which looks at case studies within the affordable housing sector - available online at http://orca.cf.ac.uk/27168/

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Contents:

Learning

Climate Change: The Need for Action

"Climate change represents a potentially catastrophic threat, but it is within our control to address it – and address it we must"[1]

'The Stern Review: the Economics of Climate Change' demonstrated that there is overwhelming clear evidence of climate change and recommended strong and deliberate policy action in order to motivate carbon emission reduction. The UK emitted 550 million tonnes of CO_2 in 2005; energy use in buildings accounted for almost half this total and more than a quarter came from energy used to heat, light and run our homes. Since 2006 the UK has been a net importer of oil and is dependant on imported gas during a period of rising prices and increasing global demand. The UK has agreed to EU targets of a reduction of over 750 million tonnes of CO_2 by 2030.[2]

'The Climate Change Act' (2008) set an overall target for the net UK carbon account for the year 2050 at a minimum of 80% lower than the 1990 baseline. The Act made the UK the first country in the world to have a legally binding long-term framework to cut carbon emissions and created a framework for building the UK's ability to adapt to climate change. The *'UK Low Carbon Transition Plan'* (2009) set out the government's proposed route to meet the targets. This was superceeded in 2011 by *'The Carbon Plan'*, which sets out how the UK will achieve decarbonisation within the framework of its energy policy, to make the transition to a low carbon economy while maintaining energy security.

The Committee on Climate Change (CCC) is an independent statutory body established under the Climate Change Act to advise UK government on setting and meeting carbon budgets and report on progress. They concluded in their June 2012 *'Meeting Carbon Budgets Progress Report'* that greenhouse gas (GHG) emissions did decrease by 7% in 2011. However, mild winter conditions and socio economic factors such as rising energy prices and falling real income were cited as the primary cause of the reduction. They estimate around 0.8% reduction was due to implementation of measures to reduce emissions. The Executive Summary concluded that *"this rate of underlying progress is only a quarter of that required to meet future carbon budgets."*

Currently, developments in UK legislation are focussed around the amendment to the Energy Bill, anticipated later in 2013. The introduction of a carbon intensity target to limit emissions from energy production is under discussion.

Timeline to zero carbon education buildings

UK Government		Welsh Government
DCSF: Zero Carbon Ambition All new schools to be zero carbon by 2016		
DCSF: Climate Change & Schools All new schools to achieve 60% reduction in emissions over 2002 Building regulations	2007	**Sustainable Building Standards** Minimum standard of BREEAM 'Excellent' and 10% recycled or reused materials on funded schemes
Climate Change Act 80% reduction in CO2 emissions by 2050. Carbon Budgets introduced; 42% reduction in emissions from Education sector by 2022	2008	**WAG zero carbon aspiration** WAG announces aspiration for zero carbon homes by 2011
Energy Performance Certificates (EPC's) EPC's introduced for all buildings over 50m2 and Display Energy Certificates (DEC) for those over 1000m2	2009	
CLG: Definition of zero carbon for non-domestic consultation Suggests zero carbon schools by 2016		**Planning Policy Wales** 1000m2+ non-domestic buildings expected to meet BREEAM 'Very Good' plus 'Excellent' energy credits. BREEAM 'Excellent' required for WG grant-funded schemes.
Building regulations Part L 2010 25% reduction in energy use over BR2006	2010	
Carbon Reduction Commitment Incentivises energy saving		**21st Century Schools** WG, WLGA & Local government launch programme to deliver schools fit for 21st century.
Zero Carbon Task Force Suggests 10kgCO2/m2/yr target for 2013, 80% reduction over BR 2002	2011	
James Review Suggests 30% saving to school construction costs		**Building Regulations** Devolution of the Building Regulation to Wales
Education Funding Agency DoE delivery agency for school funding and compliance with issue of Baseline Designs	2012	**One Wales Commitment** 3% reduction in greenhouse gasses year-on-year in areas of devolved responsibility
English Building Regulations Part L 2013 44% reduction in energy use over BR2006 expected	2013	**Welsh Building Regulations Part L** Consultation begins: 20%, 10% or 11% improvement on BR2010 for new non-domestic buildings
	2014	**Welsh Building Regulations Part L 2013** First amendments expected, with a suggested 55% reduction in energy use over BR2006 (40% over BR2010)
		Welsh Building Regulations A review of Welsh Building Regulations expected
	2015	
English Building Regulations Part L 2016 All new schools expected to be 'zero carbon'.	2016	**Welsh Building Regulations Part L 2016** Amended Building regulations to reflect zero carbon expected.

Low Carbon Education Buildings

In 2006, the UK Government committed to transforming every school into a sustainable school by 2020. The *'National framework for Sustainable Schools'* introduced 'eight doorways' to provide clear information about sustainable school activities. These doorways cover all aspects of a school's life:

- Food and drink
- Energy and water
- Travel and traffic
- Purchasing and waste
- Buildings and grounds
- Inclusion and participation
- Local well being
- Global dimension

In 2007 the Government reported that greenhouse gas emissions from schools account for around 2% of the UK's total emissions, roughly the same as all the energy and transport emissions of Manchester, Newcastle and Bristol combined and approximately 15% of public sector emissions.[2] A 34% reduction in greenhouse gas emissions by 2020 is required by the '*Climate Change Bill'*, while a higher target for schools has been set (42% reduction). However, as energy use in schools has gone up rather than reduced since 1990, a cut of 53% over current emissions from schools is required to meet this target.

Further and higher education buildings have to achieve the same carbon reduction targets as the wider education sector (34% reduction by 2020).

Targets for low carbon education buildings

In 2007 the Department for Children, Schools and Families report '*Climate Change and Schools'* introduced a target for all new school buildings to reduce emissions by 60% over Building Regulations 2002 and annual emissions during the school day were required to be less than 21kgCO_2/m2.[3] Some individual funding programmes have different funding requirements, but both the Primary Capital Programme (PCP) & Building Schools for the Future (BSF) programmes required a 60% reduction in energy use over Building Regulations 2002 in line with this report.

In 2007 the Sustainable Development Commission announced the ambition for new school buildings to be Zero Carbon by 2016.[4] This ambition was to be assessed and a suitable route to achieving this goal to be delivered by the Zero Carbon Task Force. In their final report, delivered in 2010, the task force defined their role as seeking:

'to provide a roadmap by which those working and studying within the school sector can begin to radically reduce the emissions of greenhouse gases…' and '…sets out proposals for what local authorities, schools and others can do to reduce emissions'.[5]

The main findings of the review were as follows:

- Completed carbon calculators for over 70 schools suggested a 60% reduction over Building Regulations 2002 could be achieved for approx £50sqm;[6]
- Modelling demonstrated that energy efficiency measures can reduce carbon emissions through by up to 12-14kgCO_2/m^2 relative to the 2006 building regulations requirements; however, some of these measures including the highest levels of

floor and roof insulation are not financially viable.
- Most LZC energy sources were not economically viable even after the inclusion of Feed In Tariffs in cost calculations.[7]
- Zero carbon schools (100% reduction in energy use) could not be delivered cost effectively using on site measures alone.
- The payment mechanism for PFI Schools includes an interim operational target of $27kgCO_2/m^2$ for core hours; This target is expected to be revised as actual performance information of new school buildings becomes available.

The report suggests a potentially achievable goal of $10kgCO_2/m^2$ for new schools by 2013, representing an 80% reduction over Building Regulations 2002. The report concluded that zero carbon schools could be achieved, but it would require:

- Engagement
- Knowledge and Skills
- Feedback
- Access to renewable energy and low carbon supplies
- Sufficient investment

James Review of Education Capital - April 2008

While low carbon schools remains an aim of UK Government, due to a poor economic climate since 2008 UK Government has cut spending across public services. The James Review of Capital Spending aimed to provide guidance to the Government for future delivery models for schools in England from 2011-12 onwards. The report gave a final verdict on the BSF programme and suggested:

- A cost saving of 30% could be achieved by streamlined processes;
- *"Standardised drawings, specifications and processes"* could ensure *"far less waste."* This would allow for continuous learning and development, improved quality and reduced costs;
- complex procurement routes and regulatory hurdles were an impediment to delivery of new school buildings;
- BSF was not designed to provide either high quality deign or low cost; designs were too bespoke and lessons have not been learned from mistakes (or successes).

The review has no consideration of sustainability, other than reducing consumption and criticism of the detailed nature and complex bureaucracy of BREEAM. The Review is likely to impact on the sustainable schools programme, not least in its suggestion that school building costs should be cut by a third.

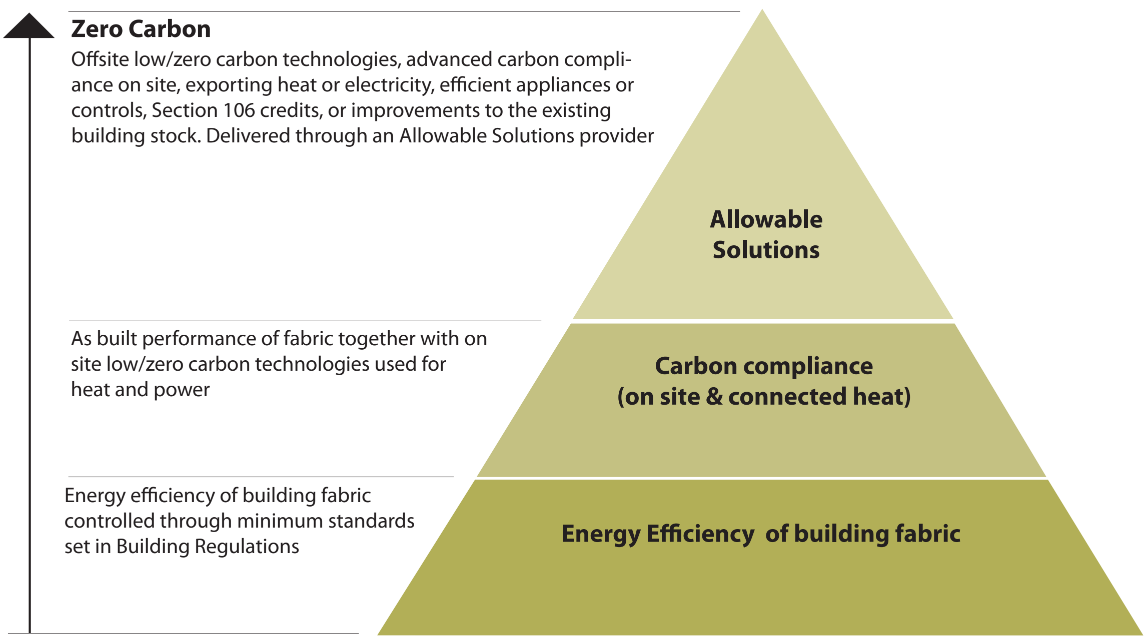
What does ‘Zero Carbon’ for New Schools mean?

In the 2009 consultation document *‘Zero Carbon for New Non-Domestic Buildings’*, the government suggests that the zero carbon framework in use for housing will be adapted to suit the non-domestic sectors. The most significant differences are:

- The wider variety of building types: In the Building regulations 2010 this was reflected by an aggregate approach, with building types required to meet different targets that in aggregate amounted to 25% improvement over Building Regulations 2006;
- The increased complexity and size of non-domestic buildings;
- The greater potential for use of on site renewables.

In line with the approach to housing, the government is suggesting a three tiered approach to achieving ‘zero carbon’:

- Ensuring an energy efficient fabric-first approach
- Reducing CO_2 emissions on site through low and zero carbon technologies
- Mitigating remaining carbon emissions through allowable solutions



Picture of Basic Need

Currently, England is in a situation where the Public Audit Office have issued a picture of ‘basic need’ to be an extra 417,000 new pupil places at primary level before 2015. Areas of need are not distributed evenly - they tend to cluster in large cities of dense population. As would be expected, this need will transfer to secondary schools in subsequent years.

This ‘basic need’ has become a priority for the Government, hence the move into a period of more prolific school premises development and an investment of £1.6billion funding between 2013 and 2015.

Education Funding Agency

Following the closure of the Partnership for Schools programme, England have been experiencing big changes to the way schools are delivered. The introduction of a new body, the Education Funding Agency, has acted as a catalyst for restarting school development. One fundamental difference between the remit of the two lies in the procurement route for new school construction:

- Under Partnership for Schools framework, Local Authorities were directly procuring schools with the aid of technical advisors and school management teams.
- The Education Funding Agency takes the role of the centralised client and procures schools in relation to ‘need’ based on national assessment.

The EFA has selected 261 ‘priority schools’ in England in desperate need of a premises overhaul and is funding a roll out of these schools using £380million capital funding and private finance arrangements. Raising long term bank debt in the stifled economic climate had been a barrier to development for several years following the financial crash of 2008. HM Treasury has developed a model capable of accessing short and long term debt markets using an ‘aggregator’ system, effectively lumping loans together for greater effect. Reponding to criticism of private finance arrangements (PFI) of the last decade, the reformed model (PF2) aims to :

- bring greater transparency to delivery of services.
- exclude the provision of soft facilities management which, in past PFI arrangements, have limited schools’ and LAs’ flexibility.

Priority Schools Building Programme

One action of the EFA has been an audit of the entire built school stock. Those schools in worst condition, both in terms of teaching environment and energy performance, are placed in a geographically defined 'batch' under the Priority Schools Build Programme (PSBP).

The programme differs from Building Schools for the Future (BSF) in several ways.

- The EFA have reduced the number of 'client heads' involved in procurement.
- Strict time constraints have been imposed on design and consultation stages limiting opportunity for variation.
- Budgets are tightly controlled with with new build budgets for school buildings capped at £1400per m^2.

As a result, it is thought communities, schools and teachers will be less involved in design stages. With fewer consultation opportunities there will be greater pressure to use time for best effect. Design development stages will be tightly controlled, with prescriptive requirements of design teams, and strict budgets. Potentially, there is little flexibility for low carbon design within this programme, beyond the perscription of the building regulations.

Baseline Designs

In Autumn 2012 and again in May 2013, the Education Funding Agency issued school design templates, known as 'baseline designs' with the aim of demonstrating to design teams a way of meeting criteria set out in Building Bulletins whilst conforming to the imposed budget restraints.

Baseline Designs were formulated after studying 50 post-occupancy evaluations carried out on schools produced under BSF. They were looking at building performance and energy taking into account aspects such as ideal floor-to-ceiling height and depth of room for natural ventilation. The intention is to standardise those aspects of the design that enable lower operational emissions targets from passive measures, and apply them in a formulaic way. This shares the thinking behind low carbon design with all bidding teams.

It is intended that baseline designs are viewed as a briefing tool to provide a deliverable solution to bidding teams, not that bidders are restricted to these templates. The EFA hopes that baseline designs can be construed as physical representations of the school Building Bulletin guides. This may lead the way to the EFA reissuing Building Bulletins in a graphic format in the future.

Regrettably, the aspirational design apporach and some research streams coming from BSF - in particular looking at links between quality of education buildings and educational standards - has been given little significance under the EFA. It is of some concern to many architects and educationalists that the results from these studies is not being acted upon.

The government is promoting linked measures to achieve the zero carbon goal: National planning policy, which regulates the location and design of development; the Building Regulations, particularly *'Approved Document Part L2: Conservation of Fuel and Power'*; and BREEAM, a measure of sustainability. The aim is to use these policies to develop a clear framework in which zero carbon education buildings can be procured and delivered.

National Planning Policy

The white paper *'Planning for a Sustainable Future'* emphasised the importance of planning in delivering sustainable development. *'Planning Policy Statement (PPS) 1: Delivering Sustainable Development'* and its supplement *'Planning and Climate Change'* put sustainability at the heart of planning policy. These outline how regional and local planning can create places with low carbon emissions that are suited to the future climate, promoted through spatial strategies. The PPS places a duty on planning authorities to ensure spatial strategies contribute to the mitigation of and adaptation to climate change. Development plans should consider how development can be delivered to reduce emissions from transport and buildings, create opportunities for decentralised renewable or low carbon technology, minimise future vulnerability to climate change and sustain biodiversity.

Building Regulations

The government's preferred method of achieving zero carbon is through progressive improvements in energy performance, to be set through the *'Building Regulations Approved Document Part L2A: Conservation of Fuel and Power in Buildings Other Than Dwellings'*. These step changes started to be implemented through the 2010 revisions to Part L, amounting to a 25% improvement over BR's 2006.

The amended Part L2A 2010 for non-domestic buildings introduced a revised target-setting process. The new process acknowledges that it is easier and more cost effective to make improvements in some building types than in others. To this end, the aim for a 25% reduction in CO_2 emissions from new non-domestic buildings is achieved across the new-build stock rather than each individual new building. Some building types will need to achieve a greater improvement than 25% and others considerably less.

In the *'2012 consultation on changes to the Building Regulations in England'* Government acknowledged that an overall aggregate target for 2019 zero carbon on-site standards has not been set for non-domestic buildings. For the 2013 revisions to the Building Regulations Part L in England, the emphasis is on setting challenging but cost effective on-site targets.[8] The consultation presented the Government's preferred improvement level of 20% on Part L2 2010, achieved through fabric and services enhancements and LZC technologies. This step change forces a steep learning curve and pushes fabric and services close to the limit of likely zero carbon levels, necessitating the use of renewables in most cases. The 2013 amendments to Part L came in to force on 6th April 2013 and must be read in conjunction with the amended 2010 edition.

BREEAM

The Building Research Establishment Environmental Assessment Method (BREEAM) is an internationally recognised environmental assessment method for non-domestic buildings. The scheme awards points across ten categories, which are added together to give an overall score of Pass, Good, Very Good, Excellent or Outstanding. The categories are:

- Management
- Waste
- Materials
- Health and well being
- Energy
- Land use and ecology
- Transport
- Water
- Pollution
- Innovation

	Target
2005 Targeted Capital Fund Letter DCSF	All new build schools to achieve BREEAM 'Very Good'
2005 Building Schools for the Future DCSF	60% reduction in energy use over Building Regulations 2002
2005 Building Schools for the Future DCSF	PFI providers must achieve an interim target of 27kgCO2/m2 for core hours
2007 Climate Change and Schools DCSF	60% reduction in energy use over Building Regulations 2002 for all new schools; annual emissions during the school day required to be less than 21kgCO2/m2
2007 Sustainable Building Standards Welsh Government	Minimum standard of BREEAM Excellent and 10% recycled or reused materials on funded schemes
2010 Road to Zero Carbon Zero Carbon Task Force	Recommends a target of 10kgCO2/m2 from 2013
2012 Priority Schools Programme DfE	DfE considers scrapping BREEAM requirements for PSP and Academies programmes

An assessment is carried out at design stage and a post completion assessment must be made for full certification to be awarded. Assessments must be undertaken by accredited or licensed assessors.

Currently BREEAM is the measure used to assess a school's sustainability. The Department for Education (DfE) requires a BREEAM rating of 'Very Good' for all new build and refurbishment projects receiving capital funding if it is:

- A major new build primary school with an area over 500m^2 or a major new build secondary school with an area over 2,000m^2;
- A primary school refurbishment over 500m^2 or a secondary school refurbishment over 2,000m^2 affecting 10% or more of the floor area.[9]

The Learning and Skills Council (LSC) has set a target for all major new further and higher education buildings to achieve BREEAM 'Excellent'. In the higher education sector, a tailored BREEAM Higher Education model is available. While there is no over-arching strategy with universities able to make their own decisions on sustainability, it is expected that funding councils will increasingly set high BREEAM targets. The Scottish Funding Council, the Higher Education Funding Council for Wales (HEFCW) and Central government already require BREEAM 'Excellent' for new buildings and commonly 'very good' for refurbishment.

However, under the Priority Schools and Academies Programmes in England, the Department for Education is considering removing BREEAM requirements in response to the James Review. This could be extended to include acoustic and thermal performance requirements.

Passivhaus

Passivhaus is a voluntary construction standard which can be applied to dwellings and non-domestic buildings and aims to provide excellent comfort conditions and reduce energy needed for space heating and cooling. The assessment method was designed by the Passivhaus Institut in Germany and has been in operation since 1996. Passivhaus aims to assist architects, developers and builders to, in practice, achieve buildings which have an exceptionally low space heating energy demand through the incorporation of passive design principles and a highly thermally efficient and airtight building envelope. Passivhaus is a step towards zero carbon buildings; with the greatly reduced energy requirements making it easier to meet demands through use of renewables.

A typical Passivhaus building includes the following:

- very good levels of insulation with minimal thermal bridges
- well thought out utilisation of solar and internal gains
- excellent level of airtightness
- good indoor air quality, provided by a whole house mechanical ventilation system with highly efficient heat recovery

To achieve Passivhaus, the energy requirement for space heating must not exceed 15 kWh/m2/yr. Also, total primary energy use for all appliances, domestic hot water and space heating and cooling must be less than 120 kWh/m2/yr. To achieve the energy and comfort requirements in the UK, this typically requires the following:

- Super-insulation: opaque U-values must be less than 0.15 W/m2K
- U-values for windows and doors need to be 0.8 W/m2K or less (for both the frame and glazing). This requires the window frame to incorporate insulation and triple glazing
- Thermal bridging needs to be minimised, and ideally eliminated
- Airtightness: n50 of 0.6 h-1 @ 50 Pa or less
- Whole house mechanical ventilation with heat recovery (75% efficient or better, with a low specific fan power).

The Passivhaus Planning Package (PHPP) is a modelling package and energy calculation tool used to verify Passivhaus standards have been met. In the UK, Building Research Establishment (BRE), WARM: low energy building practice, Cocreate consulting and the Scottish Passive House Centre are certified to register Passivhaus buildings.

Why might it be a suitable measure for schools?

The approach to the design of buildings suggested by Passivhaus is to first focus on consuming less energy, before applying appropriate renewable technologies.

Passivhaus is a specific energy performance standard that delivers very high levels of energy efficiency, while BREEAM is a much wider assessment of a large number of environmental issues. Government policy is aimed at reducing energy demand and cutting carbon emissions. BREEAM's wide range of targets could be seen to undermine this aim, widening the focus of design teams and encouraging tick-box approach to sustainability rather than focussing on more sustainable solutions.

The Passivhaus target offers a fabric first approach that can achieve considerable energy reductions without the need for renewables. Its rigorous certification process and demanding targets focussed solely on energy could result in schools that consume less energy due to their enhanced fabric.

Passivhaus buildings are designed to require minimum heating, in most cases using MVHR allows improved comfort conditions in the classroom as CO_2 conditions can be accurately controlled, which enables increased concentration from the students.

PHPP takes account of unregulated energy use (IT systems, screens and equipment), whereas the energy calculation used in BREEAM does not. This results in a wide difference between predicted and actual use.

If BREEAM and Passivhaus are used together, the enhanced 'fabric first' approach means the level of renewables needed to deliver higher BREEAM scores is reduced. Any renewables used by a Passivhaus-standard school should achieve a greater profit, as energy demands will be reduced, allowing a greater amount of generated energy to be fed back to the energy supplier.

Association for Environment Conscious Building (AECB) CarbonLite

The AECB CarbonLite programme is a 3-step programme developed from the expertise of experienced industrial members and is concerned with energy use and carbon emissions. The standards are categorised in to performance targets (energy and CO_2) and prescriptive standards, which identify the means for delivering the target construction.
Step 1 Silver - broadly equal to the German Low Energy Standard and the Swiss MINERGIE standard and is based on the use of best widely-available technology, potentially delivering up to 70% carbon reductions.
Step 2 Passivhaus - equivalent to the German Passivhaus standard and anticipates a delivery of between 75-80% reductions.
Step 3 Gold - Thermally equivalent to Passivhaus or the MINERGIE P standards but sets lower standards for energy use and emissions and includes the generation of on-site electricity, may reduce emissions by 95%.
AECB presses for the recognition of Passivhaus in Part L1A 2013, asking that - Passivhaus compliant dwellings are 'deemed-to-satisfy', this presumably would pave the way for the Passivhaus standard to be optionally accepted for non-domestic buildings also.

Building Information Modelling

Building Information Modelling (BIM) is a tool designed to allow all design disciplines to work collaboratively on a 'live' model of the proposed building, with the aim of improving the integration of design and services, reducing waste and unknown risk factors and, ultimately, offering better value to the client.

In May 2011, UK Government announced its ambition for BIM to be used on all centrally procured projects by 2016[15], to include infrastructure, healthcare and educational facilities. Therefore all public projects are affected by this requirement which challenges the traditional procurement route and design team responsibilities. Alongside reducing cost, the strategy aims to cut the carbon burden created by the construction and operation of the built environment by 20%. The RIBA produced a 'BIM Overlay to the RIBA Outline Plan of Work'[16] which, along with the 'Green overlay', was incorporated in to the new RIBA Plan of Work 2013. Industry needs to adjust to the additional demands within the procurement process to allow time for the production of an informative BIM model prior to construction mobilisation.

BIM enables the production of data which can be analysed by the design team, meaning that, in conjunction with thermal modelling software, the energy use of a building throughout its life may be predicted and minimised. The data may also assist designers with reducing waste materials during construction and building management and eventually aid sustainable demolition. Information showing the embodied energy of materials may inform the design choices made throughout the process and allow Facilities Managers to predict the life-cycle costs and maintenance regimes required from an early stage.

The key is that BIM provides the design team with information that they can use to identify issues which may require design adjustment. The process allows each scenario to be reported, providing the opportunity for (and relying upon) the designer to accordingly select the most appropriate and efficient solution[17].

Increasing Awareness of Zero Carbon

The Government has a further range of measures which aim to reduce the UK's carbon emissions to meet the target set by the EU, the Climate Change Act and the Energy Bill:

Energy Performance certificates (EPC's)

Since 2008 Energy Performance Certificates (EPC's) have been compulsory for all dwellings and all non-domestic buildings over $50m^2$. EPC's are based on design stage modelling of the building performance and do not include energy used by appliances. An EPC is accompanied by a report with recommended steps to increase the energy rating of the building.

Display Energy Certificates (DEC's) have been required for all buildings over $1000m^2$ since 2008, including schools. These contain carbon ratings based on actual energy use, not predicted energy as seen in EPC's. These include energy used by appliances and have highlighted the often dramatic difference between predicted and actual energy use.

Carbon Reduction Commitment

The Carbon Reduction Commitment (CRC) was announced in the Energy White Paper (2007) and obliges local authorities and large private sector organisations to reduce carbon emissions by at least 4 million tonnes of carbon dioxide per year up to 2020. School buildings account for up to 50% of local authority building stock in the UK and as such are a priority area. However, many BREEAM 'Excellent' schools use far more electricity than predicted. For example, although new schools built across Bristol have seen a dramatic reduction in gas use, they on average require 38% more electricity than those replaced.[10] This is due to a number of reasons, not least the increase in unregulated energy uses such as ICT equipment.

Feed in Tariffs (FIT)

Feed in Tariffs are incentives for the generation of renewable electricity. The tariff has three financial benefits: payment for electricity produced using renewable means; additional bonus payments for any electricity exported to the grid; and a reduction in standard electricity bills from using the energy generated using renewable means. Payment for the tariff comes from energy suppliers, not from the Treasury. Most forms of renewable electricity generation are eligible up to a size of 5 megawatts; payment levels vary depending on the energy source and scale of generation. Schools may be eligible for FITs provided they can demonstrate an EPC (of less than 10 years old) with an energy efficiency band rating of A-D.

Renewable Heat Incentive (RHI)

The RHI is a financial support scheme to encourage uptake of renewable heat installations and encourage use of renewable heat. The scheme pays the installation owner for heat generated through a renewable system that meets the criteria of the scheme; payment is direct from the Treasury.

The RHI launched for the non-domestic sector in November 2011 with additional fine tuning implemented in the 2012-13 financial year. This included amendments covering air quality, issues related to biomass sustainability, and measures to control the maximum cost of the scheme.[11]

The Welsh Perspective

The 2006 report *'The Learning Country, Vision into Action'* published by Welsh Government placed emphasis on sustainability in the education sector. The document aimed to ensure:

- All school buildings would be fit for purpose;
- Sustainability and security is at the core of the design of new schools as well as in significant refurbishment by requiring local authorities to have regard to BREEAM and to incorporate sprinklers;
- Local authorities use effective procurement and project management through collaboration;
- Schools are promoted as a focus for the local community including out of hours activities.

The 21st Century Schools Programme launched in 2010 is a collaboration between Welsh Government, Welsh Local Government Association and Local Authorities. It aims to achieve a strategic approach across the whole estate in Wales from 2012 and continuing for 15 years or more, with funding provided in three year bands. Its budget covers schools and further and higher education facilities.

The programme aims to create *"a sustainable education system through better use of resources to improve the efficiency and cost-effectiveness of the education estate"*[12] and to embed sustainability in all aspects of school life. The programme further aims to create a 21st century standard for schools in Wales which reduces recurrent costs, energy consumption and carbon emissions. This will provide minimum standards to be met in all schools.

At the launch of 21st Century Schools in March 2010, Leighton Andrews, then Minister for Children, Education & Lifelong Learning explained the programme:

"The current school estate needs to become more sustainable; both environmentally and financially. We need to make best use of our limited resources. Deliver more for less....the programme will build on upon success and accomplishments to date. But we recognise there is still a lot to do".[13]

The first round of 21st Century Schools projects are ongoing. Details of the programme can be found at www.21stcenturyschools.org/, while a supporting guide exploring the design of sustainable schools developed as part of the programme can be found at http://www.sustainableschoolswales.org/.

All schemes promoted or supported by Welsh Government through their sponsored bodies are required to meet WG's sustainable building standards. This requires BREEAM 'Excellent' or equivalent and a minimum of 10% of the total value of materials used should be recycled or reused.[14] The Higher Education Funding Council for Wales (HEFCW) require BREEAM 'Excellent' for new buildings and commonly 'very good' for refurbishment.

In July 2013, Welsh Government secured a further £25million of capital Funding for school construction projects, with £12.8million going to projects already underway and £12.2million allocated for new schemes.

Endnotes:

1 DCSF, 'Sustainable Schools: A Brief Introduction' p4
2 DCSF, 'Climate Change and Schools: A carbon management strategy for the school sector' p7
3 DCFS, 'Climate Change and Schools'
4 Sustainable Development Commission, 'The Children's Plan-Building brighter futures'
5 DCFS, 'The Road to Zero Carbon: Final Report of the Zero Carbon Task Force' p3
6 ZCTF Final report p26
7 ZCTF Final report p15
8 CLG, '2012 consultation on changes to the Building Regulations in England' p31
9 Willmott Dixon Re-Thinking, 'Briefing Note 11: Who requires BREEAM Building Assessments?'
10 Paul Isbell, Bristol City Council, presentation at 'Sustainable Schools Debate', CREATE Centre, Bristol, 11 May 2011
11http://www.decc.gov.uk/media/viewfile.ashx?filetype=4&filepath=11/meeting-energy-demand/renewable-energy/4742-departmental-note-support-for-renewable-heat-tech.pdf&minwidth=true
12 WLGA, '21st Century Schools: Information Document' p5
13 http://www.sustainableschoolswales.org/background.php
14 http://wales.gov.uk/topics/sustainabledevelopment/design/standards/?lang=en
15 Cabinet Office, 'Government Construction Strategy', p13
16 http://www.ribabookshops.com/uploads/b1e09aa7-c021-e684-a548-b3091db16d03.pdf
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HM Government, The Carbon Plan:Delivering ourlow carbon future, Dec 2011
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http://wales.gov.uk/

Hauptschule, Klaus, Austria. Dietrich Untertrifaller Architekten

Lessons from Practice: Case Study Schools

The following case studies have been selected in conjunction with our industrial partners and demonstrate current best practice within Wales, with selected other examples from the wider UK and Europe.
These projects have been identified to provide examples of a prototypical nature, across a range of educational facility types. Whilst there are other good quality examples of low energy school design in Wales, they are of a similar nature in construction and procurement and so have not been included in this instance.

- Coleg Cymunedol Y Dderwen, Bridgend (new-build secondary school)
- Blaenavon Community Campus (new build primary)
- Taf Ely Learning Campus (new-build tertiary college)
- All Saints Academy Plymouth (retrofit and extend secondary school)

Passivhaus Schools:

- Oakmeadow Primary School, Wolverhampton, UK
- Hauptschule, Secondary School, Klaus, Austria.

Standardised Schools:

- The Paxton' by Scape, (standardised model for primary), with precedent:
    - Kingsmead Primary School, Cheshire,
    - Ynysowen Primary School, Merthyr Tydfil.

Scott Brownrigg Limited

Coleg Cymunedol Y Dderwen, Bridgend

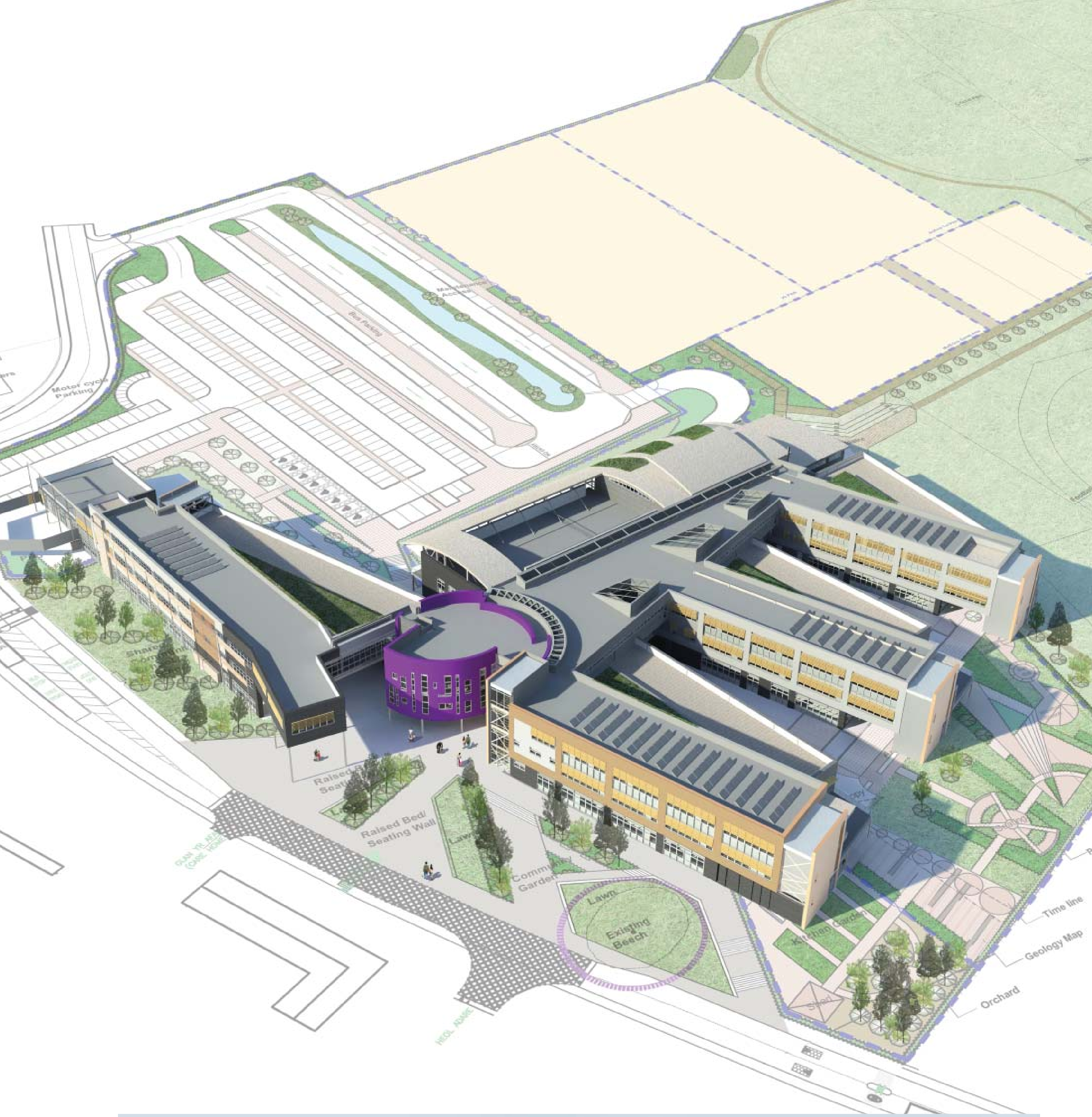
New secondary school and community facility for 1570 students at Tondu, Bridgend, achieving BREEAM ‘Outstanding’

A new-build secondary school with dedicated community facilities for 1570 students, including special facilities for those with additional sensory and motor needs, at Tondu, Bridgend, for Bridgend County Borough Council on a 122,500m^2 (12.3 Hectare) site. The building provides 14,450m^2 over 2 and 3 storeys for young people aged 11-18 and the wider community. As well as the sports facilities and other areas of the building being open to the community both during and outside the school day, there are dedicated community areas which house a children’s day care centre, a multi-agency community support team, meeting rooms and cafe.
The school aims to be Wales’ first BREEAM ‘Outstanding’ secondary school.

Located on the site of the existing Coleg Cymunedol Y Dderwen Tondu campus, adjacent to the River Ogmore, North of Bridgend, the site benefits from good existing infrastructure and is close to the local shops and train station with rural views of the valley to the North. The new school replaces Coleg Cymunedol Y Dderwen’s Bryncethin and Tondu campuses and provides many additional facilities for young people attending the school and wider community.

The project was commissioned by Bridgend County Borough Council (BCBC) in 2009 and funded through their School Modernisation Programme, which includes a £27million grant from Welsh Government. The programme preceded the new ‘21st Century Schools’ initiative brought in during early 2010. Under the conditions of funding from Welsh Government, the new building is required to achieve a BREEAM rating of ‘Excellent’, supporting their agenda for reducing carbon emissions. With a proactive client and recommendation from the architect the project exploits the potential to achieve a BREEAM rating of ‘Outstanding’. The scheme is therefore targeting the BREEAM EL01 energy credit of ‘’Outstanding’.

The school is intended to act as a beacon to the local community, and is designed to encourage interaction between the public, students and staff. A new main entrance square will provide a pedestrian friendly environment which will be complemented by a sustainable high quality landscape to aid wellbeing, learning and diversity. The design also allows the school to operate ‘schools within a school’: there will be 6 colleges of 250 students each, with each college having its own geographical identity.


Motor cycle Parking
Raised Bed/ Seating Wall
Lawn
Existing Beech
Orchard
Geology Map
Time line

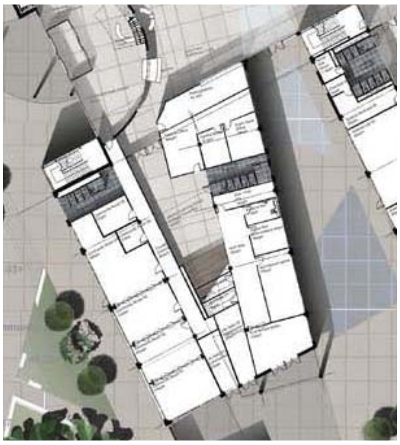
Passive Design:

The passive design strategy has been designed to provide a careful balance between natural daylight, ventilation and avoiding solar gain and glare. The school design enables the environmental strategies to be implemented alongside renewable technologies within the constraints of the life-cycle costing for a new build.
Existing site features and nearby buildings generate strong axes around which the layout principles have been developed. The focus is on a large atrium running West/East from the main entrance, on to which classroom activities extend, encouraging interaction and making use of what would otherwise be simple circulation.
Individual 'V-shaped' colleges of 2 and 3-storeys are orientated to the south with their main elevations facing east and west. A flat roof covers first floor classrooms on the 2-storey easterly edge and the 3-storey secondary atrium within the 'V' is day-lit by clerestory windows to the east.

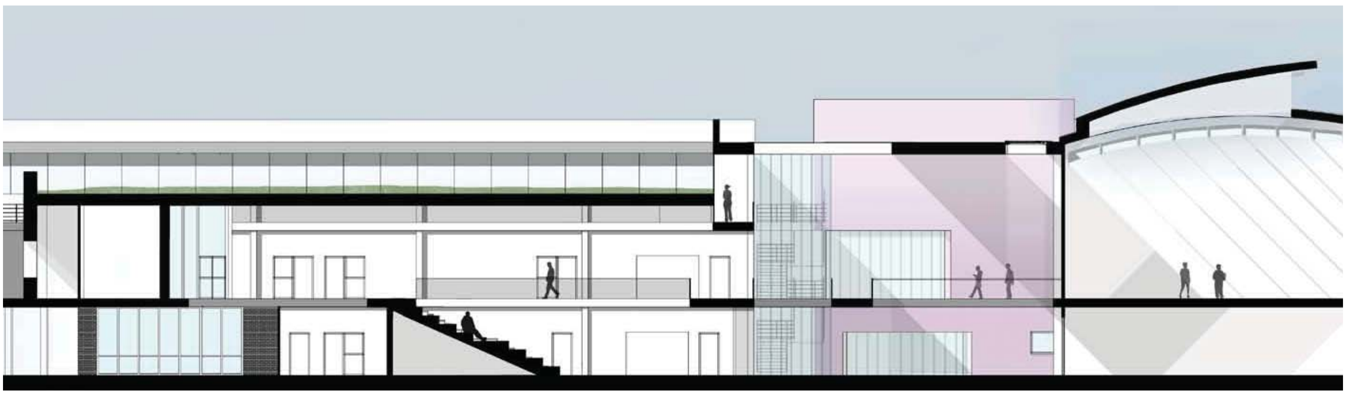
Colleges are based on an 8.2m grid which provides the optimum size for a teaching space with cross-ventilation. To maximise the natural ventilation across this span some acoustic derogations between classroom and corridor have been accepted by staff, allowing a reduction in the distance and number of turns normally associated with acoustic dampening within ductwork. The school is designed to meet the equivalent space standards as set out in the Department for Education's Building Bulletin 98 in order to provide the most flexible accommodation.

Adult learning centres and community facilities such as café, meeting spaces and child care facility with dedicated garden are located along the western edge of the building, giving a community presence along the main road while allowing a distinct line of security between the public and school uses. Catering, main hall and sports departments sit along the northern side of the main atrium. There is potential for future expansion to the end of the atrium, which currently opens up to the sports pitches and River Ogmore to the East.

The building fabric is highly insulated and large areas of glazing allow a strong connection with the surrounding landscape. The landscape is conceived as a semi-public space and an extension to the learning environment. Some classrooms have direct access to outside learning spaces and between the colleges the landscape extends up to the central atrium space, which enlivens and maximises natural daylight to this critical area. A new public square is generated between the main road and the building entrance, which helps to blur the boundary and fully integrate the school in to the community's activities.



Above :Main atrium BIM modelling, Hellerup stair view and plan of individual college.



Steel frame construction on site: looking South through one of the colleges (top) and starting the weathertight boarding layer (bottom).

Windows have deep reveals to assist solar shading. Underground tanks have been included to allow rainwater harvesting and grey water recycling, reducing the volume of water consumption per pupil.

Fabric:

U-values:
Glazing: 1.65 W/m^{2}k (double glazed units)
Roof: 0.1875 W/m^{2}k
Floor: 0.1875 W/m^{2}k
Walls: 0.2625 W/m^{2}k

Air permeability target: 5 m^3/(hr.m^2)@50Pa

The primary structure is steel frame with pre-cast floor planks. Although a concrete frame may have provided further thermal mass, a steel frame was determined to be more suitable under BREEAM with regard to material recyclability and speed of construction. The lightweight metal sub-frame is made weathertight with a cementitious particle board, vapour barrier and 90mm Kingspan K15 insulation. The external cladding of brickwork, render or coloured board acts as a rainscreen system. Flat roofs are single-ply membrane with minimum 95mm Tapered EPS insulation laid to falls, 50mm Rockwool Acoustic board and Rockwool acoustic membrane.

Materials were selected in accordance with the current Green Guide to Specification and reach an 'A' rating or 'A+' where possible.

Systems:

Heating:	Biomass boiler, underfloor heating, solar hot water panels, gas boiler back up.
Ventilation:	Naturally ventilated classrooms
Electrical:	Photovoltaic panels, CHP sited at the Council owned swimming pool opposite the site
Water:	Rainwater recycling

Anticipated Heating Energy Demand: 37.38 kWh/m^{2}a
As designed Building Emission Rate: 6.9 kgCO_2/m^{2}a
As designed Energy Performance Certificate rating: A (8)

The building has been designed to be a 'learning tool' with opportunities allowing for education of the building's response to its environment. The scheme is powered by a biomass boiler, capable of using wood chips from local suppliers, which is housed to allow supervised access by students so they can witness the processes involved. There will be visible monitors so that energy usage can be seen by students in graphical form which respond immediately to changes in power usage, i.e. turning off lights in the classroom. Lighting is set to automatically dim almost unnoticeably after switching on, further reducing energy output but without detriment to the user.

There is underfloor heating throughout (except to sports hall and changing rooms) and solar hot water and PV panels are located on the roof of each learning block, serving these locally to avoid lengthy runs to and from the main plant room. The school is also fully sprinklered. The solar hot water system supplies the changing rooms and main kitchen, providing the majority of usage for the building. Water consumption will also be monitored.

All systems are monitored by the Building Management System which provides detailed information regarding actual energy usage. IES software was used for thermal modelling during design.

Resilience is provided by a gas boiler back-up. The infrastructure for a link to the CHP (combined heat and power) system, which has recently been installed at the Council owned swimming pool opposite, is included. A significant proportion of electricity from the CHP will feed back in to the school.

Building services (to include biomass, sprinklers and underfloor heating) represents approximately 30% of the total build cost.

Procurement:

Design and Build Contract: NEC3 Option C, Target Cost with Activity Schedule.

Scott Brownrigg were appointed in 2009 by Bridgend County Borough Council to develop the scheme design from RIBA stage A to E. Three options were explored in detail through to stage C: refurbishment of the existing school, refurbishment with new extension and a complete new-build proposal. All three options were costed and assessed against BREEAM criteria. The new-build option represented best value for

the longer term and allowed a greater flexibility for future use and was subsequently detailed to Stage E, which was required to represent 85% cost certainty against the Target Cost. Leadbitter were appointed under the South East Wales Capital Working Group (SEWSCAP) framework at this stage and in accordance with the BCBC contract Scott Brownrigg were subsequently novated to a full service contract with Leadbitter, along with the other consultant teams. Although the tender stage appointment of Leadbitter has proved to be extremely successful, some minor changes were required to incorporate the benefits of Leadbitter's skills and technical experience. An early partnering agreement may have allowed these to be included from the outset, thus avoiding some later design changes.

The scheme was required to meet BREEAM 'Excellent' in accordance with the conditions for funding from Welsh Government. The analysis of each design option against BREEAM criteria showed that the new-build design would provide the opportunity to raise this to 'Outstanding'. BCBC were keen to meet this and an 'Outstanding' target became conditional within the contract, meaning that credits were safeguarded against any later 'value-engineering'. The school aims to be Wales' first BREEAM 'Outstanding' secondary school.

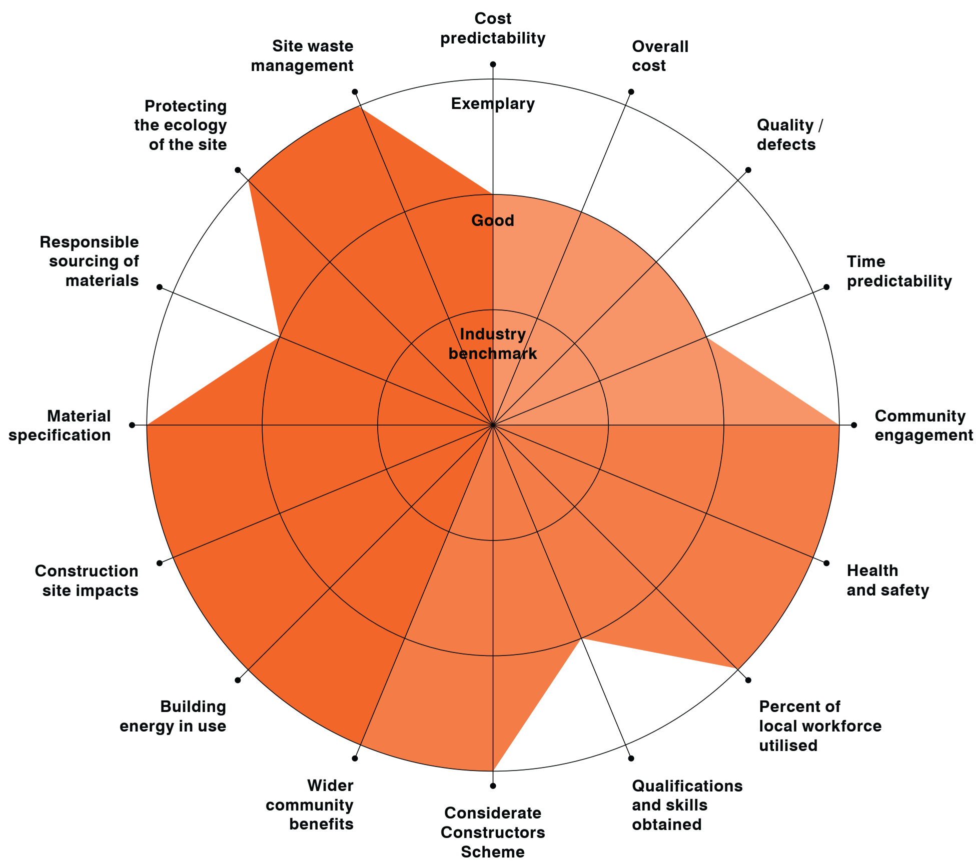
Building Information Modelling (BIM) was used by Scott Brownrigg and the consultant teams from the outset of detailed design, enabling the realistic analysis of early stage intentions with a high degree of cost certainty and specification. The tool allowed the design team to create accurate solar studies and monitor the impact of any later changes upon the environmental calculations. IES modelling software was also used alongside this to provide detailed thermal analysis.

KEY PERFORMANCE INDICATORS (KPI)

= Environmental

= Social

= Economic



Teaching:

The building has been designed to be a ‘learning tool’, for example, the biomass boiler is housed to allow supervised access by students. There will be visible monitors so that energy usage can be seen by students in graphical form which immediately demonstrate the active building in use, i.e. turning off lights in the classroom will show on the monitors.
In connection with The Wildlife Trust, a school sustainability champion is responsible for bringing energy and the environment on to the school curriculum.

Community:

The building dedicates 600m^2 for use by the community, such as children’s day care and meeting rooms, all of which are heated by the biomass. These areas face on to the new public square created along Heol yr Ysgol and forge a link with the elderly care home and swimming pool opposite, both of which are under BCBC ownership. A CHP system is included within the scheme for the school and has been installed at the swimming pool. Energy generated will feed back in to the school and the intention is for the CHP to supply all three buildings in the near future.

Project details:

Area: 14,450m^2 (includes 600m^2 community use)
Completion due: New build school completion by July 2013, second phase (further demolition and parking) Summer 2014
Cost: £39m total projects cost (£27m funded by Welsh Assembly Government)
Contract: NEC3 option C, Target Cost with Activity Schedule
BREEAM rating ‘Outstanding’ 89.82% (Management 100%, Energy 92%, Water 87.5%, Waste 100%)
The scheme has been awarded the 2013 BREEAM Education Building of the Year

Design Team:

Architect; Scott Brownrigg, Cardiff
Contractor: Leadbitter
Client: Bridgend County Borough Council
M&E consultant: Arup, Cardiff
BREEAM consultant: Arup, Cardiff
Structural & Civil Engineer: JUBB
Landscape Architect: TACP
Cost Consultant: Davis Langdon
Project Manager: Davis Langdon
Air Tightness Consultant: Building Analysis and Testing Ltd, Bristol

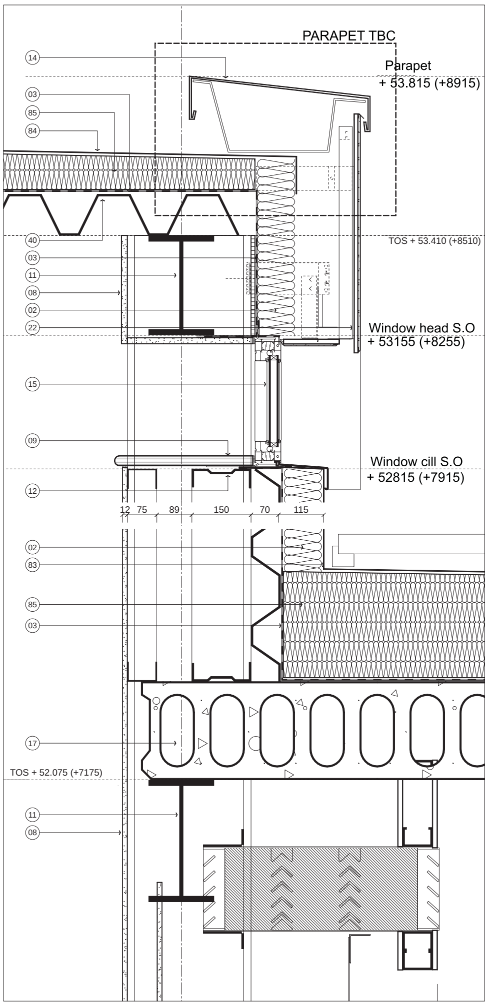
All images credits: Scott Brownrigg

drawings not to scale

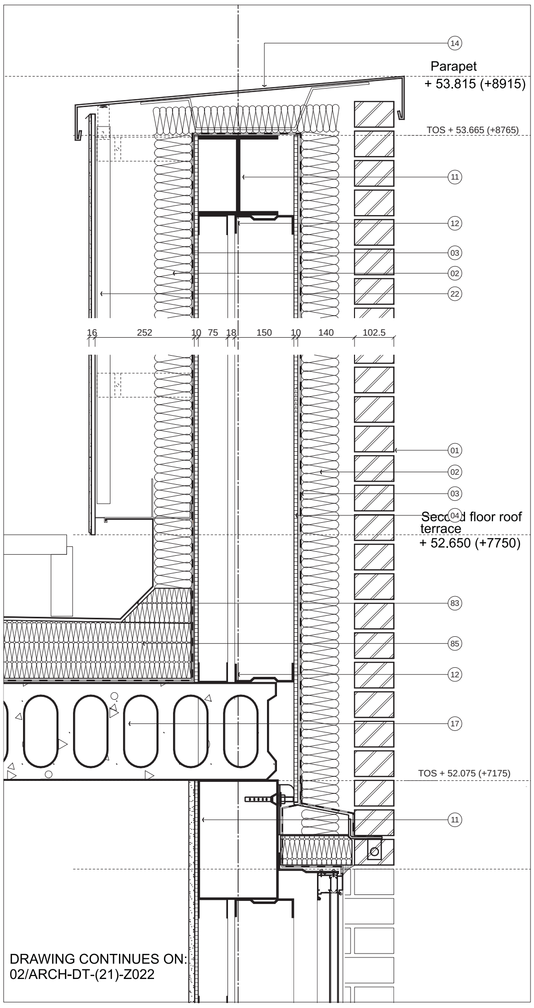
KEY

01. Black brickwork F10/110
02. Insulation K10/125A (NOTE: Spec has been revised by Leadbitter)
03. Vapour barrier P10/310A
04. Cementitious Board (Part of Rainscreen system/ elsewhere contractor choice)
05. 100mm insulation F30
06. 9mm Plywood
07. Mastic fill K10/555, P12/338, L10/790
08. 15mm plasterboard K10/408
09. Timber window cill P20/110, P20/120
10. Cavity Closer F30/180A, 182, 184
11. Steelwork frame to SE design
12. Light weight metal sub framing to specialists details
13. Rigid Sheet Cladding Trespa H20/155A
14. PPC Aluminium flashing H72/470A
15. Aluminium framed window L10/330A
16. Proprietary Lintel F30/735 - 755B (Refer to ST. engineer for final spec and details.)
17. Concrete floor plank to SE requirements
18. Timber skirting P20/110, P20/120
19. Screed/ U/F heating zone M10/115 and M13/110 (NOTE: Specialist U/F heating contractor to confirm screed spec.)
20. Rainwater goods R10/110 (NOTE: Spec has been revised by Leadbitter)
21. DPM F30/320
22. Render system rainscreen M20/160A
23. Screed Stop Strip
24. Brise Soleil
25. Curtain Walling H11/110A
26. Metal profiled sheet roofing H31
27. Balustrade L30/550A (The extend of glazed handrail is to be reviewed LB alternative spec. required)
28. Flush finish steel door L20/280
29. Metal Louvres to M&E requirements L10/650A
30. Shear wall to SE design
31. Window fixing lug
32. Steel external door L20
33. Sports store internal door L20/410
34. Sports hall entrance door L20/410
35. Fire sleeve P12/150
36. Wall tie, to SE requirements F30
37. 75mm Insulation F30
38. Wall starter F30/241
39. Acoustic Plasterboard providing class C sound absorption
40. Single skin profiled sheet
41. Metal Composite Panel Fixing H43 (steel size by subcontractor & SE)
42. 15mm Duraline Plasterboard K10 (refer to wall type drawings (AS-(22)-series)
43. Cladding rails by S.E.
44. Aluminium Fixing to Polycarbonate glazing unit
45. 15mm Soundbloc Plasterboard K10 (refer to wall type drawings (AS-(22)-series)
46. 25mm insulation
47. Sealed filler P12/110
48. 50mm insulation F30
49. Aluminium carrier & spacer as part of render system M20/160A
50. Wall lining type 01 K10
51. Hi-point Roof
52. Head channel fixed through Gyproc core board
53. Compressible cable firestop strip
54. Fire collar
55. Acoustic intumescent sealant
56. Fire damper
57. Metal C stud
58. Partition type 01 K10/125B
59. Partition type 02 K10/125C
60. Partition type 03 K10/125D
61. Partition type 04 K10/125E
62. Block Wall Partition type 05 F10/355 (refer to wall type drawings (AS-(22)-series)
63. Wall lining type 02 K10
64. Isolating gasket
65. Perforated metal decking to St Eng spec.
66. Fire barrier P10/410A
67. 18mm External Grade Ply 0n 50 x 50mm SW battens
68. Sliding Stacking Partition L20/545A
69. Ground Drain
70. Timber packer
71. Sports Hall Flooring M50/150
72. Wall tie, cavity up to 300mm, to SE requirements F30/211A
73. L-Lintel F30
74. C-Lintel F30
75. Wall tie F30
76. Aluminium framed doors L20/480
77. Internal screen L10/560
78. Precast concrete cill F30
79. Suspended ceiling system K40 (refer to ceiling drawings GA-(35) series for details)
80. Metal Composite Panel H43
81. 50mm Roof sound insulation duorock J42/425A
82. Internal Timber Doorset L20/410
83. Single ply roof membrane to paved areasroof J42/110B
84. Single ply roof membrane to lightweight roof J42/110A
85. Cut to falls roof insulation J42/420
86. Bed re-enforcement
87. Cavity Tray F30
88. DPC F30
89. 140mm blockwork (Sports hall and changing) F10/255
90. 140mm blockwork (Lift shaft) F10/355
91. Secondary Steel to SE & subcontractors requirements
92. Polycarbonate glazing unit L10
93. 16mm resilient bar
94. Resilient strip
95. 40mm floor insulation
96. Resilient hanger
97. Roller Fire Shutter L20/610A
98. 10mm insulation

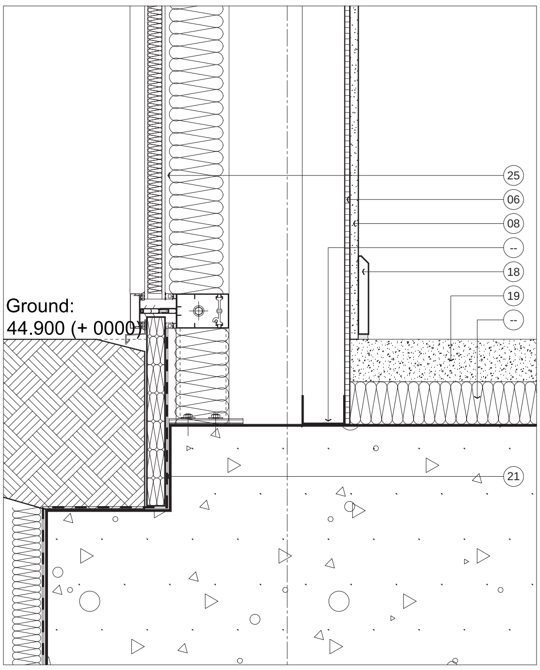
Line of Air Seal



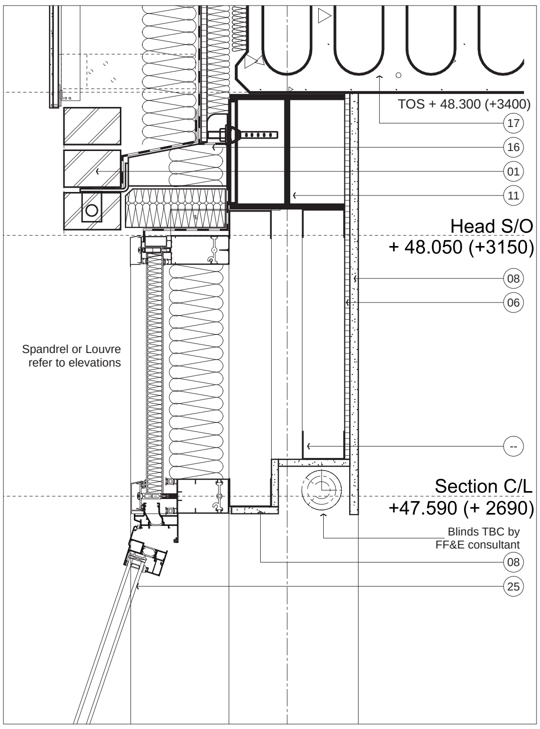
01
DT-(21)-Z026
TERRACED ROOF TO 2 STOREY BLOCKS
WINDOW HEAD AND CILL



02
DT-(21)-Z026
TERRACED ROOF TO 2 STOREY BLOCKS
PARAPET DETAIL



02
DT-(21)-Z041
GROUND FLOOR CURTAIN WALLING
TOE DETAIL



01
DT-(21)-Z041
GROUND FLOOR CURTAIN WALLING
HEAD DETAIL

Blaenavon Community Campus

A BREEAM 'Excellent' new build 450 place primary school and leisure facilities on a steep site overlooking Blaenavon.

Blaenavon Community Campus incorporates a 450 place primary school, leisure facilities, healthcare facilities (by others), a 130 place nursery (catering for 65 pupils at any one time) and Flying Start childcare. The school is designed to create a range of personalised learning environments from individual and small group study right through to open plan flexible learning plazas capable of holding several classes. It is linked to leisure facilities including a two court badminton hall, dance studio, fitness suite and changing rooms. At a later date a Primary Care Resource Centre will be added to the campus and will include further community facilities including meeting rooms.

Blaenavon Community Campus replaces two early 20th century primary schools and a prefabricated nursery with an integrated campus suitable for the 21st century. Torfaen County Borough Council intends to deliver innovative teaching exploring virtual as well as physical teaching methods. The school consists of three reception classrooms, 4 infant classrooms and a junior suite of 6 classes, two of which are plazas. These are larger and more flexible teaching spaces that can accommodate up to 60 children which aim to encourage group working and collaborative learning. Reception and infant classrooms are linked to outdoor learning spaces with a strategy of encouraging social interaction, personalised learning and didactic learning processes.

Passive Design

The campus is located on a steeply sloping south-west facing site overlooking the World Heritage town of Blaenavon, formerly the site of a recreation centre. The site is embedded in a busy residential area, maximising the potential for sustainable transport for pupils to the Campus. The leisure complex provides a gateway into the site and locates community facilities along the street. Separate entrances for the nursery, leisure, Flying Start and junior school allows controlled access and a separation of user groups.

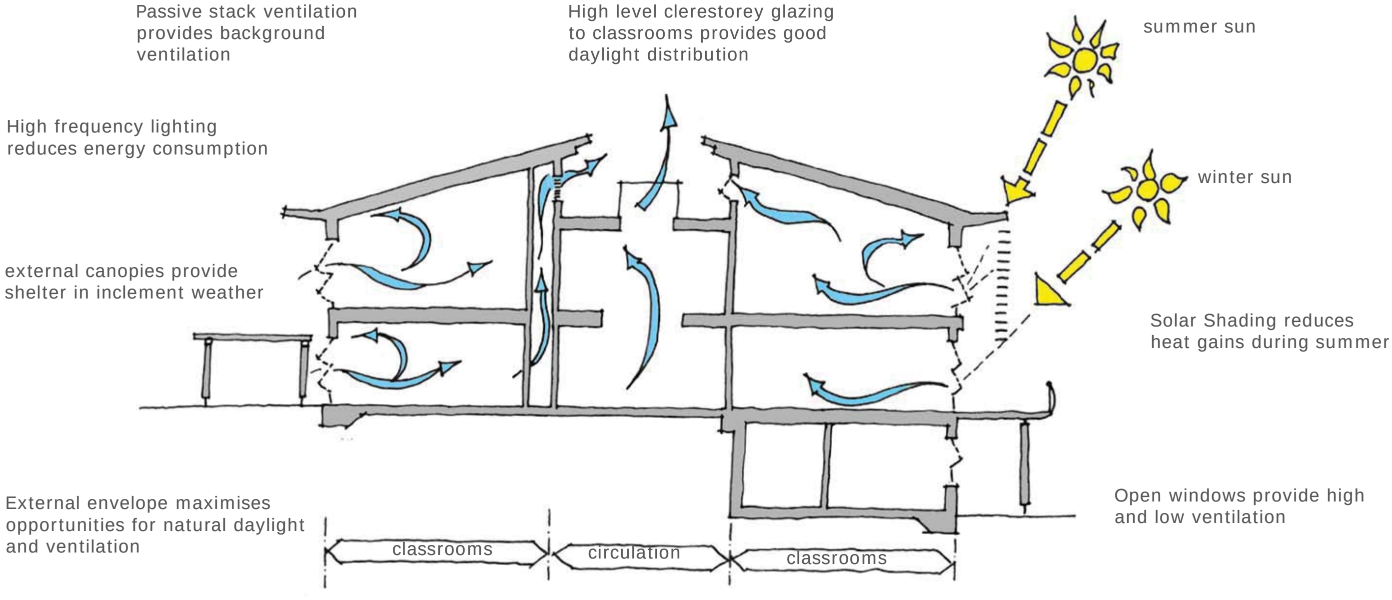
The building is designed to maximise passive design. A compact building form minimises external envelope. Classrooms are located around a two storey east-west

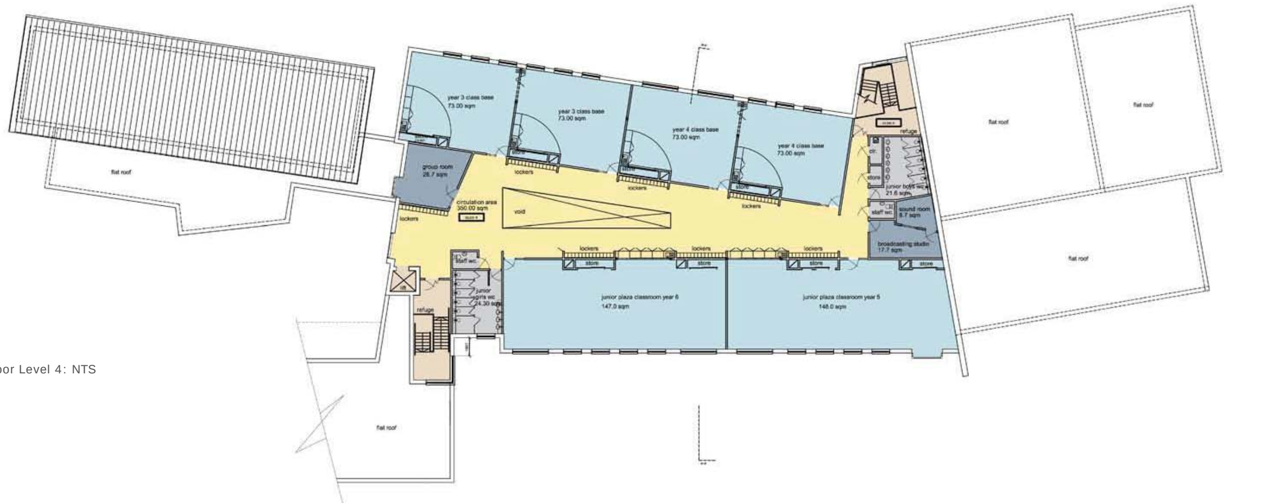
atrium at the heart of the scheme. The nursery, Reception and Infant classrooms face north, while junior classrooms face both north and south, taking over the whole second floor. Clerestory glazing provides additional daylight to the rear of classrooms. Deep overhangs provide protection from solar glare and inclement weather; south west facing elevations have an external brise soleil and internal blinds. Solar glass to east and west facades prevents overheating.

The school is designed to make visible the hierarchy of spaces within. Classroom blocks are articulated with pitched roofs with a standing seam roof. Pitching the roof enables clerestory glazing to light the rear of classrooms and encourage natural ventilation. Supporting spaces with varying levels of environmental conditioning are treated differently. These environmental differences driven by depth of plan and room function are then expressed externally architecturally, to create variety in massing, height, materials, roofscape and crucially glazing.

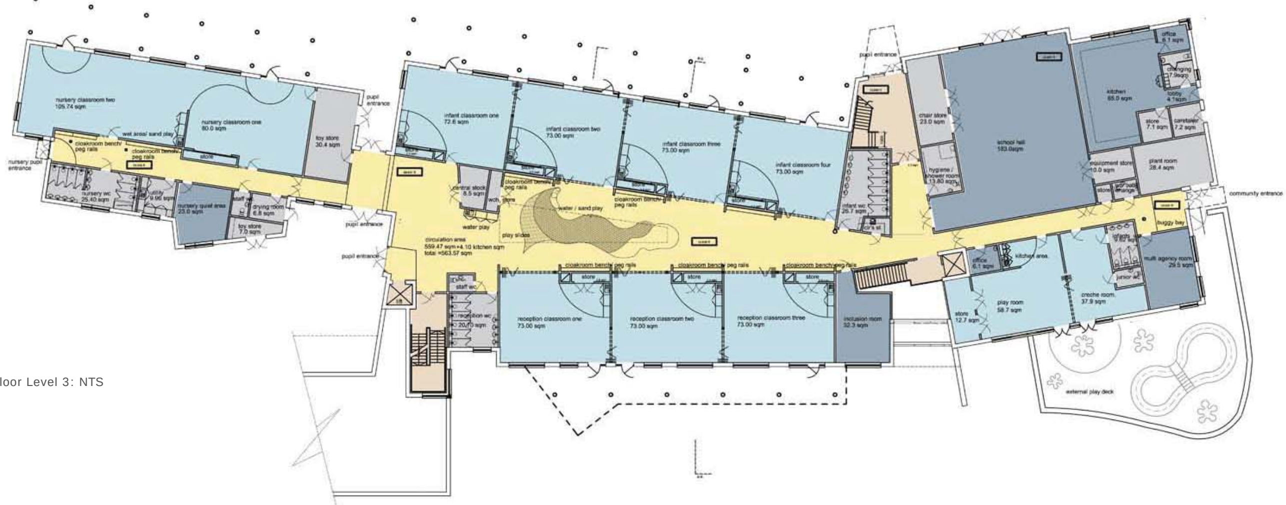
The building is primarily lit using natural daylight. The classrooms are daylit through full height vertical windows. This design decision relates to teaching methods at primary level. As pupils are often moving around between desks and floor, vertical windows ensure views out at desk and floor level within the classroom. In a secondary school, this would be less important as pupils spend more time at desks. Large windows provide a high glazing ratio and good light penetration; high frequency automatically dimming lighting responds to natural light levels, reducing energy use. Brise soleil to the south façade and internal blinds provide protection from direct solar gains.

Classrooms are predominantly naturally ventilated. Passive stack ventilation shafts at the rear of ground floor classrooms draw air through from opening facades to vents above the atrium. First floor classrooms ventilate through clerestory vents above the atrium. The atrium itself is ventilated through stack ventilation with opening vents at roof level; voids within the atrium facilitate air movement. Ventilating the classrooms through the atrium was considered, but the solution of ventilation shafts and clerestory glazing avoided potentially expensive noise attenuators between the classrooms and atrium. Mechanical ventilation is provided in high load areas, such as the broadcasting

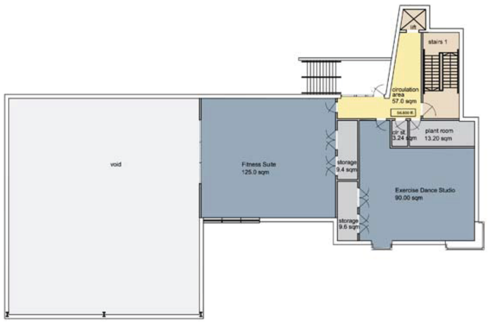




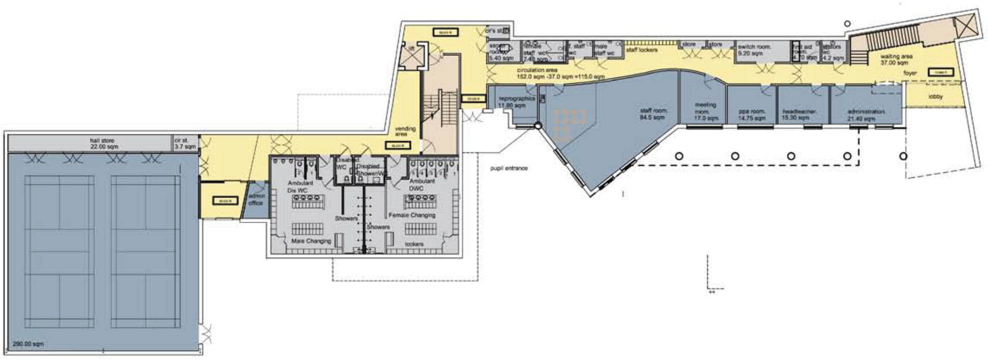
Floor Level 4: NTS



Floor Level 3: NTS



Mezzanine Floor: NTS



Floor Level 1 & 2: NTS

studio, kitchen and WC areas. All openings are occupant controlled, except in the atrium where ventilation in controlled by the BMS.

All nursery, Flying Start and infant classrooms have direct access to outdoor space to the north of the building. A generous balcony is provided to the south façade. The reception classes have a yard area to the west of the building as well as the balcony, while Flying Start has an elevated playdeck. The wider site includes a range of outdoor learning environments, including allotments, a multi-use games area, covered outdoor teaching spaces and a forest school.

Fabric Performance

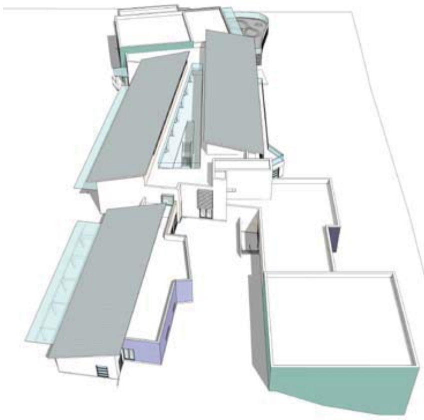
U-values:
Roof: 0.17 W/m²k
Walls: 0.21 W/m²k
Floor: 0.20 W/m²k
Glazing: 1.55 W/m²k

Air permeability rating: 7.3 m³/hr/m²@50Pa

The building fabric is designed to achieve a 20% reduction in U Values against 2006 Building Regulations.

The sloping site created challenges in detailing the fabric of the building. Large areas of ground had to be cut and retained, in some cases up to two storeys. Concrete retaining walls are used to create a stepped building form across the site, with three storeys to the south and two to the north, while the sports hall and changing areas are sunken further.

The school uses a steel frame system with Metsec subframe. Claddings, a mix of Pennant stone, dark grey rain screen cladding and render, were chosen to respond to the heritage location. A mix of high performing composite timber windows and small areas of curtain glazing have been used throughout. All openings are manually controlled with the exception of high level windows in the atrium.



shallow mono pitch roofs provide opportunities to bring clerestorey light into the back of classrooms.

Sequence showing construction build-up of cement particle boards on steel SFS framing, taping to provide weathertight and airtight seal, insulation (middle image to receive render), rainscreen cladding with carrier rails and insulation batts

Plant room with Combined Heat and Power unit

In previous school projects, Powell Dobson had used exposed thermal mass to balance temperature fluctuations, in particular exposed concrete ceilings to classrooms. For the Blaenavon Community Campus, an alternative approach of including 5% free areas was taken. These free areas act as a buffer to temperature fluctuations, removing the need for exposed thermal mass. This has the added benefit of enabling the use of composite floors which are lightweight and have an improved MAT 1: 'Life Cycle Impacts' score under BREEAM (2008).

Airtightness targets were stricter than Building Regulations; a reduction to 7.3m2/m2/yr was achieved through use of an airtightness membrane and careful construction processes, including taping of all joints and services penetrations.

Systems

Heating:	CHP supplemented by gas boilers
Electrical:	Mains, CHP
Hot water:	CHP
Water:	Rainwater harvesting, SUDS

Anticipated Heating Energy Demand: 55.88 kWh/m^{2}a
EPC Rating: B
Regulated Carbon Emissions : 25.1 KgCO$_2$/m^{2}a (Including leisure facility)
Regulated Carbon Emissions : 17.6 KgCO$_2$/m^{2}a (Excluding leisure facility)

The building required a minimum EPC of 40 under planning regulations. The final regulated carbon emissions and EPC ratings were reduced by a further 20% as a result of the continuing refinements in the design and construction to 25.1 KgCO$_2$/m^{2}a and a rating of 32 respectively.

The project's location in a conservation area imposed planning restrictions on what systems could be used on the building. Renewables were considered at the outset of the project. However, in negotiation with the planning authority, the design team decided against wind turbines or roof mounted panels and instead chose to rely on highly efficient mechanical plant to generate electricity. This eliminates the impact of visible systems within the conservation area. Simplicity, ease of use and maintenance were key concerns for the client. A biomass boiler was considered, but concerns over supply and the sustainability of biomass systems led to other options being explored.

Heating demand is met by a gas fired Combined Heat and Power (CHP) system that feeds wall mounted radiators and localised underfloor heating. This is sized to run continuously to optimum capacity in all four seasons. The electricity generated by the CHP is used on site or sold to the National Grid when not required. The services approach using CHP had been successfully applied in schools elsewhere by Kier and Torfaen CBC, meaning it was understood and acceptable to all parties. This was of particular importance to ensure the client understood the system and could operate it effectively.

The CHP was specifically appropriate to this project as the anticipated additional hot water demand from the leisure facility and its extended hours of use ensured the CHP was operated at optimal efficiency and created large quantities of electricity on site as a result.

Water efficient systems help reduce the water demand of the building. Rain water is harvested from the roof and reused to flush toilets, reducing running costs. 48,000 litres of rainwater can be stored in tanks embedded under the atrium. Clear pipes, vision panels and education boards ensure the process is visible within the building. A SUDS system is utilised in areas of hard landscape to attenuate flow of runoff into local watercourses.

Procurement

JCT Design and Build with an 18 month contract length (completion in 83 weeks)

The building was procured through Torfaen County Borough Council's single contractor framework with Kier Western. Projects procured under the framework follow a two stage process, a design stage to Workstages C/D and a construction phase. The continuous involvement of a contractor throughout the process ensures close collaboration.

Kiers pre-contract team were aware of BREEAM requirements, having been involved in other 'Excellent' projects in the past. Kier's design and construction phase managers have "on the ground" experience of BREEAM, however are often "time poor" when it comes to controlling the flow of evidence. In more recent projects, Kier have involved a cross-project BREEAM coordinator to ensure targets are met, paperwork is in place, and to manage continuity across projects.

Designing out waste

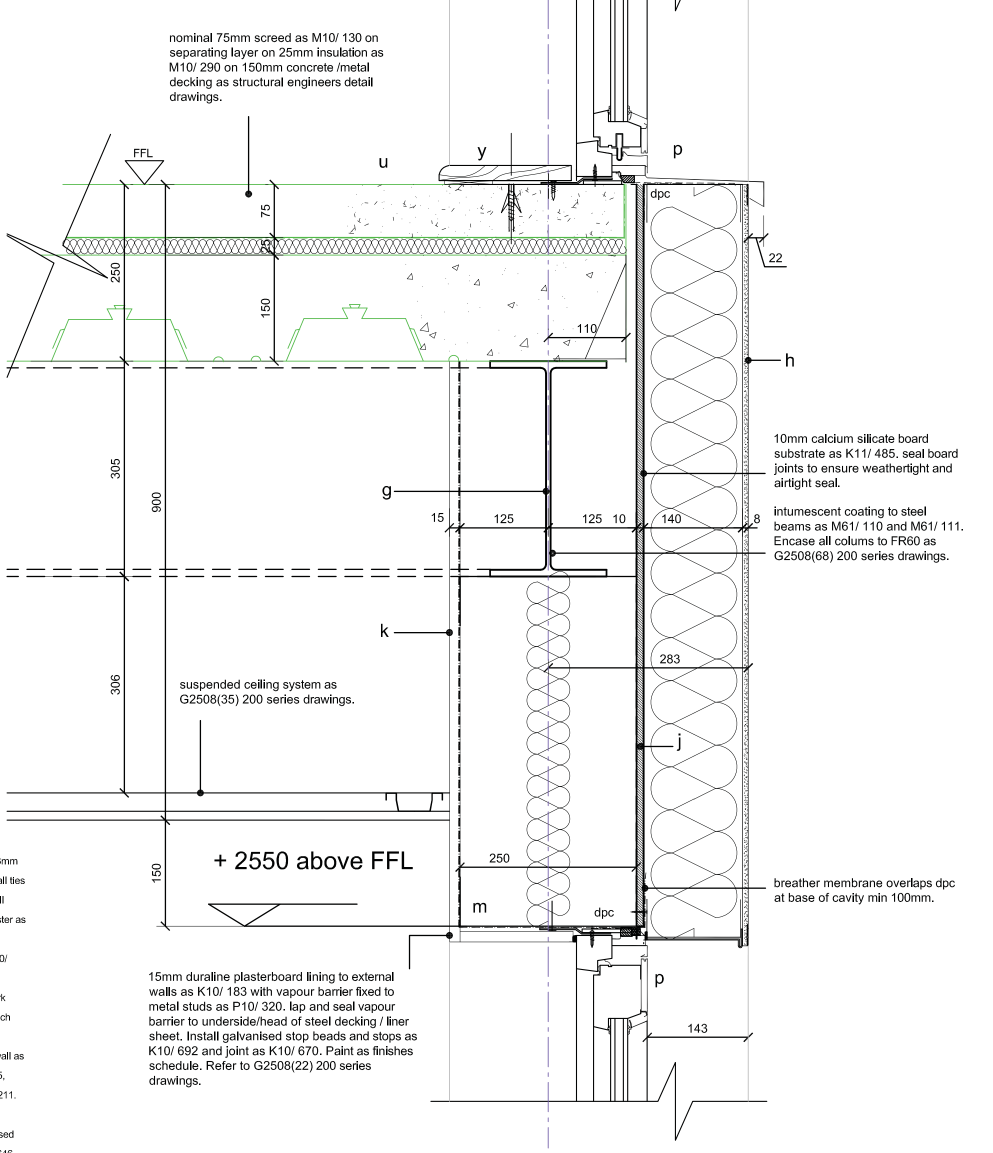
Material waste was minimised due in part to Welsh Assembly funding criteria and contractor policy. Minimum bench mark targets set out at the beginning of the project were exceeded as a result of the design and the management of the process. Key areas targeted were:

- Maximising recycled content of building products: Using the Waste and Resource Action Programme (WRAP) Net Waste (NW) tool a minimum target of 15% (by value), was set at the outset of the project. However as a result of team workshops, 57 "quick wins" were secured, these measures such as the careful specification of locally sourced block work, aggregates and doors, this target was subsequently raised to 21% at no additional cost to the client.

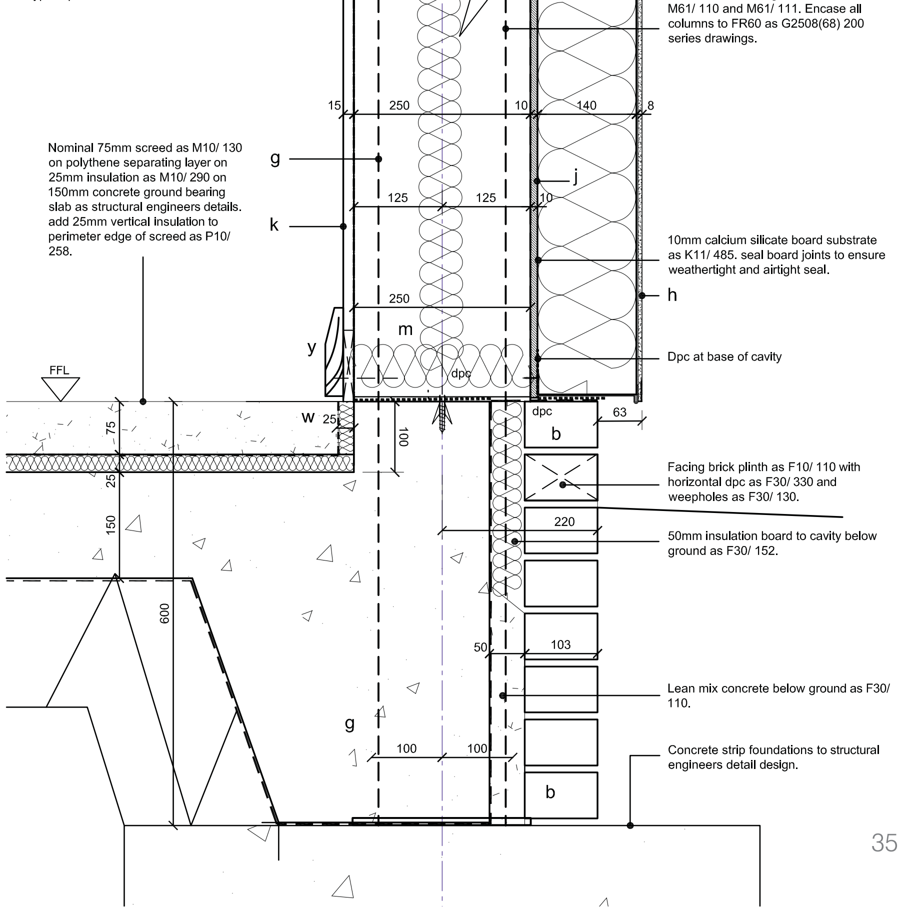
- Building construction waste reduction: While no contractual minimum standards were stipulated, TCBC encouraged the reduction of waste on site as a means of mitigate the environmental implications of landfill. These aspirations were supported by Kier's company policy and their commercial interests.

- The Site Waste Management Plan (SWMP) was commenced before planning alongside the WRAP NW tool. The SWMP was subsequently reviewed at key stages of the project to ensure the highest standards could be both targeted and maintained throughout the project. Design initiatives such as specifying fewer materials and patronising sub contractor "take back" schemes resulting in less than 9.2m^3 of waste per 100m^2 of gross internal area being created, whilst the segregation of waste, including the re-use of 6800m^3 of spoil within the site, ensured that 94% of non hazardous waste was diverted from landfill.

typical perimeter wall section detail
140mm thick insulation render system



typical perimeter wall foundation detail.



Key

- a 100,140mm medium dense blockwork partition as F10/ 353 with 13mm plaster finish as M20/ 200. Fix 200mm stainless steel debonded wall ties shot fired into rhs/shs at 450mm vertical centres as F30/ 220. install compressible filler and acoustic seal as F30/610.paint finish to plaster as finishes schedule.
- b Facing brickwork below dpc as F10/ 110 with horizontal dpc as F30/ 330 with cavity trays as 345, 370, 380 ,385 and 390.
- c pennant stone walling as F20/ 110 fixed to 100mm dense blockwork backing wall as F10/352. Install stainless steel angle wall ties at each course and to each stone as F30/212.
- d 100mm dense blockwork backing wall to pennant stone masonry wall as F10/ 352 with 100mm partial fill mineral wool insulation as F30/ 155, 80mm clear cavity and with stainless steel cavity wall ties as F30/ 211.
- e 100mm blockwork above dpc as F10/ 350 to masonry walls.
- f 13mm internal plaster finish to blockwork as M20/ 200 with galvanised angle stop beads , engaging beads etc as M20/ 630 and 640 and 646. Acoustic seal to perimeter. Paint finish as finishes schedule.
- g structural steel to engineers drgs with 2 coats bitumen paint to all sides within cavity as M60/190. Paint finish to exposed steelwork as M60/130. Intumescent paint finish to steel beams as M61/ 100 and M61/ 111.
- h Insulated render system with mineral wool insulation as M21/ 220 on galvanised SFS system with bracing as G10/ 150 as manufacturers recommendations. Install fire barriers as M21/510. Provide suitable support for services and fittings as M21/520. Install as manufacturers recommendations to ensure weather-tight and air tight finish.
- j 10mm cement particle board substrate to insulated render system as K11/ 485 fixed securely to galvanised steel SFS system as G10/ 150. Seal board joints to ensure weathertight and airtight seal.
- k 1 x layer 15mm british gypsum duraline plasterboard lining as K10/ 183 with polythene vapour barrier fixed to metal studs as P10/ 315 . Fire stop around services. Apply acoustic seal to perimeter. Install galvanised stop beads, corner beads and engaging beads as K10/ 692. seamless joint finish as K0/670. paint as finishes schedule.
- m galvanised steel support framing studs @600mm centres unless otherwise stated as G10/ 150 as structural engineers detail drawings and specification. Install 60mm mineral wool acoustic slab insulation between studs.
- n Aluminium polyester powder coated double glazed sealed curtain walling system as H11/111. seal as H11/ 770.
- p polyester powder coated aluminium composite double glazed window /screen /door system as L10/400. seal as L10/810.
- q polyester powder coated double glazed aluminium windows as L10/330. seal as L10/ 810
- r polyester powder coated double glazed aluminium doors as L20/ 485. seal as L20/ 820
- s polyester powder coated aluminium louvre door as L20/ 480.seal as L20/ 820.
- u 75mm screed as M10/ 130 with underfloor heating on separating layer as M10/ 290 with trowelled finish as M10/ 540. Fix 25mm insulation as M10/ 290 to achieve 100mm nominal finish.
- w 25 mm perimeter insulation to screed edge perimeter as P10/ 258
- x 50mm partial fill insulation to cavity below ground as F30/ 152
- y 125 x 19mm chamfered softwood timber skirting and 200 x 19mm windowboard as P10/ 120 with satinwood paint finish as M60/135.
- z Facing brick above dpc as F10/ 111 with horizontal dpc as F30/ 330 with cavity trays as F30/ 345,370, 380, 385 and 390.

- Construction activity waste reduction. - Waste can arise as a result of the site activities such as transport and water consumption. 7 initiatives were identified to minimise the waste from site, these were tracked from the commencement of the site set up to completion to benchmark the contractor's performance on an ongoing basis.

These initiatives resulted in securing top credits for BREEAM's Management 3 "Construction site impacts", and Waste 1 "Construction Site Waste Management " as part of the wider BREEAM "Excellent" strategy.

Construction

The architects and the contractor worked in close collaboration throughout the project. Details were often discussed and revised to ensure buildability, reduce cost and meet client requirements. In some cases, this close collaboration and revision of details meant that the architects were producing drawings later in the construction process than would ideally be the case and working to very tight deadlines in order to not breach the contract terms. However the benefits of this "just in time" approach to design, ensuring that details obtained cross discipline agreement, outweighed the risk.

Buildability

The construction process was relatively smooth for the building, with the main hindrance a harsh winter. Kiers were erecting the concrete retaining walls during a period of extremely cold weather and sub zero temperatures. This affected the speed of pouring and the speed of setting, delaying the programme. Despite this, the building was competed early.

- Airtightness was a key area the contractor targeted in order to achieve the initial target of $8m^3/(h.m^2)@50Pa$. As part of Kiers framework agreement, HRS Services Limited was engaged on an extended contract covering a range of services prior to and including the formal air test. These additional services included:
- Holding workshops with the team to set air tightness targets, construction principles and line of continuity of air tightness.
- Construction site visits conducted with the aim of assisting the construction phase sub contractor teams in inter-operating the details, identifying areas of improvement and where necessary advising on suitable construction sealants.
- The production of reports to support on site discussions and coordinate with wider team members.

An initial target air tightness of $8m^3/(h.m^2)@50Pa$ was targeted as part of a wider the energy strategy. The line of continuity was identified as the substrate board to the built up render system and the liner tray to roofing systems. The final air tightness exceeded expectations achieving $7.3m^3/(h.m^2)@50Pa$, further reducing the final carbon emissions.

Project cost

Total project cost:£10.1 million.
Total services cost: 15%

Completion

February 2012

Project details

Client: Kier Western/Torfaen CBC
Main contractor: Kier Western
Architect: Powell Dobson Architects
M&E: Hoare Lea
Structural Engineer: Bingham Hall Partnership
Acoustics: Hoare Lea Acoustics
Airtightness: HRS Services Limited

Image credits: Powell Dobson

Taf Ely Learning Campus, Coleg Morgannwg

A new build tertiary learning campus on a brownfield site with facilities for students, staff and the community.

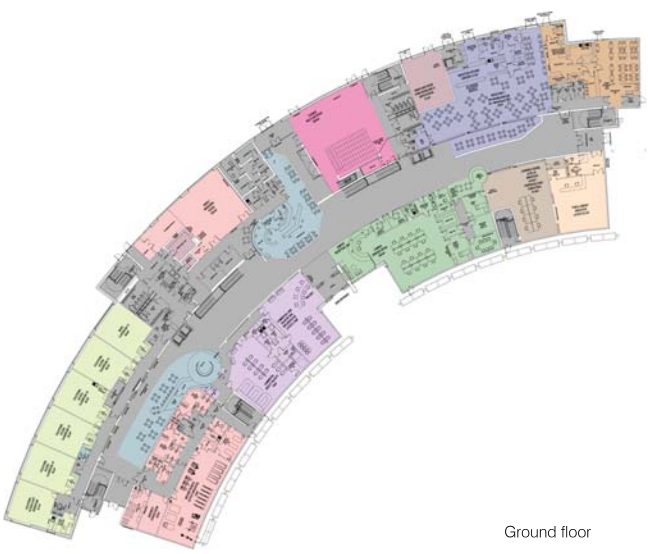
The Taf Ely Learning Campus is a £40 million extension on a 7.74 acre site opposite Coleg Morgannwg's existing site at Heol Yr Odyn, Nantgarw. The facility will replace existing college buildings at Rhydyfelin and provide 12,500m^2 of new facilities.

The client's aspiration is for "an iconic beacon for learning" that will meet the needs of the varied curriculum provided by the college and provide facilities for over 3000 staff and students. Over four floors of accommodation the campus will incorporate facilities for Computing, Information Technology, Science, Care & Childhood Studies, Business & Professional Studies, Sport, Catering, Hair & Beauty, Music and Performing Arts. An important aim is to enable the community and local businesses to engage with the college seven days a week throughout the year.

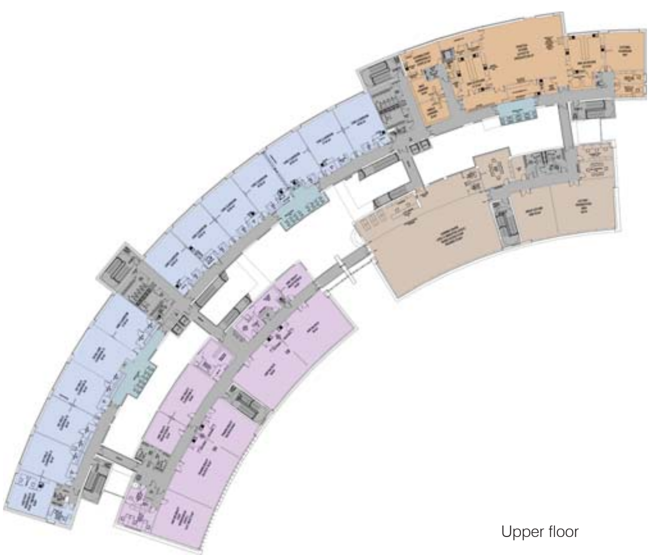
The client's aim at the outset was for BREEAM 'Outstanding' to better their existing BREEAM 'Excellent' campus buildings on the same site. The building uses BREEAM Education despite the complex nature of the programme. Early points were gained from the brownfield site and use of existing infrastructure and amenities. Early involvement of a BREEAM professional ensured that BREEAM requirements were integrated from the outset of the project. Early cost pressures however meant that the target of 'Outstanding' was replaced by 'Excellent' and the final scheme rated at 72.43%.

Passive design

The site is a rectangular plot with little overshadowing. The curved form of the building was chosen to create a courtyard for parking and entry. The early design of the building aimed to maximise passive design, particularly daylighting. The building is divided into two wings around a covered boulevard that allows daylight to penetrate into the plan and natural ventilation from the classrooms. Four storeys of deep plan north and west facing teaching rooms are naturally ventilated using chimneys that rise through the



Ground floor



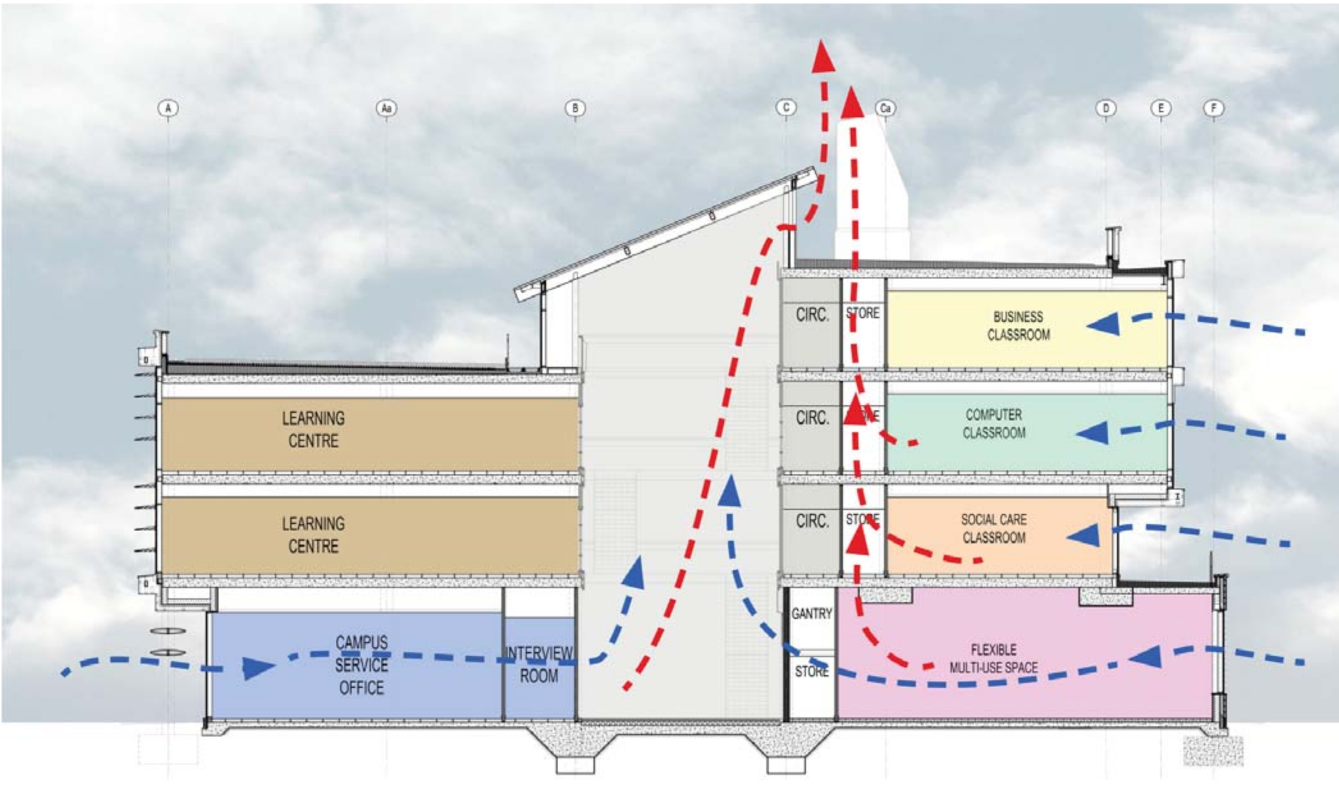
Upper floor

plan, while the south and east facing learning centre is predominantly mechanically ventilated. Linking to two wings is a 7.5m wide boulevard, containing at ground floor many of the public facing facilities- a gym, crèche and library in addition to a training restaurant, a hair and beauty salon and large spaces for music and performing arts.

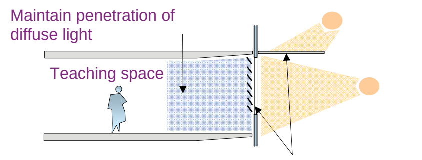
Glazing ratios are high throughout the building. The south façade has 40% glazing, while the north façade has 60% glazing to maximise daylighting. All windows are double glazed and aluminium framed. While high levels of daylighting were required, glare and direct sunlight needed to be controlled. Louvres have been integrated into the design of the facades; to the south façade horizontal louvres cut direct sunlight, while vertical louvres to the east and west façade minimise low angle morning and afternoon sun. Internal blinds provide additional glare control during periods of low angle sun. The north facade has no louvres, maximising natural light to these teaching rooms.

Meeting the latest guidance on acoustic requirements in teaching spaces required a reduced level of glazing to the north façade, but this would have reduced the daylight factor and result in no BREEAM credits for lighting. However, as the requirement was only guidance, the client decided to maximise the BREEAM score as long as the acoustic levels matched those in their existing buildings.

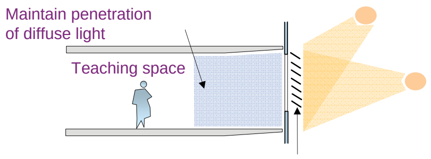
Passive options were limited due to the complex interaction of spaces with different heating and ventilation requirements. Despite this, the ground floor offices, flexible spaces, multi-storey classroom block and teaching spaces are naturally ventilated. The street is used to create a stack effect with feature natural ventilation stacks providing exhaust for the classroom spaces. Spaces with higher heating loads, such as the learning centre, are mechanically ventilated.



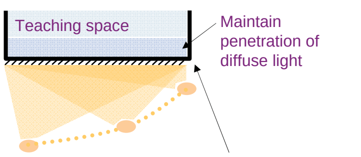
Solar Control



Horizontal overhang used to control the penetration of direct solar radiation during peak periods. Internal blinds provide glare control during periods of low angle sun.



Horizontal louvres used to control the penetration of direct solar radiation. Increase effectiveness of louvres by manual/motorised angle adjustment.



Vertical louvres used to control the penetration of direct solar radiation. Increased effectiveness of louvres by manual/motorised angle adjustment.

Materials throughout have been specified to meet BRE Green Guide rating A or A+. Claddings aim to highlight the individual elements of the brief and include copper, cedar, Trespa, fibre cement and brick. The aluminium framed glazing system used 100% recycled aluminium. Kalwall has been specified for the boulevard roof; this insulating GRP product filters light into the Boulevard preventing direct solar gains, has limited maintenance and good thermal performance.

Fabric performance

U-values:
Glazing: 1.80 W/m²k
Roof: 0.20 W/m²k
Floor: 0.20 W/m²k
Walls: 0.28 W/m²k

Air permeability target: 8 m³/hr/m²@50Pa

The design team aimed to make the fabric of the building as efficient as possible to reduce energy demand before applying systems to the buildings. Early structural designs for the building investigated a steel frame solution with Metsec infill panels. However, the contractor preferred a prefabricated twin wall concrete system. This would save time on site but would require more up front design to finalise opening locations early in the project. In situ concrete columns and floors complete the structural frame, while Metsec infill panels provide subdivision. An added benefit of using a concrete frame in floors is increased thermal mass, used to even out temperature differences throughout the day. Exposed soffits increase the thermal mass of the building.

Insulation is applied as part of the Metsec panels and the rainscreen cladding system. Overall the building has 280mm Rockwool insulation to external wall giving a U Value of 0.28W/m²K.

A green roof to the southern block mitigates ecological damage to the site as well as attenuating rainwater dispersal and absorbing $C0_2$.

Modelling the fabric performance using SBEM gave a fabric-only pre-planning EPC rating of B and a BER over TER of 91% (excluding any renewable systems).

Systems

Heating:	Biomass boiler, backup gas boiler; Solar thermal collectors
Electrical:	Photovoltaic panels
Water:	Rainwater recycling

An energy centre to the north of the building houses a biomass boiler that provides all the heating to the Learning Campus and a new crèche facility. Other options were considered but rejected: CHP was not suitable due to the reduction in demand during the summer recess; As the area has been affected by mining a ground source heat pump was rejected as the ground conditions were uncertain; wind power was not suitable due to the lack of wind. Underfloor heating provides background heating to the boulevard. The biomass boiler meets the base heating demand for the building; when required, a back up high efficiency gas fired boiler can provide additional heat.

The biomass store is situated above ground and uses hook bins to minimise on site handling of biomass fuel.

A Building Management System monitors energy usage throughout the building so that improvements in efficiency can be made throughout the building's life.

Rainwater from the flat roofs to the northern block is harvested for greywater recycling and reused in WC's. All fittings are low flow, minimising water use, and a leak detection system is fitted.

Modelling the fabric performance and the impact of the systems specified using SBEM gave a pre-planning EPC rating of A(23) and a BER over TER of 46%, a Building Emmission Rate of 10kgCO_2/m^2/yr.

Predicted energy figures:

Predicted electricity consumption:	47.1 kWh/m^2
Predicted fossil fuel consumption:	12.8 kWh/m^2 Gas
Predicted renewable energy generation:	53.1 kWh/m^2 Biomass,
	0.34 kWh/ m^2 Photovoltaic
Predicted water use:	6.68 m^3/person/year
22% of water provided by rainwater	

Procurement

Contract: NEC Option 3

The project was procured as a two stage tender. The involvement of the contractor at an early stage enabled close dialogue between the design team and contractor.

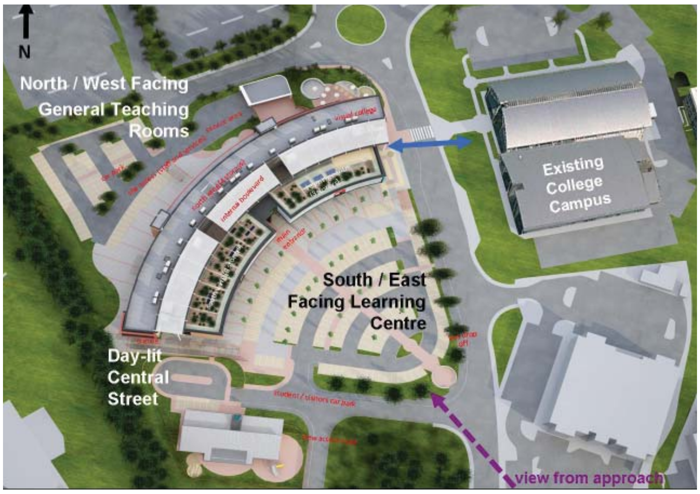
A or A+ rated materials were specified, FSC timber throughout, and 100% recycled aluminium in windows. ISO 14001 rated suppliers were required. However, the paperwork to record these material and supplier credits was so onerous that they were dropped from the assessment after pre-assessment stage, saving a considerable sum for the contractor.

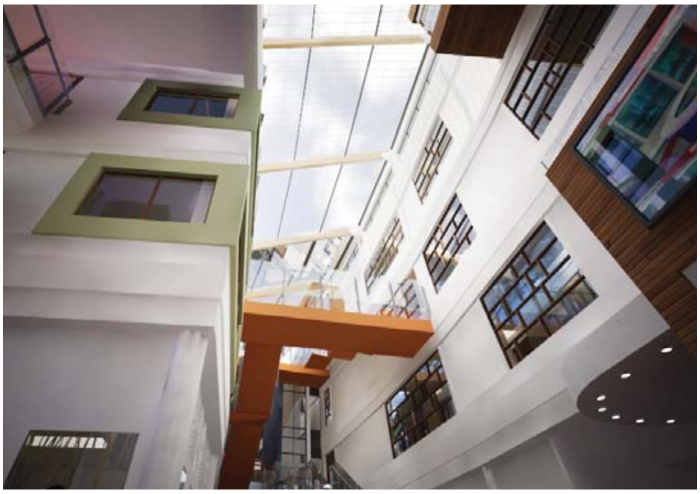
Project details

Client: Coleg Morgannwg
Architect: Boyes Rees Architects
M&E: Hoare Lee
Project manager: Gardiner & Theobold
Main contractor: Laing O Rourke
Structural engineer: Hyder Consulting

BREEAM Scheme: Education 2008
Final stage rating 'Excellent' 72.43%

Images: Boyes Rees


N
North / West Facing
General Teaching
Rooms
Existing
College
Campus
South / East
Facing Learning
Centre
Day-lit
Central
Street
view from approach



White Design, Bristol

All Saints Academy, Plymouth.

An extend and retrofit secondary school for an expanding local population in Plymouth, with BAM Constuction.

A Case for retrofit

The 2008 Climate Change Act called for an 80% reduction in greenhouse gas emissions, from 1990 levels, by 2050. Low carbon retrofit of the UK's existing building stock will play a key role in meeting this technically and logistically ambitious target. Retrofit continues to be critical in upgrading the built environment to meet the challenge of a low carbon future.

During the first decade of the century, the desire to sweep away inefficient and worn-out school facilities was encapsulated in the Building Schools for the Future programme. It was considered to be an opportunity to re-examine how we learn and to create high quality low-carbon learning environments in which to do this. The current UK situation has changed over the intervening years. Concerns over the state of potential public finances, the increasing need to reduce carbon emissions, and questions over the suitability of PFI are all pointing to a future that is likely to see the refurbishment of existing school buildings gain preference.

Where as the BSF programme can be praised for its vision and strategic approach, refurbishment projects often come under criticism for lacking such qualities. Many school campuses are blighted with a selection of add-ons and refits that suffer from lack of a clear over-pinning strategy at masterplan level. This results in awkward external spaces, schools that are difficult to manage and are confusing or disorientating for visitors and pupils alike. Such schools can be equally problematic in building services strategy terms. Different qualities in building fabric and services across the campus lead to energy wastage, convoluted service runs and ultimately schools that are very costly to run. Schools continue to need significant capital investment and in many cases new build may be the only option available. However, the refurbishment of existing schools may have a valuable place in contributing to the reduction of the UK financial deficit whilst significantly helping to raise educational standards and contribute toward that 80% reduction in UK's GHG emissions.

When assessing a school masterplan in view of improvements, complex decisions are made based on many factors. Most schools have been developed in a piecemeal fashion over time and can suffer from no clear strategy, unsuitable space standards, haphazard circulation and lack of accessibility. The value of different parts of the school buildings vary greatly. By analysing these individually and thoroughly with a clear educational strategy at the forefront of the decision making process, a successfully considered retrofit solution can result. A successful retofit has potential to offer reduced capital costs and less disruption to the school, whilst maintaining characterful elements of the old school and delivering an environment fit for 21st century teaching.

Ajacent:

Modelled image of All Saints Academy, Plymouth showing new build extension to the left ajoining retrofit on the right.

Credited to White Design

Building Bulletin 82 was introduced in 1996 (superceeded in 2004 by BB98). It was the first document to give detailed recommendations for space standards in schools, in many cases increasing classroom sizes by around 18%. School buildings that predate it may prove difficult to retrofit becuase principal spaces don't allow for current standard space requirements. This may mean that building structures that have inherent flexibility for moving internal divisions are favoured for retention. Alternatively existing buildings may be turned into ancillary spaces or support rooms to make the best use of their limitations.

In comparison with the option of demolition and complete newbuild, the 'retrofit and extend' route will almost certainly result in reduced embodied carbon emissions by minimising the use of new, carbon-intensive structural materials needed on site, and by reducing mixed waste rubble. Many buildings are demolished because of failings in fabric, services and fit-out, rarely as a result of structural failure.

Retaining existing buildings can be costly if the required refurbishment work is too extensive, but in many cases the decision to retrofit is based on financial limitations as this route can require less capital outlay and reduced risk.

A new Academy for Plymouth

All Saints Church of England Academy is a business and enterprise college that opened in September 2010 on the existing John Kitto Community College site in Pennycross, Plymouth, serving approx 1000 students. A school first appeared on the site in 1958, with just 300 pupils on its books. It expanded rapidly through the 60's and 70's. In the 1988, a substantial new 3 storey building was constructed to serve 900 students. Since then, extensions, temporary buildings and additional department blocks have appeared to accommodate a bulging student population up to 1200 during the early 21st century.

In 2010 John Kitto re-opened as All Saints Church of England Academy. In December of that year it was one of 71 academies awarded a capital funding grant with the intension of investing the funds in a new building by 2013. In March 2012, Plymouth City Council announced the preferred contractor for new buildings and a refurbishment project was BAM Construction Limited. The decision to award the contract was made following a tendering exercise through the Partnership for Schools Construction Framework.

This project was to invest £11.3 million in the Academy campus providing 4188m^2 of new build and a complete remodelling and refurbishment of the 1980s east wing building. The 1960s and 70s buildings had all reached the end of their life, being deemed fit only for demolition. A new 4 storey building was designed to abutt the existing block to provide level access transition between the two, with extensive landscaping and new provision of sports facilities helping to refigure the entire campus fit for 21st century students.

On completion, the Academy will have flexible and adaptable learning spaces, a new theatre and creative arts area and over £2 million of investment in new ICT facilities, furniture and equipment. The campus will have full DDA access for use by the community as well as the students.

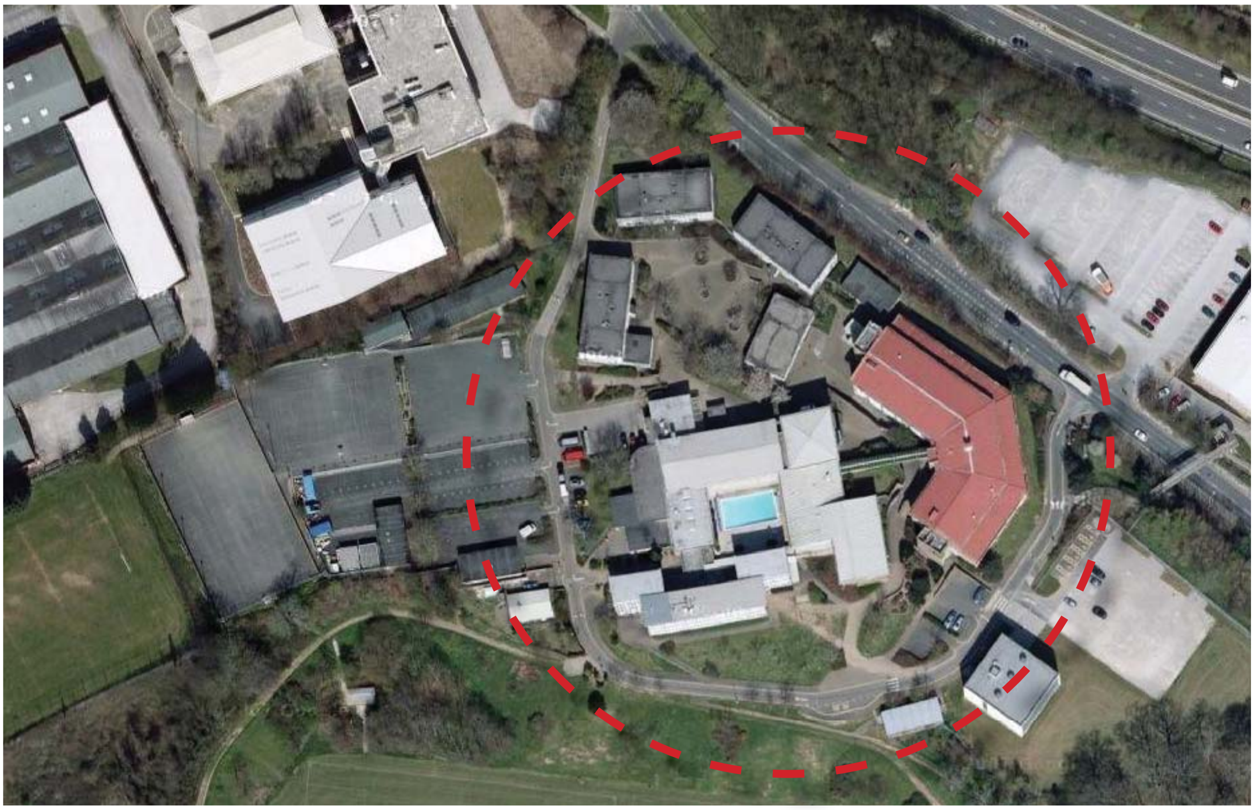
BAM Construction Ltd estimate that 80 per cent of the contract value will be spent in the local economy, directly contributing to the city's economic growth. As part of the contract, BAM Construction Ltd has committed to creating a number of apprenticeships, giving young people opportunities to train whilst in employment.

Above left:

Aerial photograph of the All Saints Academy campus, with the red roofed 'E' block and a miasma of other buildings from many ears.

Below left:

Proposed landscape layout showing the outline of the new school comprising retained 'E' block ajoining the new 4-storey building.



The retrofit

The building to be retained is 'L' shaped with the main teaching spaces on the north west and north east side of the building facing onto the adjacent main road. The layout reflects the design thinking at the time – cellular rooms with long spine corridor running the length of the building. Ancillary spaces such as toilets, and support rooms occupy the inner bend.

The original building is over three floors, with entry points on two levels to respond to the natural gradient falling across the site to the north. It is of steel frame construction with profiled metal floor plates topped with concrete. Internal partitions are non structural blockwork. There is a profiled metal deck roof. The wall fabric is an uninsulated cavity blockwork wall, The façade had ribbon windows with fibreglass infill panels running horizonally particularly to the north elevations, with single glazing throughout.

Existing services comprise gas fired boiler supplying radiators with a hot water, naturally ventilated classrooms via openable windows, electrical installation typical of the era. Large expanses of glazing to the north provide a good quality of natural daylighting to principle teaching rooms.

The building is now 25 years old and considered to be structurally sound. Its steel frame and profiled metal decking construction offers a great deal of flexibility – the ability to remove and replace internal partitions or adjust the existing fabric to accept new servicing routes is of significant advantage. The nature of the panelled façade construction also lends itself well to fabric upgrade.

The quality of the internal environmental is beleaguered by several problems typical of buildings of this type. Maintaining a satisfactory room temperature is costly and energy intensive during cold months because of the inadequate insulation; the extent of unshaded glazing results in an overheating issue during summer months. There is inadequate provision for effective cross ventilation unless a strong prevailing wind is evident, although this in turn leads to draughtiness. Over the years since construction, the quantity of road traffic has increased ten fold. With it comes the associated noise and atmospheric pollution that today's building engineers are better equipped to mitigate.

Regulatory framework for retrofit.

Consequencial improvements refer to energy efficiency improvements required in section 6 of Approved Document L2B, relating to proposed works to existing buildings with a total floor area of over 1000m^2, including extensions and installations or upgrade of new fixed building services. Consequential improvements require the whole building to comply with Part L of the Building Regulations to the *'extent that such improvements are technically, functionally and economically feasible'*. The team at BAM approached this by setting an achievable budget allocated to environmental enhancements to the existing building. Measures to achieving greater energy efficiency were targetted in order of effectiveness, such as greater insulation depths, cold bridging details, and glazing specification.

Costs:

Available budget for the project is much reduced from levels seen five years previously. Where as in 2007, BAM were providing new build secondary school schemes for a typical 1700m^2, current pressure to reduce costs by 600 - 700 m^2 has a knock on effect on many aspects of the quality of the build, but in particular services and finishes. Whereas elements of the build such as structure and foundations cannot be value engineered, it is unfortunately the elements that end users can see and touch that inevitably suffer most from reduced budgets. Care over material specifications, such as product longevity and associated embodied carbon have little shout when budgets are tight - even if such products will mean it is a false economy by taking a longer term view of maintenance and finishes replacement. Budget cuts to service provision runs in hand with this.

In the majority of situations, low-carbon measures such as natural ventilation are inherently low cost. In a retrofit scenario such as this, where natural ventilation is failing due to factors such as depth-of-room and an unadaptable fenestration strategy, environmental modelling showed fixing the problem would require the introduction of cutting strack chimneys into the floor plates. Additionally, complex acoustic baffling would be needed to couteract traffic noise. The necessary extra costs of measures to make natural ventilation viable in this case resulted in mechanical ventilation becoming the chosen route forward, to the detriment of post occupancy emission rates and the low carbon agenda. Environmental 'extras', such as rainwater harvesting, solar hot water and PVs cannot be exploited with budget constraints seen on the job. The focus of the retrofit centred around enhancing the thermal performance of the fabric, providing adequate ventilation andf preventing overheating.

Programme.

Initial site analysis was carried out by Plymouth City Council and their technical advisors. Decisions about the extent of existing school to retain and how new-build elements addressed the existing buildings were made prior to the Invitation To Tender stage.

BAM Construction and their design team were successful at tender, so became Selected Panel Members in March 2012. A 16 week programme followed to develop the concept scheme with the school, the local authority, designers and engineers. Once contract agreement was reached in June 2012, BAM started on site the following week, in preparation for the school becoming unoccupied during the summer months.

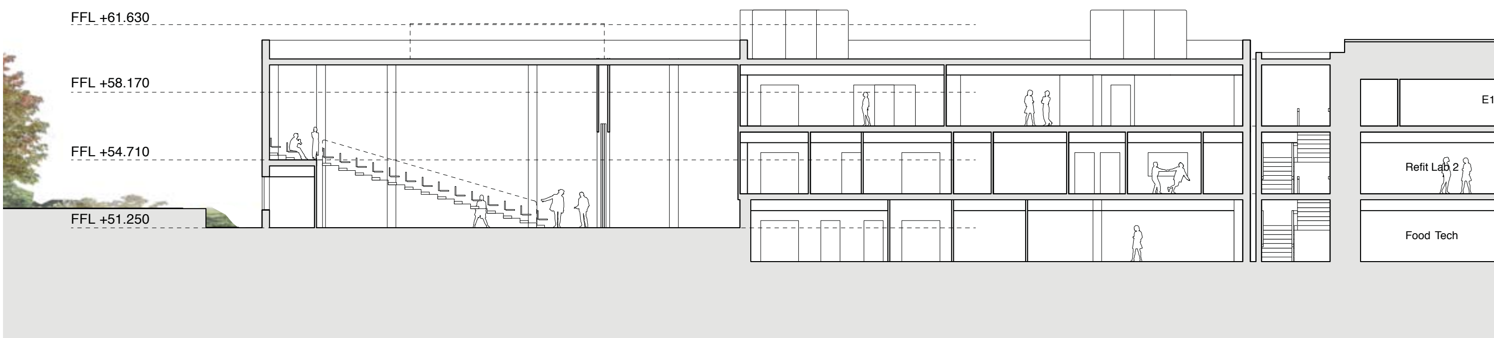
The works commenced on site in July 2012, with the partial demolition of the school building that will not be retained, in order to make way for the new school extension. During this year long build, constructed and designed by the same team, the school has been able to operate on its reduced footprint (approx 15% less area) with manageable amounts of disruption. In July 2013 when the school becomes unoccupied again, retrofit work will commence on a tight 6 week programme to prepare the 'L' block for reopening in time for September. During the following academic year, the remaining 35% bound for demolition will be removed. External works and landscaping, including replacement and disposal of 4000m3 of spoil, is due to complete in February 2014.

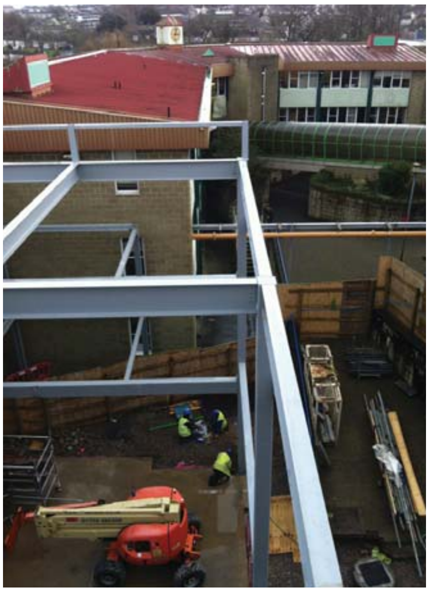
Methodology for retrofit of 'E' block

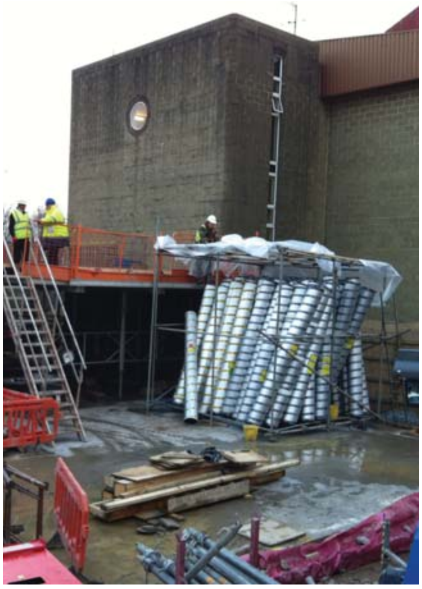
The design process began with an analysis of thermal performance of all building fabric and systematic approach of tacking elements in greatest need with the budget available. The building will be given a complete strip-down of all services and an extensive fabric upgrade, to bring it's performance in line with the low carbon extension.

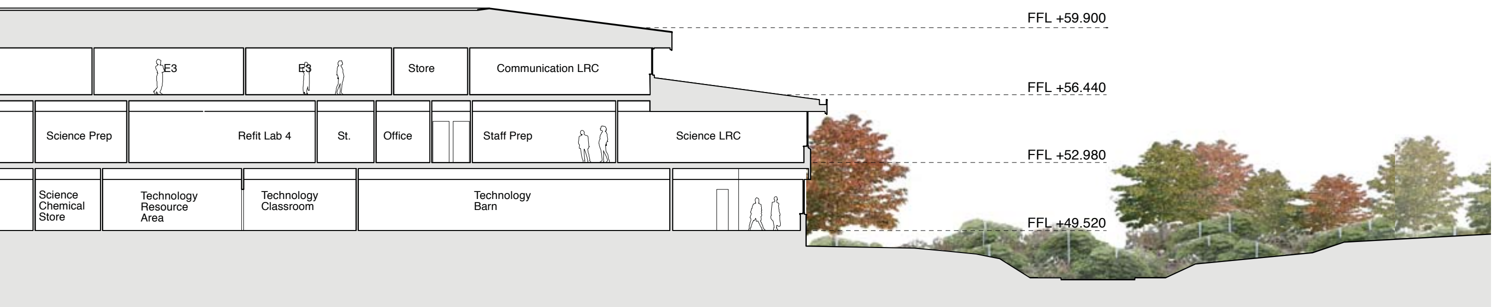
Fabric

U-values:
Roof: 0.18 W/m^{2}k
Walls: 0.17 W/m^{2}k)
Glazing: 1.15 W/m^{2}k








FFL +59.900
E3
E3
Store
Communication LRC
FFL +56.440
Science Prep
Refit Lab 4
St.
Office
Staff Prep
Science LRC
FFL +52.980
Science Chemical Store
Technology Resource Area
Technology Classroom
Technology Barn
FFL +49.520

Essential repairs to the existing roof will include it being overclad and insulated to a depth of 140mm bringing the U-value to 0.18W/m2k. Fibreglass panels below the windows will be retained in situ and reinsulated from the inside by blowing expanded polystyrene beads through precut holes. The blockwork cavity walls will also recieve this treatment, providing150mm depth of insulation to reach a target U-value of 0.17W/m2k. There will be a complete replacement of all glazing elements to bring their performance up in line with the new building. The same specification will be used throughout, of argon filled double glazing with solar controlled sunguard applied to south facing glazing.

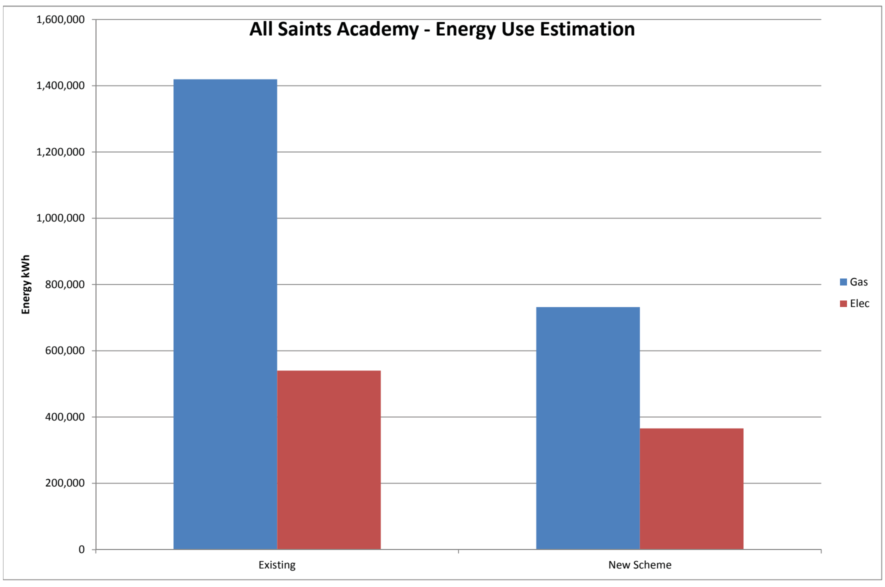
Systems

Heating:	Biomass
Hot water:	Biomass
Electrical:	Mains
Water:	SUDS

EPC Rating: B

There are several factors that contribute toward the decision to mechanically ventilate the main teaching spaces. Firstly, classroom spaces are fairly deep plan and there is little scope for retrofitting cross vent stacks over 3 floors. The location of opening windows is neither high nor low enough in the facade to encourage cyclic ventilation. On top of this, traffic noise form the adjacent road makes the reality of natural ventilation undesirable in acoustic terms. Installing mechanical equipment has brought some design challenges. The roof does not have the structural capacity to support centralised AHU system; therefore individual units will be fitted to each large teaching space, ceiling mounted between down-stand beams. These units will supply and extract with heat recovery to all principle teaching rooms. Smaller spaces will rely on natural ventilation through window openings.

A new overarching strategy for space heating will provide a combined system supplying both the retrofit building and new extension. A Biomass boiler will be installed running

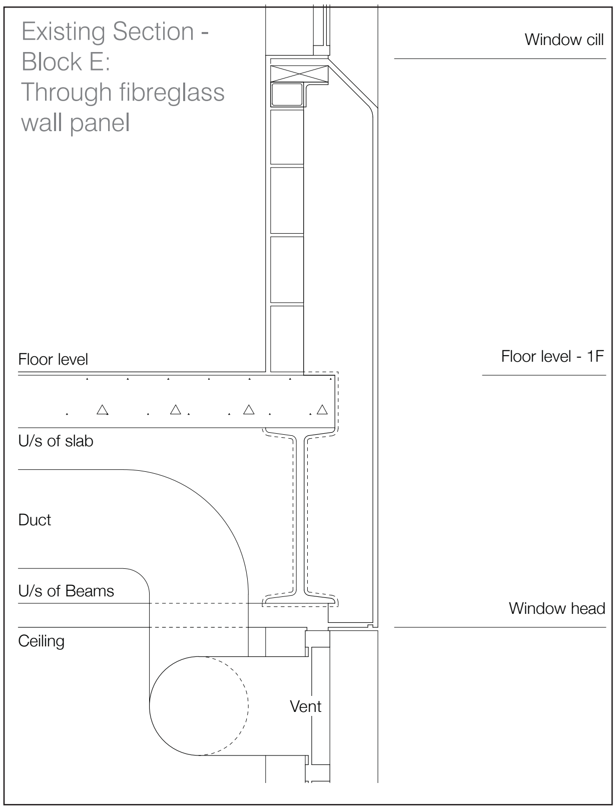


with gas backup, offering a wet system delivered through new radiators. Care has been taken to use existing service penetrations where possible although some cutting and making good is inevitable.

Because of the inherent spatial and servicing flexibility of 'L' block, it has been possible to include laboratory spaces and a kitchen in the retrofitted section of the building. There will also be heavy IT use, so supplying electrical, water and gas provision will be an important feature of the upgrade. The local electricity substation will require replacing because of increased electrical loading of building systems and electrical equipment used by the school.

'E' block has proved an ideal candidate for retrofitting. The building's qualities lie in its inherent structural longivity; its flexibility to adaptations to plan, use and to service requirements; with the outdated fabric proving simple to upgrade in thermal efficiency.

The strategic design and detailling decisions made at ASAP show how a low carbon solution has been achieved under budget restraints that reflect a new era in school commissioning. In the current economic climate, the project demonstrates an approach to providing improved school facilities that recognises a commitment to the low carbon agenda by prioritising fabic enhancement and making the most of existing assets. The retrofit means savings in embodied carbon of materials and constuction may be as great as 70%. A low carbon solution need not rely on design or technical innovation; this project demonstrates how essential good strategic decisions are.



Costs:

Contract Value:	£11 million
New Build:	£1058 per m2
Retrofit:	£700 - 800 per m2
GIFA:	9000m2 (combined new and retrofit)

Design Team:

Client:	Plymouth City Council
Contractor:	BAM
Architect:	White Design Associates
M&E:	Hoare Lea
BREEAM consultant:	Hoare Lea
Structural and Civil:	Hydroc
Landscape Architect:	White Design Associates

Architype, Hereford

Oak Meadow Primary School

Wednesfield, Wolverhampton

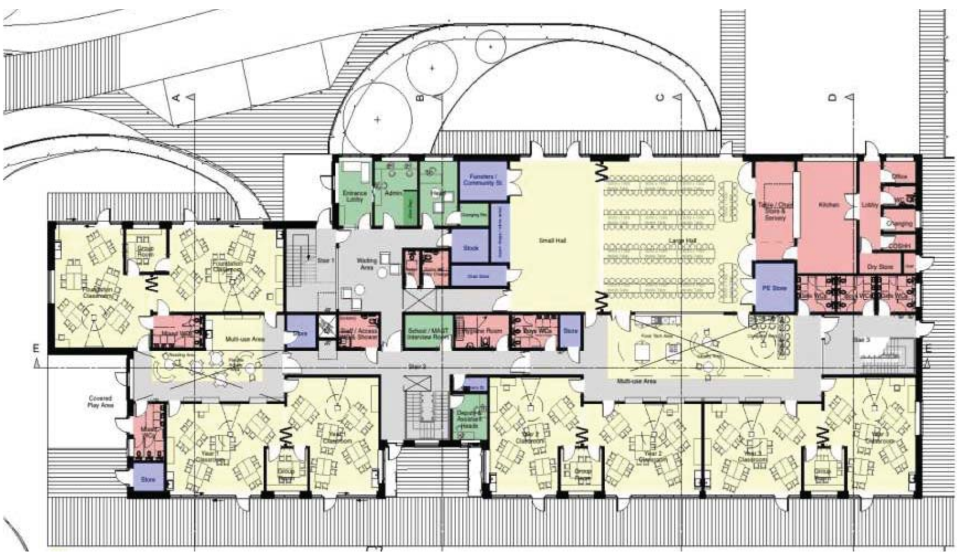
Oak Meadow Primary School in Wednesfield is amongst the first primary schools in the UK to be Passivhaus certified

Oak Meadow is a 2 form entry primary school, plus multi-agency support provision, serving 420 pupils in Wolverhampton. The project builds upon the practice's previous experience of completing St. Luke's Church of England Primary School (the first UK primary school to achieve BREEAM Excellent). The aim was to achieve a high standard of design quality while achieving Passivhaus, for an equivalent cost to standard (pre-James review) primary school cost estimates. The project is one of two Passivhaus certified schools completed by Architype for Wolverhampton City Council, along with Bushbury Hill Primary School and these, with Montgomery Primary School in Exeter by BAM Construction and NPS Group, were the first schools to be Passivhaus certified in the UK.

Why Passivhaus?

Architype suggested the Passivhaus standard to the client as an energy target, in order to reduce running costs and improve internal comfort. A major benefit of applying full Passivhaus principles to achieve accreditation is the quality assurance

First Floor



Ground Floor

procedure using the Passivhaus Planning Package (PHPP) from the outset. Whereas the Simplified Building Energy Model (SBEM) and Standard Assessment Procedure (SAP) are tools to show compliance with Building Regulations, PHPP proves the performance of the design and systems. There is a rigorous requirement for proof placed on the designer; PHPP calculations, air pressure tests, evidence that specified items were installed as intended (for example, windows and insulation) through delivery receipts and photographs. Thermal bridging calculations, and commissioning reports are all required to certify the building.

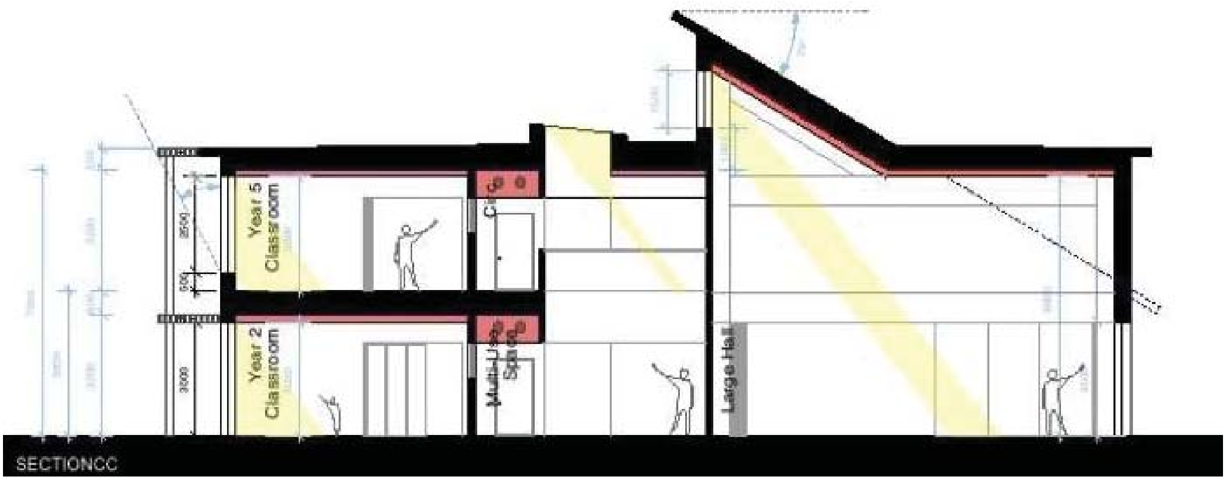
Achieving Passivhaus allows for an 80% reduction in energy use by adopting a passive and fabric-first design. This approach makes the building itself the primary source of energy savings, rather than relying on compensatory renewable technologies.

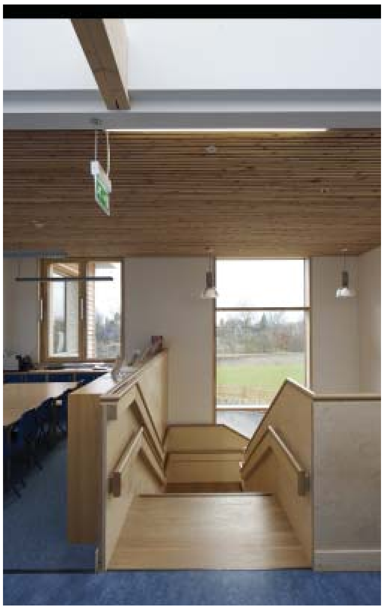
Passive Design:

Passivhaus ensures that the design of buildings is based upon fundamental principles of minimising energy consumption and increasing comfort such as the use of solar gain, daylight and a rigorous detailing of the fabric to prevent heat loss. Working within these fixed parameters allows the design team to focus on embodied carbon, construction methods and life cycle analysis. PHPP requires careful consideration of building form, orientation, fabric and detail to test and prove compliance. A compact form is often necessary to optimise the useful floor area to heat loss area ratio (form factor). As buildings become more spread out more heat loss occurs from the larger surface area. This applies equally in section as well as plan, often necessitating a 2 storey approach.

The plan is positioned on an east-west axis on site; classrooms are orientated mainly to the south to maximise on solar gain, whilst the least occupied spaces i.e. hall, kitchen, administration areas and main entrance occupy the north of the plan. Openings have been avoided at the gable ends of the building to prevent ingress of difficult to control east/west day light. A stepped section with clerestory glazing allows controlled southern light into the double height hall and central hub spaces.

The south facing facade consists of fixed glazing, opening lights and louvred insulated panels. Through PHPP analysis, optimum amount of glazing and ventilation panels have been designed in to achieve good daylight factors (20% of classroom floor area), daytime ventilation (5% of floor area) and night ventilation (1.5% of floor area).





Fabric:

U-values:
Roof 0.10 W/m²k
Walls 0.13 W/m²k
Floor: 0.064 W/m²k
Windows 0.9 W/m²k

Air permeability 0.48 $m^3/hr/m^2$@50Pa

The school is a two-storey timber-framed building with a 2,434m^2 floor area. The fabric is designed to meet the strict fabric performance requirements and 0.6 $m^3/hr/m^2$@50Pa airtightness limit imposed by Passivhaus. It incorporates high levels of insulation, timber-aluminium composite triple-glazed windows, curtain walling and is clad with British-grown Douglas fir boards.

The building sits on a concrete raft foundation which sits on and is fully surrounded by expanded polystyrene insulation, which is returned up to meet the wall insulation, eliminating thermal bridges. Below the slab, 250mm of EPS is installed in two staggered layers, while a 200mm insulated rendered upstand provides insulation around the slab. A two layer external wall consists of a 200mm external timber cladding and blown cellulose (from recycled paper) insulation "duvet", and an inner, thermally separate, structural zone consisting of an insulated, load bearing timber stud wall. The external duvet hangs from the structure using a Larson truss, minimising thermal bridges due to its high timber content, benefitting from its reduced thermal conductivity.

400mm deep timber framed roof cassettes are used for both flat and pitched roofs. These are fully filled with cellulose insulation.

Passivhaus airtightness targets required rigorous attention to detail in design and construction. Oriented strand board (OSB) with taped joints provides an airtight layer without the need for a continuous membrane. This layer is protected by a service void inside the wall finish, detailed to minimise penetrations. Airtightness tape is used where construction elements join to minimise air leakage, for example between the

OSB lining and floor slab, at window sill and head, and at the joints of OSB panels. Airtightness membrane is used around the perimeter of floor cassettes to ensure air cannot leak through the floor zone.

Windows are thermally broken, triple glazed, argon filled timber/aluminium composite units. Window design is optimised for both natural lighting and for day and night cooling. Large glazing areas reduce the frame area, reducing thermal losses. Windows were assembled in the UK using components sourced from the continent.

Other finishes were selected for their green credentials and include natural linoleum and recycled rubber floors, Fermacell wall linings made from recycled gypsum, cellulose and water, wood fibre and cement Troldtekt ceiling tiles and natural paints.

Systems:

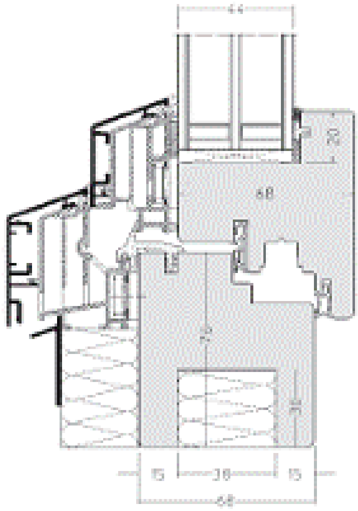
Heating: MVHR, gas condensing boiler
Ventilation: Natural ventilation & MVHR

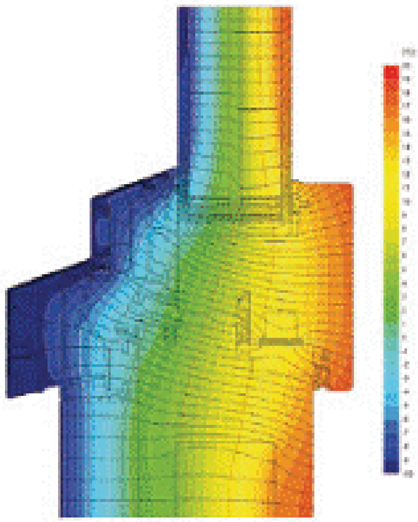
Heating Energy Demand: 15 kWh/m^{2}a
Primary Energy Demand: 113 kWh/m^{2}a (calculated)
Energy Performance Certificate: B(35)

Using Passivhaus standards for school buildings differs to the use for domestic projects; different, more complex issues arise due to greater numbers of people using the buildings at varying times. To resolve this, the building is designed to be lightweight and respond quickly to changing patterns of use, opening hours and climatic conditions. Combinations of manual and automatic ventilation controls provide user flexibility. Overheated and stuffy classrooms are traditionally cited as apparent contributors to the students' lack of focus; the aim at Oak Meadow was to ensure high levels of ventilation through a combination of natural ventilation and mechanical means.

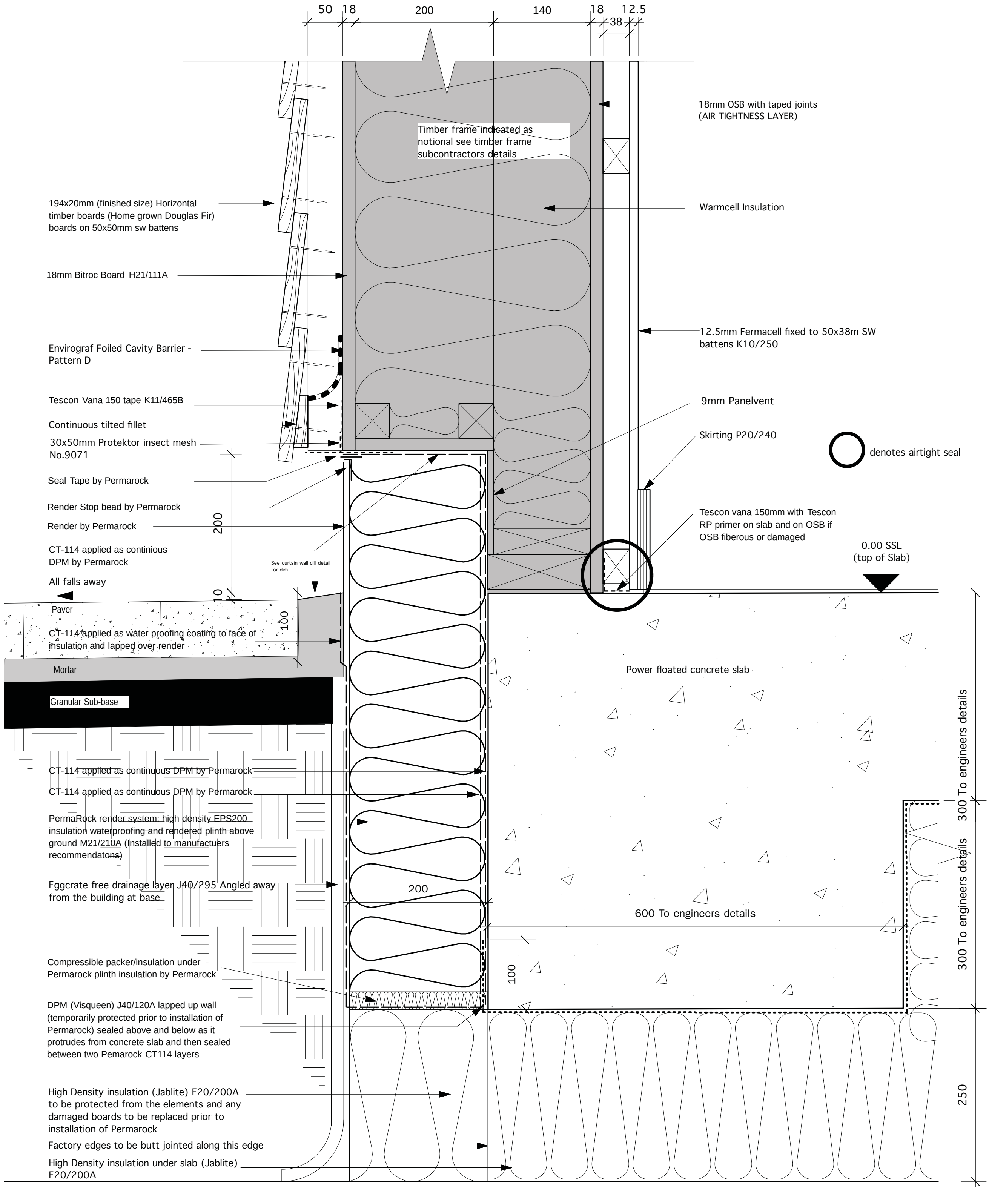
The ventilation system combines natural ventilation with a highly efficient mechanical ventilation and heat recovery system. Unlike the UK, many Passivhaus schools in Europe do not have kitchens, which reduces energy demand and difficulties of ventilation and overheating. A standard school kitchen requirement of two gas ovens and one gas hob requires a ventilation rate of 3600m^3/h. At Oakmeadow, switching to electrical appliances and, in particular, an induction hob, reduced the demand to 2400m^3/h. The induction hob also has a much lower radiant heat loss to the kitchen, allowing reduced ventilation rates to the kitchen generally.

Energy demand is reduced during the summer by using natural ventilation in lieu of the MVHR unit. Opening windows and secure louvre panels, activated by automatic and manual controls, generates cross ventilation from the classroom to the shared hub space via attenuated air paths which avoid excessive noise transfer. The stack effect draws hot air out of the hub at high level through actuator controlled openings. This method can also be used to cool th einternal spaces through night purging. During winter, the MVHR system supplies the classrooms and group rooms with fresh warm air, with CO_2 monitoring and control in the hall. Extract from the toilets and hub spaces is passed through a heat exchange unit to warm incoming fresh air. Generally, heating is sufficiently provided by internal gains (approximately one third of that required) and recovered heat (one third). Two domestic sized gas boilers with low temperature radiators provide the remaining additional quick response heat. The system is easy





AM Profiles window section and thermal performance



See Structural Engineers drawings for sub-bases, underslab insulation, slab and below ground drainage

Rev.	Note	Date	By	Checked
C5	Protektor added	15/3/11	tm	na
C4	Tescon tape revised	17/2/11	tm	lf
C3	Further to discussions with timber sub-contractor, panelvent omitted	13/12/10	jl	hm

FOR CONSTRUCTION

ARCHITYPE

Architype, Upper Twyford, Hereford, HR2 8AD
t 01981 542111 f 01981 542112 e west@architype.co.uk www.architype.co.uk

Project: Oakmeadow Primary School		Dwg Title: DPC Typical	
Client: Wolverhampton City Council		Dwg No.: **6320 DD 50**	Revision: **C5**
Drawn by: lf	Checked by: hm	Scales: 1:5 at A3	Date: 08 November 2010

to understand and can be controlled thermostatically on a room by room basis using TRV's. This system can respond quickly to changing conditions and occupancy, aided by the lightweight structure. If required, radiators can also be placed where they are least obtrusive as they do not need to be underneath windows. In classrooms, two switches control lighting levels, allowing lights closest to the whiteboards to be adjusted independently to those elsewhere.

Procurement

Oakmeadow and Bushbury Hill Primary Schools were procured under Wolverhampton City Council's £16.6m Primary Capital Programme and used the JCT Standard Building Contract with Quantities 2005, revision 2.

Achieving Passivhaus accreditation was added in as a requirement under the contract, however with no additional funding for Passivhaus available the school had to be delivered to an equal budget and timing as that of a typical school. Thomas Vale Construction were appointed through the OJEU tender process and their previous 5-year working partnership with Architype, which included the delivery of the BREEAM 'Excellent' St Luke's C of E Primary School, also in Wolverhampton, proved to be of great benefit. The partnership combined the expertise of both parties in developing a construction system which allows the flexibility of site-specific designs, while benefiting from standard techniques and good relationships throughout the process. Passivhaus was, however, a learning curve for the whole team; no one had undertaken a Passivhaus building before and taking on two schools simultaneously was an added challenge. To familiarise themselves further with the certification requirements of Passivhaus, the operational team went to Germany to visit the Pro Clima training centre to gain first hand experience of the methods required for details such as taping and sealing. Architype also use BIM in conjunction with PHPP to improve efficiency within the design process and improve collaboration, also allowing a visual interrogation of the building energy model and accurate reporting of live numerical data.

Construction

The construction team ran workshops throughout the build programme to determine and demonstrate best practice to the site teams. These would include subcontractors for the timber frame details, window and doors, roof details and M&E installations.

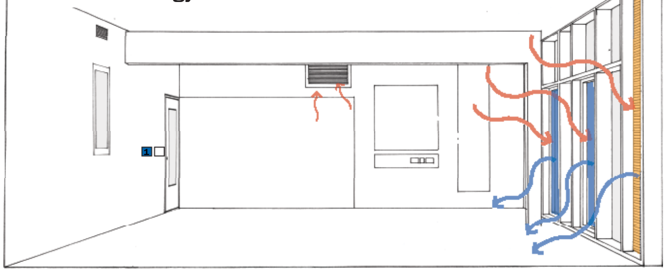
Intermediate air-tightness testing was carried out following installation of the timber frame, roof, windows and flooring, although the sequence of work was adjusted to allow early testing before first and second fixes. The initial tests achieved a score of 0.34 $m^3/h/m^2$@50Pa, which was better than required and the challenge was to ensure this was not compromised by the following subcontractors' works. Final test results were certified on 0.48 $m^3/h/m^2$@50Pa.

Cost

Oak Meadow was built for £2,045/m^3, only slightly more than Architype's BREEAM Excellent St Luke's School, which cost £2,030/m^3 (NB, based on total costs. Building only costs £1754/m^2). Using Passivhaus, additional costs are incurred through additional insulation, high performance triple glazed windows, tough airtightness targets and the need for an MVHR system. However, costs are reduced through the minimal heating requirements, no underfloor heating, simplified controls and no renewables. The M&E installation, excluding lift and sprinklers, represents approximately 21% of the contract value (contract build costs with preliminaries included), which is lower than the 23.6% figure from Davis Langdon's recent primary school cost analysis.

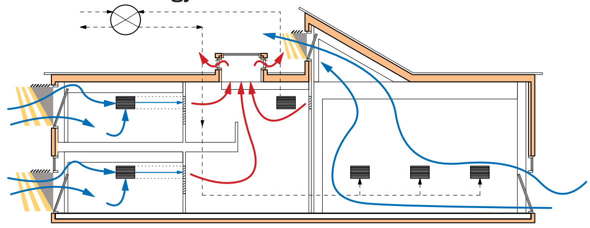
Summer:
The building is naturally ventilated and therefore supplied by fresh air from outside.

Classroom Strategy



Day	Night	Night
Electrically operated windows hot air out cool air in	Ventilation panel (opened at any time. opened automatically at night)	1 — Push button operated window panel control

Passivhaus Strategy



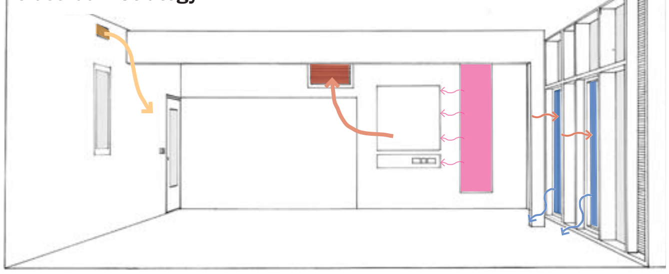
Heating:
The highly insulated building fabric keeps the building cooler during the summer.
Solar heat gain is controlled by the brise soleil.

Ventilation:
Summer cross ventilation is controlled by opening windows and ventilation panels.
Air from outside enters the classroom and passes through them into the hub space. Air leaves the building through high level vents in the hub space.

Heat exchanger | Air transfer duct | Locally controlled radiator | Ducted air | Cooling air flow

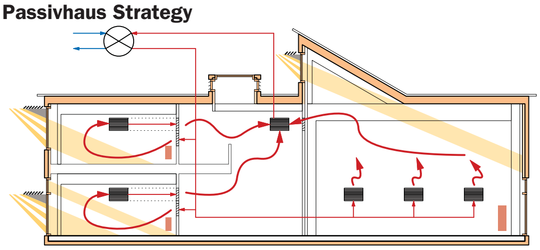
Winter:
The classrooms are supplied with a constant flow of pre-heated fresh air, which will keep the building at a fairly constant temperature.

Classroom Strategy



Fresh supply air	Radiator	Exhaust air	Window can be opened (when open heat will be lost)

Passivhaus Strategy



Heating:
Heat is contained within the building by the highly insulated airtight walls, and triple glazed windows. The building is heated by solar gains and radiators that can be individually controlled.

Ventilation:
A central heat recovery system supplies fresh air to classrooms via supply grilles, air is then extracted through grilles from classrooms to hub spaces.
Windows and ventilation panels can be opened to supply air direct from outside, however heat will be lost.

Warming air flow | Solar gains excluded | Beneficial solar gains | Sun angle

Teaching

Students and teachers from the existing school were involved throughout the process and undertook awareness-raising activities such as collecting newspapers which were then converted to cellulose insulation for use in the new building.
Both Architype and Thomas Vale Construction promoted a 'soft-landings' handover and met with the teachers and children on a regular basis througout the construction and continued to do so for the year after completion.

Findings

The scheme's success came from Passivhaus standards being integrated into a carefully considered design approach from the outset, with an enthusiastic client, by the appointment of a contractor committed to achieving the target, through teamwork and continuous and rigorous site inspection.
Although no funding was available for detailed post-occupancy modelling, indications are that energy demands are as predicted, with 90% less gas consumption and heating demand than the old school, while capital costs are comparable.

Design team:

Architect: Architype
Client: Wolverhampton City Council
Passivhaus consultant: Elemental Solutions
QS :Smith Thomas Consult
M&E engineer: E3 Consulting Engineers LLP
Structural engineer: Price & Myers LLP
Acoustic consultant: Ion Acoustics
Passivhaus accreditation: WARM: Low Energy Building Practice
Contractor: Thomas Vale Construction
Landscape architect: Coe Design Landscape
Timber frame sub-contractor: Cygnum
Window/curtain-walling subcontractor: AM Profiles
Airtightness tapes: Ecological Building Systems (Pro Clima)

Started on site: September 2010
Completed: October 2011 (external works March 2012)

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Images: With thanks to Architype and AM Profiles

The timber frame construction on site (right, top to bottom, and incorporation of services, below.

Dietrich Untertrifaller Architects, Bregenz, Austria

Secondary School, Klaus-Weiler-Fraxern

Vorarlberg, Austria

The first PassivHaus accredited school in Austria, reducing energy demand by 75%

A timber-framed secondary school designed to house 350 pupils from within the Rhine River valley municipalities of Klaus, Weiler and Fraxern, and incorporating a communal library. This was the first school in Austria to be designed to Passivhaus standards. It was procured via a 2-stage competition organised in 2001 by the local authority, aiming to improve upon the excessive operating costs of the poorly insulated concrete-framed existing school, which was commissioned in the 1970's.

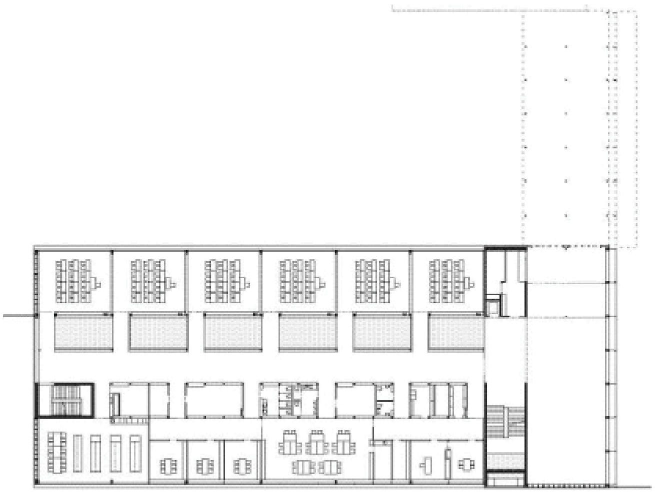
The school cost around 3% more to build than a standard school building at the time, but energy use is cut by approximately 75%.

Passive Design:

An L-shaped block contains the classrooms, double-height assembly hall, main entrance and upper level communal library, with the classroom and atrium areas designed to Passivhaus standards and the hall and library to low-energy standards. The hall and library address the main road and create a public square. The classrooms sit behind, sheltered from the noise of the street, and face east and west, running in parallel along a three storey north-south atrium, which allows daylight through the centre of each storey. A wide central corridor is open to the atrium and contains a zone of services such as WC's, storage and escape stairs. It also acts as a gathering and social space for the children during breaks.

General classrooms face east and are accessed via individual bridges across the atrium void, which have glazed balustrades to allow more light in to the corridors and provide pupils with views along the length of the atrium. These classrooms have high level glazing on the atrium wall to allow light from both sides in to each classroom.

Opposite:
A view through the central atrium with glazed balustrades.



Ground floor

First floor

Special purpose classrooms and administration rooms face to the west and are sheltered from the noise of the main corridor by the services zone. The lower floor level of the atrium zone is covered by a wide bed of gravel, which delineates a ‘no-go’ zone to deter children from dropping objects on to the activities below, without requiring walls or a balustrade which could lessen the light at lower ground level.

The assembly hall and library benefit from large glazed areas which face south and therefore require shading to prevent excessive overheating. In order not to compromise the view, instead of louvers a full height corrugated copper screen sits on a lightweight steel frame 50cm away from the glazed façade. The screen is perforated with an open area of 30% and acts as a ‘veil’ to shade the glazing but still allowing views out to the landscape. Externally, during the day this screen appears to be solid, providing privacy to the school activities, while during the evening a filtered view of the lit interior is afforded.

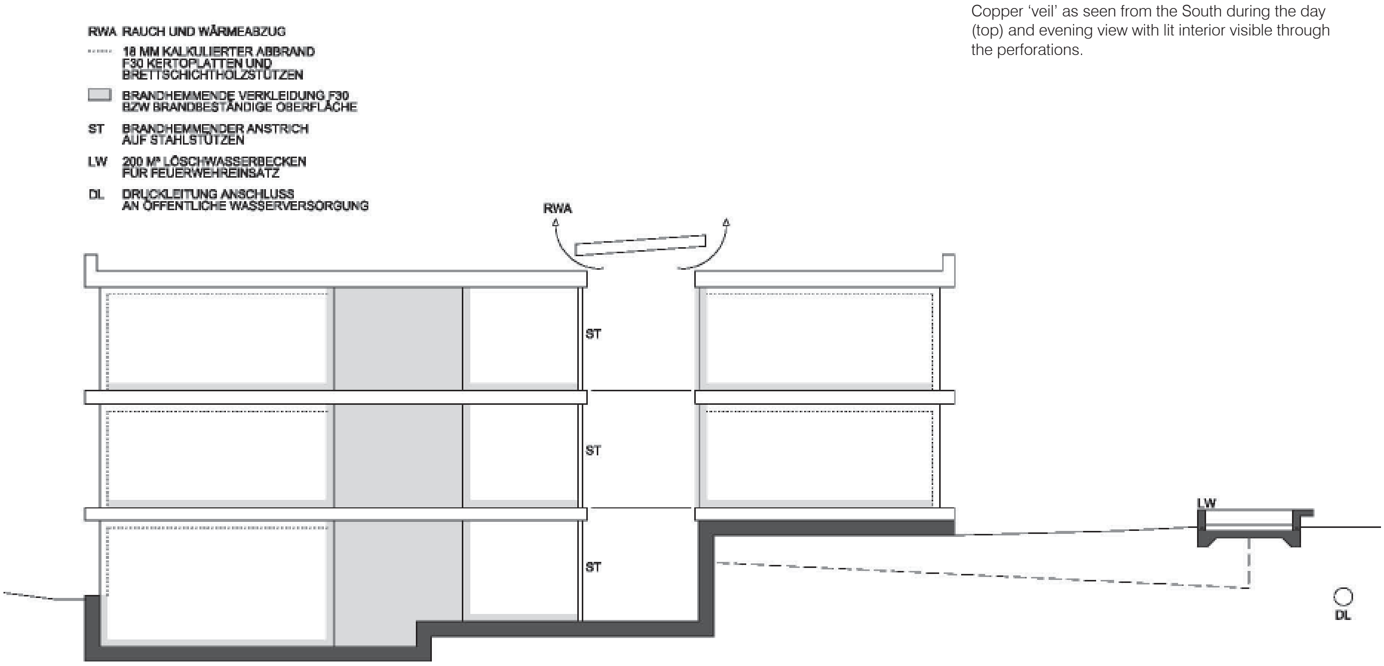
The east and west facing classrooms are provided with automated external blinds which can also be manually operated if required. Lower level openable windows are placed at seated eye level and are recessed from and shaded by the main elevation. Natural ventilation through the atrium is achieved through openings at rooflight level which operate via ceiling level sensors and the building is sprinklered throughout. A long pool stretches in front of the eastern façade and creates an attractive feature reflecting the building and surrounding light but also serving as part of the specific fire control strategy.

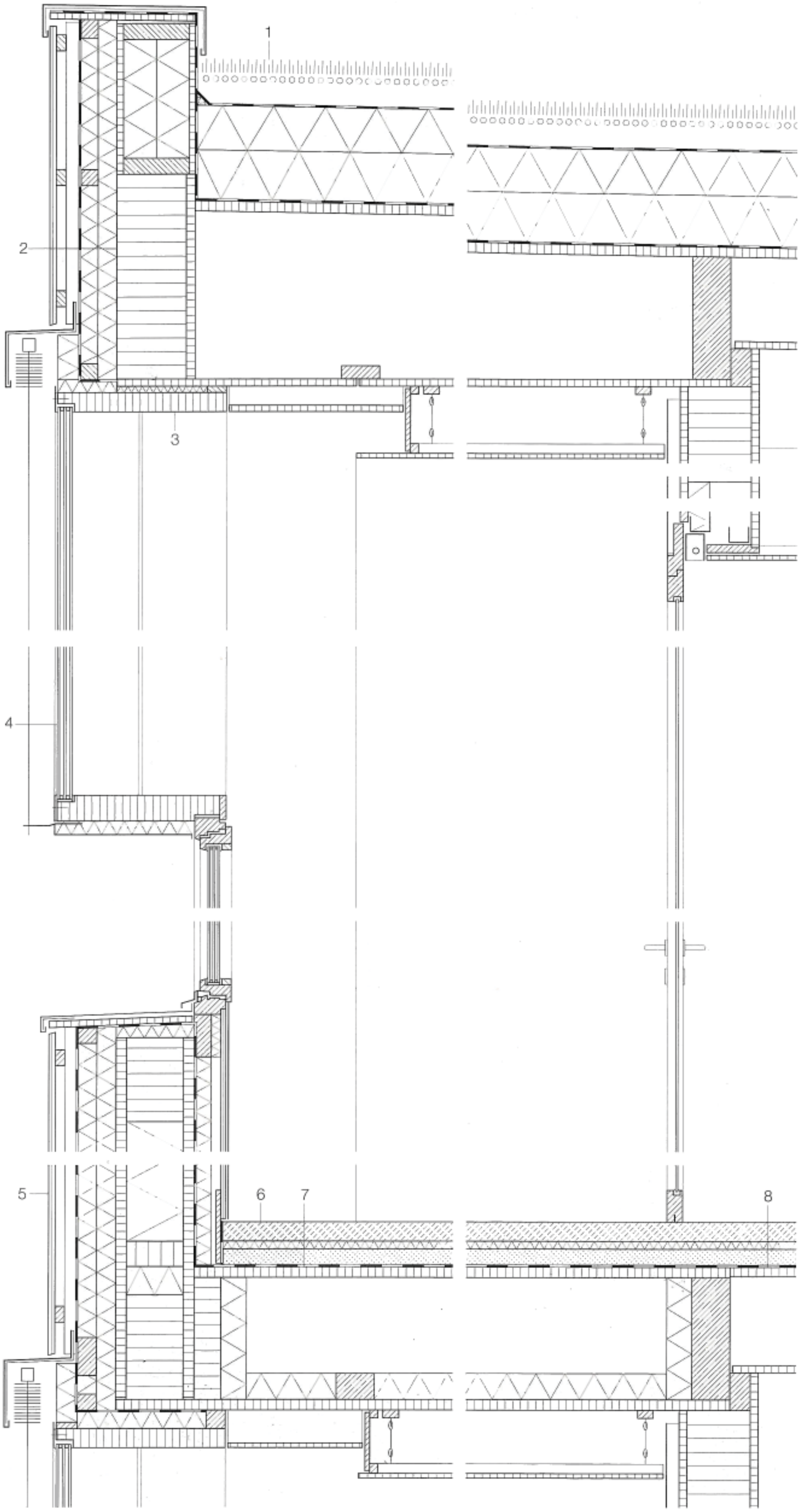
Fabric:

U-values:
Roof 0.11 W/m²k
Windows 0.6 W/m²k (fixed) and 0.76 W/m²k (opening)
Walls 0.11 W/m²k

Air tightness (measured): 0.6 1/h
Heating Energy Demand: 11.4 kWh/m²a

Copper ‘veil’ as seen from the South during the day (top) and evening view with lit interior visible through the perforations.





1 100 mm extensively planted layer
three-layer bituminous sealing membrane
300 mm rock-wool thermal insulation
vapour barrier; 22 mm oriented-strand board
520–380 mm laminated timber beams to falls
22 mm oriented-strand board
12 mm birch plywood suspended soffit
2 220/640 mm laminated timber edge beam
3 540/60 mm laminated timber lining to reveal
4 triple glazing (U = 0.6 W/m²K)
5 20 mm natural silver-fir boarding on
30 mm battens and 40 mm counter-battens
windproof layer; 2x 40/60 mm halved bearers with
rock-wool insulation
33 mm laminated construction board
180 mm rock-wool insulation between
180 mm laminated timber beams
33 mm lam. construction board; vapour barrier
50 mm rock wool between 84 mm battens
35 mm cavity; 12 mm birch plywood
6 3 mm sealed epoxy-resin floor finish
60 mm screed on 25 mm impact-sound insulation
50 mm stone chippings
7 33 mm laminated wood sheeting
100 mm rock wool between
80/380 mm laminated timber beams
33 mm laminated wood sheeting
12 mm birch plywood suspended soffit
8 30 mm oriented-strand board
80/280 mm timber joists
22 mm oriented-strand board
9 laminated wood sheeting, impregnated

To facilitate a quick timescale from competition selection to completion, a prefabricated timber structure was constructed using locally sourced Silver Fir supplies. These lightweight timber box-structures sit upon a basement level of concrete, which was poured in-situ and avoided the need for costly pile foundations. The building design is compact with a repeated structural system which is highly efficient and allowed for economies during construction and future maintenance. The large open areas of the assembly hall and entrance are constructed in laminated timber beams and columns which also support the fully-glazed south façade.

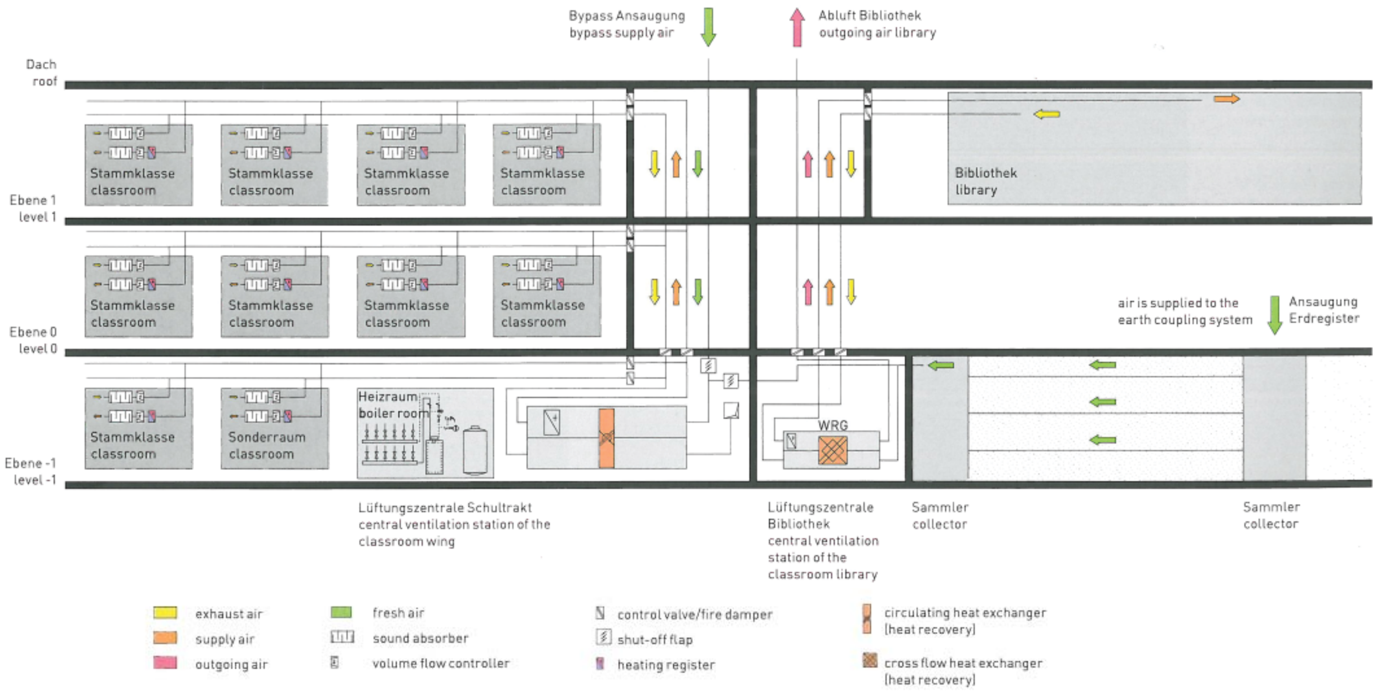
Walls are insulated with 180mm rockwool sandwiched within the timber frame zone, with an additional 2 layers of 60mm rockwool between the external timber battens, and then a continuous vapour barrier and a further 50mm insulating layer between internal battens. The roof is insulated with 300mm rockwool and then finished with a 100mm planted roof which collects water for reuse.

Windows are triple glazed to all sides, including the rooflights.

Systems:

Heating: Ground Source Heat Exchanger, MVHR, gas condensing boiler back up
Ventilation: MVHR
Electrical: 240m² Photovoltaic panels
Water: Rainwater harvesting for sprinkler system

Alongside the automated shutters, the classroom and atrium areas benefit from a MVHR system that heats or cools as required, with about 85% of heat being recovered from the exhaust air, and includes thermostatic controls to each classroom. Air is



background heated in winter or cooled in summer to 18 degrees Celsius via a ground source heat exchanger of 27 polyethylene pipes at 400mm diameter and 26 metres long each. Additional heating can be provided using a condensing gas boiler and the intention is to replace this with a wood-chip biomass boiler and the fittings were installed at the outset.

240m² of photovoltaic panels provide 20kWp which is fed back in to the grid and provisions are in place to connect the water system to solar collectors.
The assembly hall and library are equipped with underfloor heating, providing low temperatures which also aid the drying of the entrance area if conditions are wet outside.

Rain water is collected and used to further supply the sprinkler system with the external feature pool assisting the fire fighting strategy.
The whole building is monitored and controlled by a building management system (BMS) to ensure optimal efficiency of all systems.

Construction

The detailed design and construction period was only 18 months, a record-breaking time for this building type within Austria.

Project details

Area: 4520m²
Competition selection: 2001
Construction: 2002-2003
Cost: 7.3m Euro (£6.3m)

Design team:

Architects: Dietrich Untertrifaller Architekten
Concrete structural engineering: Mader-Flatz, Bregenz
Timber engineer: Merz-Kaufmann, Dornbirn
Building Technology: Gludovatz IGT, Hohenems
Building physics: Bernhard Weithas, Bregenz
Landscape architect: Rotzler-Krebs, Winterthur
Acoustics: Karl Brüstle, Dornbin
Electrical engineer: Andreas Hecht, Rankweil
Fire consultant: BS IBS, Linz

References:

Dangel, Ulrich. 'Sustainable Architecture in Vorarlberg. Energy Concepts and Construction Systems'. Birkhauser Verlag AG 2010. page 124-131.
Zschokke, Walter. 'Dietrich Untertrifaller: Buildings and Projects since 2000'. Springer Wien New York 2008.
'Techniques & Architecture; Bois 1 Structure Timber' Issue 476, February/March 2005, 'Pragmatic Sobriety' pg. 37-41.
'Detail: Timber Construction'. January/February 2004, 'Secondary School in Klaus' pg 65-69.

All images: Dietrich Untertrifaller Architekten website, Bruno Klomfar

Paxton Primary School by Sunesis

A multiple form entry standardised school based on award winning designs by White Design.

The fluctuating rate of the UK's school building program witnessed since the turn of the century has led to an increased demand for standardised design in the educational building sector. A number of experienced education sector contractors have subsequently entered the market with pre-engineered and typically pre-fabricated solutions.

Scape is a Local Authority controlled company formed with the objective of bringing economy and efficiency to the build process through standardisation. Their product is Sunesis, formed in partnership with Willmott Dixon. It comes as a response to the Government's drive to improve and increase the country's stock of schools, despite tighter budgets and shrinking council teams. Partnerships like Sunesis offering standardised solutions claim advantages for clients such as a streamlined procurement process, certainty of a fixed cost and predefined time scale; value through reduced costs and faster builds. They claim up to 35% price reduction and 12 month programme reduction through the use of their standardised school design package.

Working with a number of architects and consultants, Sunesis have developed a range of standardised schools, each with potential to tailor to the Client's needs and budget. Recent recommendations of the James Review of Educational Capital shine fresh light on the potential benefits of the standardised approach, both for funding bodies and users alike.

'[It can] provide high quality teaching spaces that are fully and very cheaply adaptable to suit particular needs, and the use of widely available, off-the-shelf materials means that prices can be negotiated hard.'

Sunesis currently offer 4 standardised primary schools and 1 secondary school model. Each offers adaption for alternative student population sizes, including the addition of nursery rooms. With each selection, the respective costs are published up front. This is a key aspect of the company's selling point, giving absolute guarantees of quality, costs and timescales, removing client risk.

Standardisation and low carbon buildings

Standarisation brings some clear advantages to a low carbon agenda. Many clients aspire to make sustainability a feature of their school building, and cite low future running costs as an important consideration. Yet with the more typical process of developing design individually with clients, it can be difficult for clients to navigate all implications of those necessary yet complex decisions. The decision making process results in inevitable compromises too often at the detriment of low carbon design. By offering pre-designed, fully-costed solutions, a client can 'choose' its level of commitment to low carbon design without future compromise.

The standardised approach also offers more opportunity to incorporate off-site fabricated elements into the design. The low carbon advantage to offsite fabrication is well researched - benefits such as enhanced quality achievable factory conditions can ensure improved air-tightness detailing and thermal performance. Thermal and acoustic performance is very dependent on the quality of workmanship and supervision - defects and testing are easily managed in factory conditions. More offsite procedures makes construction less dependent on weather, reducing generation of site waste through damage and defects. It has been estimated that about 13% of materials delivered to site are never used but go straight into the waste stream. Shorter and simpler build-times also reduce impacts such as pollution, noise and disruption to local communities and schools operating alongside the construction site. Another potential advantage is that with factory produced repetition and mass production comes opportunity for increased material and resource efficiency, a firmer control over the supply chain, responsible specification and significant reductions in embodied carbon. As with all mass produced solutions, some of these advantages do not become apparent until a standardised system has been effective for a number of years.

However, the non-site specific design approach of standardising school design places uncertainty on the building's potential to respond efficiently to its environment. A common approach to low carbon design, including in the case of the Government's Baseline school designs, is for buildings to analysed based on optimal site arrangements, claiming a level of performance that is often difficult to recreate in reality. Can a standardised design respond directly to environmental factors such as wind direction and speed, precipitation, exposure and sun angle? The success or failure of a building for end users is often reliant on many location factors such as views, gradient and important neighbourhood features, such as shops, bus stops or major pedestrian routes. All these factors should be considered by design teams and could be argued to have effects on the societal and behavioural aspects of the local community, with potentially significant impacts on carbon.

Sunesis have spent several years developing their school design options, each prioritising different design criteria. In the case of the Paxton School, Sunesis have adopted a tried and tested solution, previously applied in the design of Ynysowen and Kingsmead Primary Schools by White Design Associates. Sunesis cite a "low embodied energy school that is beautiful, flexible and sustainable", with natural ventilation and daylighting. It is rated BREEAM 'excellent'.

Development of the 'Paxton'

Sunesis is the brand collaboration of Wilmott Dixon and Scape, a local authority controlled company owned by the city and county councils of Derby, Nottingham, Gateshead and Warwickshire.

Following Willmott Dixon's shared history with White Design Associates on delivering primary schools, White Design were appointed to develop one of the standardised proposals, and the Sunesis 'Paxton' school is the result. The model is an interpretation of White Design's original iconic Kingsmead School in Cheshire, and the further modifications found in scaled-up versions such as Ynysowen Primary in Aberfan, Merthyr Tydfil. The Paxton has many similarities with these schools and captures much of the complex thinking that went into the original designs, benefitting from the successful elements that have been live-tested during the earlier builds, also able to select features that are appropriate for a standardised approach.

With no live local education client, design decisions have been based on core criteria and on White Design's past experience of developing a brief with school staff and stakeholders. In the case of Kingsmead Primary, this client team was well informed and well organised to deliver a brief that firmly placed low carbon considerations at the heart of the design - so the project benefits from this previous investment in high quality design consideration and procurement management. Whereas the development of Kingsmead took an intense five month period, when a client engages with the Sunesis process, four weeks is all that is required for the whole design and procurement process, with one two-hour meeting, minimal technical expertise or previous client knowledge and no upfront cost (except site surveys) until the planning stage.

This streamlined process involves a box-ticking exercise with the help of online plans. This enables commissioners to configure the school interactively using a range of pre-designed, fixed-price options. Some low carbon features celebrated in previous WDA school designs at Kingsmead and Ynysowen can be found in this optional list. It is hoped that the advantages the optional extras bring are fully understood and considered by commissioners.

Education: Primary

sunesis paxton

Sunesis Paxton is based on an award-winning, tried and tested design, creating a low embodied energy school that is beautiful, flexible and sustainable. The building uses natural ventilation in the principal teaching areas and roof lights provide high levels of daylight to spaces at the centre of the plan. It is available in 1.5 and 2 form entry and the building's Glulam frame makes it easy to extend in the future. All teaching spaces have been designed to meet BB99 area requirements.

Sunesis Paxton Primary Schools are currently available in two single storey model variants with a separate nursery offering:

- **1.5 Forms of Entry**
- **2 Forms of Entry**
- **26 place Nursery**

Contact Sunesis

For further information or an initial discussion, please call 0845 475 5678 or contact tim.carey@sunesisbuild.co.uk

Sunesis Paxton schools will deliver:

Cost certainty and excellent value for money

BREEAM excellent as standard with low embodied energy

Beautiful, flexible and sustainable design

Excellent teaching accommodation and efficient internal layouts

Easily extendable design to allow future growth

Pricing and Programme

1.5FE
Cost: £3,700,000
GIFA: 1,539 m²
Min site area: 11,000 m²

2 FE
Cost: £4,200,000
GIFA: 1,915 m²
Min site area: 12,900 m²

Nursery
(Built concurrently)
Cost: £440,000
GIFA: 152 m²
Min site area: 417 m²

Programme

Preconstruction: 16-20 weeks
Construction: 1.5 FE: 41 weeks **2FE:** 44 weeks
Nursery built concurrently

All models include:

- BREEAM excellent
- Multi purpose hall
- Kitchen and dining facilities
- Open areas for LRC
- Group spaces
- Administration areas
- External hard games area
- Car parking
- Secure perimeter fence

sunesis education

www.sunesisbuild.co.uk

Design Standards

BB99 Briefing Framework. Guidelines achieved for teaching spaces

BB93 Acoustic. Full compliance achieved

BB90 Lighting. Full compliance achieved

BB101 Ventilation. Guidelines achieved for classrooms

External Specification

The external environment provides a valuable learning and teaching resource and significantly effects the quality of education. Sunesis Paxton includes many carefully designed external spaces which are all in line with BB99 recommendations. These are:

- Grass sport pitches
- Soft play areas
- Hard play areas
- Multi use games area
- Habitat area
- Car parking
- Segregated nursery area where required

Key Accommodation Areas

All models achieve the following areas with the teaching spaces meeting BB99 Guidelines.

Internal	1.5FEN	2FE	NURSERY
Nursery - Teaching / Play			78 m²
Reception Class	100 m²	72 m²	
Infant & Junior	60 m²	60 m²	
Hall	187 m²	187 m²	
Studio	60 m²	60 m²	
Kitchen	60 m²	85 m²	
External	**1.5FEN**	**2FE**	**NURSERY**
Pitches	6,300 m²	8,400 m²	
Soft play (Informal & social)	1,588 m²	1,850 m²	140 m²
Games Courts (hard surfaced)	1,230 m²	1,440 m²	
Hard Play (Informal & social)	873 m²	1,030 m²	94 m²
Habitat Area	515 m²	620 m²	26 m²
Car Parking - Number spaces	21	24	

Each teaching space has its own dedicated storage space. Toilet provision is provided adjacent to each classroom with early years having direct access.

Key Specification

Structure:	Glulam standard frame with a cost option saving for a lightweight steel frame.
External Envelope:	Rendered Insulation as standard with feature timber cladding and exposed Glulam.
Windows:	Aluminium windows and curtain wall.
Roof:	Warm insulated membrane roof incorporating roof lights.
Internal Walls:	Metal stud and plasterboard with severe impact resistance.
Doors:	Solid core heavy duty, either solid or with glazed vision panel.
Ceilings:	Plasterboard ceilings in classrooms with lighting rafts. Corridors a combination of acoustic planks and plasterboard. Hall acoustic impact resistant tiles with plasterboard. Kitchen acoustic hygiene tiles.
Floors:	Classrooms split of carpet and vinyl. Corridors vinyl. Wet areas will have slip resistant vinyl. Hall will have cushioned vinyl.
Walls:	All general walls will be painted with vinyl matt emulsion.
Heating:	Wet under-floor heating.
Ventilation:	Generally natural ventilation with mechanical ventilation in WCs and similar spaces.
Toilets:	White vitreous enamel, sized for age group.

How to order – the streamlined route to success

Enquiry

Cost:
FREE

1 Consultation

1 week

Cost:
FREE*

Key Tasks:
Meeting to understand requirements, site information, availability and need.

*excludes site survey costs

2 Appraisal

3 weeks

Cost:
FREE

Key Tasks:
Design options along with costs, programme and risks agreed.

Business case feasibility tested at this stage.

3 Planning

12 weeks

Cost:
£30,000**

Key Tasks:
Planning submitted and costs confirmed.

**excludes Local Authority Planning Application fee

4 Contract & Build

from 26 weeks

Cost:
40% of total cost on signing contract.
75% of total cost half way through build.
100% of total cost on construction completion.

Handover

Key Tasks:
- Training of staff
- Enjoy the building!
- 12 month review

Contact Sunesis

For further information or an initial discussion, please call 0845 475 5678 or contact tim.carey@sunesisbuild.co.uk

www.sunesisbuild.co.uk

Other models in the Primary School Range

sunesis keynes
sunesis newton
sunesis dewey

sunesis™ A joint venture
Scape
WILLMOTT DIXON
T: 0845 475 5678 | www.sunesisbuild.co.uk

v3 0113

Scape System Build Ltd is a Local Authority controlled company.

Specification selection
http://www.sunesisbuild.co.uk/

Site and layout

From the suite of primary schools available from Sunesis, the Paxton has been developed for schools without tight site constraints, requiring an area of about 11,000m². This allows full provision of external sports pitches in line with BB99. It enables the school building to be located on most sites at the optimum orientation for natural passive environmental systems incorporated in the building. The crescent shape of the Paxton and its predecessors was originally designed to respond to sun angles and to take advantage of favourable north light to illuminate the principal teaching spaces.

Part of the process of adapting earlier designs for standardisation was to test the building's performance by running a thermal model through a variety of simulated orientations and geographical locations throughout the UK. Designers have made necessary tweaks to fabric makeup and detail to ensure that the Paxton would perform thermally in all orientations. There is a definite sense of 'front' to the design that could require the building orientation to adjust to address the site entrance.

The single storey school can be a 1.5 form or 2 form entry type with an optional standalone nursery. The Paxton has been designed to a much smaller area than the precedent schools, resulting in the omission or reduction of the generous additional learning spaces which do contribute to the success of Kingsmead and Ynysowen. Cloakrooms, storage spaces and toilets have been reduced in number and located to one side of the central corridor. Winter gardens - or ancillary spaces to act as draft lobbies and additional teaching spaces appear in the list of extras. The Paxton model has an extremely efficient new overall floor area, approximately 11-12% lower than those recommended in the Building Bulletin 99 guidance.

1.5 FE entry Paxton Floor Plan

Costs

The fixed price of £3.4m for a 1.5 entry school includes solar voltaic panels, all external works and sports pitches, and is a turnkey solution. To include the energy saving features that would enhance the building's low carbon performance would typically add £67,500 to the budget. For example, the advantages and potential energy savings from selecting the automated BMS window system option would make an additional £18,000 very well spent. In all, with these enhanced features, the offering is £3,785,500 - coming in at approx £12,100 per pupil entry (315 pupils) and for the larger 2FE version, approx £10,300 per pupil entry (420 pupils).

Construction

The model strives to use natural sustainable materials and construction techniques wherever possible, with the design team carefully assessing both the materials in construction and at the end of its life. The school uses timber extensively in its structure and fabric - the result is a building with low embodied carbon with many tonnes of CO_2 sequestered in its structure. The distinct cedar clad appearance of the earlier schools has not survived the standardisation process - Paxton offers a rendered version as standard although cedar cladding or brick infill in available at extra cost.

The scheme is constructed from a system of paired arched glulam timber frames. The arched glulams are arranged back to back to give an M shaped section, and situated at 5m centres, each offset by 4 degrees to form a gentle crescent in plan. The structural system is easily replicable for future extensions. It allows all internal walls to be non–load bearing ensuring future flexibility and adaptability within. During adaption as a standardised offering, the team decided against the option of replacing glulam with steel or timber frame. The strong structural expression gained from the glulam and the benefits from using natural materials with high embodied carbon countered any cost benefits.

The Paxton model deviates from its predecessors by replacing internal blockwork walls with lightweight timber stud or metal stud and plasterboard. This modification decreases site time and contributes to the rapid speed of build. The loss of thermal mass that the internal block work would have provided is not significant because of the quantity of thermal mass exposed in the flooring.

Fabric

U-values:

Glazing:	1.85 W/m^{2}k (double glazed units)
Roof:	0.16 W/m^{2}k
Floor:	0.18 W/m^{2}k
Walls:	0.17 W/m^{2}k
Air permeability target:	3m^3/(hr.m^2)@50Pa

Design Team

Commissioner:
Scape and Willmott Dixon
Architect: White Design Associates
M&E: Mott McDonald
BREEAM consultant: ReThinking
Structural and Civil: Integral
Landscape Architect:
White Design Associates

Energy

The M shaped section generates a butterfly roof form which is integral to the building's sustainable measures. The resulting shape of the teaching spaces - high external wall with the ceiling profile sloping to the central core of the school - provide a form that is critical to both natural ventilation and daylighting strategies. The high external facade has both low desk level windows and high, clerestorey level windows. This fenestration arrangement promotes maximum levels of daylighting without risk of overheating or glare. Additional rooflights provide comfortable levels of natural light to the inner areas of the classrooms, allowing a deeper plan. They are fitted with motorised blinds to prevent unwanted glare.

Natural ventilation is aided by high level openings on the facade and through rooflights. The optional 'intelligent' Building Management System, capable of making tiny adjustments to clerestorey window openings and rooflights to regulate ventilation levels, seems an important feature. BMS responds to continuous environmental feedback and includes features like an automatic 'pulse' facility to provide a fresh supply of air at the beginning of the school day and during breaks in teaching sessions. It safeguards against that typical pitfall of natural ventilation strategies that fail because too much monitoring and intervention is expected from building users. A third option is a CO_2 level monitoring system that indicates to building users that more ventilation is needed.

The butterfly roof form meets over the central circulation corridor in a central valley gutter, significantly reducing the need for external guttering and downpipes. If the client chooses optional rainwater harvesting, this central valley gutter can provide up to 32% of the building's water demands serving toilets and urinals. In Kingsmead, downpipes for rainwater harvesting are translucent and exposed within the school, which means the reuse of the rainwater becomes a story that the building physically demonstrates every time it rains, adding to pupils resource awareness and learning. Can the thinking that goes into producing a building with such an intimate relationship with its enduser survive a standardised approach? It is interesting to look in some detail at the thinking and innovation that went into non-standardised design precedents upon which the Paxton was based.

Systems

Heating: gas boiler with underfloor heating
Ventilation: naturally ventilated classroom; intelligent BMS control as optional extra
Electrical: solar photovoltaics
Water: rainwater recycling as optional extra. Solar hot water provision as optional extra.

Anticipated Heating Energy Demand: $kgCO_2/m^2a$ (to be confirmed)
As designed BER: 9.4 $kgCO_2/m^2a$
As design EPC rating:

BREEAM rating: indicative 'excellent' - as the building is not yet sited, some assumptions have had to be made about the specifics of the site.

Area: 1888m^2 (1.5FE)
completion date: Sunesis launched the Paxton in Sept 2012
cost: £3.4m basic (for 1.5FE), up to £3.8m with additional energy enhancing packages

Kingsmead Primary School, Cheshire

The first in a series of primary schools where ideas that led to the development of the 'Paxton' for Sunesis were born.

White Design's first school design commission in 2003 was Kingsmead Primary, in Northwich, Cheshire. The outcome set the standard and direction of many following commissions for White Design - of which the Paxton' is the latest incarnation. Completed in July 2004, Kingsmead has since been recognised as an exemplar of environmental design. The 150 pupil school is a single storey crescent shaped building consisting of 7 classrooms situated in a North facing convex arc, with associated group rooms and support spaces, a library, administration area and a hall situated in a concave arc to the south.

The sustainability brief for the new school stemmed from the Council's frustration at a lack of progress in applying their sustainability agenda on recent projects, with one example showing that materials for the build had been transported a total of 250,000 construction miles. The council subsequently entered into a partnering agreement with Wilmott Dixon, whom in turn appointed White Design Associates, Arup as Services Engineers and Mander Structural Design, to provide a complete Design and Build Package. The Headteacher at Kingsmead haboured a strong commitment to sustainability, and as a team all parties were able to develop a scheme inline with their aspirations and set a new standard for the region.

An ambitious sustainability agenda was agreed which included reducing energy consumption by two thirds and generating one-sixth of the CO_2 emissions compared with an average existing primary school. The majority of the improvements were in the fabric of the building. In order to achieve this target, Photovoltaics were designed to provide 15% of electricity demand, Solar panels provide 20% of hot water demand, and a Biomass boiler, burning locally sourced wood pellets was to provide 60% of space heating requirements. However performance in use has not quite fulfilled initial expectations with PVs contributing just 6% rather than the intended 15%.

The material specifications at Kingsmead was well considered. The glulam timber frames were sourced from sustainable plantations in Denmark. External timber framed and clad walls include 200mm of recycled glass insulation which in combination with argon filled double glazed timber windows far surpassed the Building Regulations of the time (2003 ed.). Elsewhere natural or recycled materials are prevalent including single layer rubber membrane to the roof, timber windows and doors, timber panelled ceilings and bamboo, linoleum flooring and recycled carpets.

The building's environmental strategy has become an essential learning tool, with educational assignments making use of an accessible Building Management System which provides information related to electricity generation, rainwater collection and solar panel temperatures, and highly visible and colour coded systems which allow students to understand how the building works. Many aspects of the school build have been subject to further studies and thesis, including post occupancy evaluation. The contribution the project made to encouraging the building industry to question standard methods is significant. It has been recognized in a number of industry awards such as 'BCI' awards 2005, 'Prime Minister's Better Public Building' award 2005 (shortlisted), and 'Quality in Construction' awards 2005.

Project details

Completed: July 2004

Low Carbon features: super insulated fabric; natural ventilation with BMS controlled intelligent ventilation strategy; biomass boiler; Photovoltaics; solar hot water; rainwater harvesting; Inter-curricular school and community plan for low carbon living.
Energy Performance Rating (EPC): B
Costs: £2.3 million, with a basic building cost of £1,248 per sqm.
Additional costs including photovoltaics, biomass boiler, solar hot water, rainwater harvesting and enhanced ICT increasing cost to £1,800 per sqm.

Design Team

Client: Cheshire County Council
Architect: White Design Associates
Services Engineer: Arup
Structural Engineer: Integral Structural Design

Ynysowen Primary School, Merthyr Tydfil

A more recent primary school in Wales featuring the signature glulam cresent structure, stongly influencing the development of the ‘Paxton’.

Following the success of Kingsmead Primary School, Merthyr Tydfil County Borough Council approached White Design to commission Ynysowen Primary School, using Kingsmead as its basis. The realised school uses identifiably similar design principles, construction techniques and materials applied on a significantly larger scale to offer 300 primary school places and 40 nursery places.

Ynysowen Community Primary School is in Aberfan, located by the River Taff at the base of the valley, where the school is set against a striking backdrop of trees and hills. The principles of sustainable design and construction, such as orientation on site, natural materials, daylight and a natural ventilation system are all intrinsic to the design. The school makes use of a building management system with sensors to monitor the temperature and carbon dioxide levels of each individual classroom and control the automated windows to allow for the correct level of ventilation required.

As with Kingsmead Primary School, Ynysowen takes the structural form of M shaped Glulam frames set at 5m intervals offset at an angle of 4 degrees. Additional bays are added to elongate the crescent plan, making Ynysowen nearly twice the size of Kingsmead, and generating a distinct, almost semi-circular form. To the interior, a similar approach to organisation is maintained, with the primary teaching spaces located in the convex north facing arc and support spaces to the south. The primary entrance to the school is located to the centre of the South arc, articulated by an increased roof height and projected bay. This establishes a break in internal accommodation, with the west wing given to preschool and infant school classes, including a separate covered play area, and junior years located in classrooms in the east wing.

The winter garden model of Kingsmead is replaced in Ynysowen with a fully insulated and heated space, acting thermally as a draft lobby, but offering a useful additional group break out space.

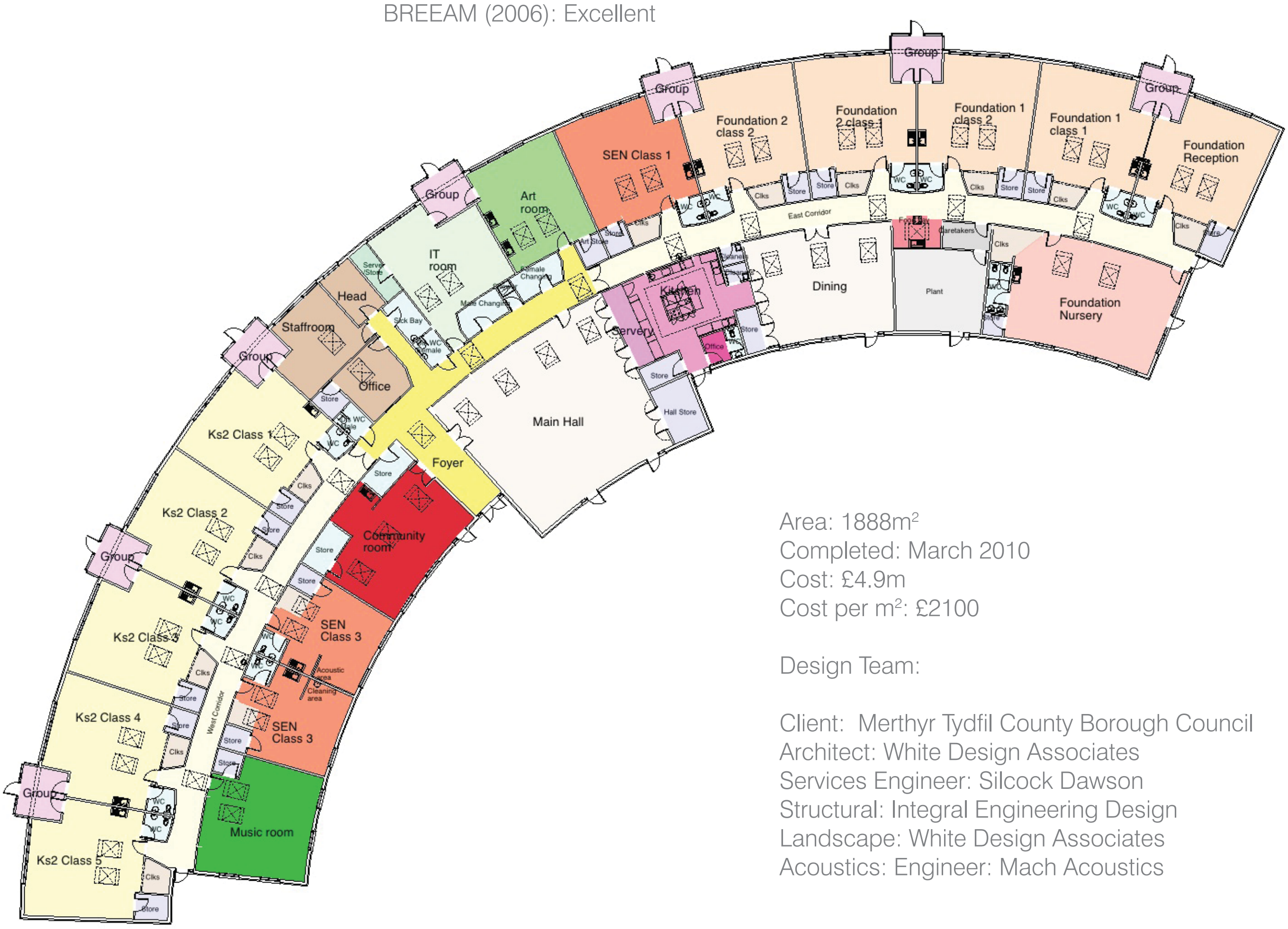
The materials were selected for their performance and durability throughout their lifetime, as well as overall sustainable credentials and aesthetic qualities. Most of the school's heating is provided by a system of 14 bore holes, each 100m deep in the ground which transfer the constant heat from the ground to heat the building, reducing the energy consumption further.

Ynysowen's alternative approach to energy sourcing was designed following extensive modeling, It was shown that the benefits of the GSHP system in lowering the building emission rate was significant in comparison to more conventional gas fired boilers and other methods. Thermal mass is incorporated into the construction of the floor and internal walls. Rainwater from the roof is collected and stored, then reused to flush all the toilets in the school, saving large amounts of water.

Fabric

U-values:
Glazing: 1.77 W/m²k (low E double glazed units)
Roof: 0.14 W/m²k
Floor: 0.15 W/m²k
Walls: 0.15 W/m²k

Air permeability target: 10m³/(hr.m²)@50Pa
As designed BER: 13.66kgCO_2/m²a
Energy Performance Certificate: B
BREEAM (2006): Excellent



Area: 1888m²
Completed: March 2010
Cost: £4.9m
Cost per m²: £2100

Design Team:

Client: Merthyr Tydfil County Borough Council
Architect: White Design Associates
Services Engineer: Silcock Dawson
Structural: Integral Engineering Design
Landscape: White Design Associates
Acoustics: Engineer: Mach Acoustics

Summary of Findings

Balancing regulatory demands

Recent years have seen a large number of changes in Government policy and capital investment schemes, resulting in loss of faith in the system, bad press and some poor quality outputs. Understandably, for some projects, this may have resulted in some confusion over standards and a prioritising of expenditure in to other areas, with low carbon options seen as a 'wish list'.

The 2013 amendments to the Approved Document, Part L, have considerably tightened up minimum standards, for new buildings, but in some opinion still rely heavily on the use of renewables to compensate for the minimum standard of fabric. The RIBA Plan of Work 2013 incorporates elements of the previously produced BIM overlay and the Green overlay, however has been criticised since its release on the lack of emphasis placed on its sustainability checkpoints, with the flexibility being offered rendering the extent of these checkpoints as 'optional'.

Welsh Government is continuing its commitment to sustainable development and opted to increase the minimum BREEAM requirement to 'Excellent' for all new schemes, including primary schools. Investment for schools remains a top priority for WG with a recent additional £25million allocated to the 21st Century Schools programme, despite cuts elsewhere within the Capital budget.

Fabric first and passive design

The fundamental principle demonstrated by these case studies, is for the school building stock to use less energy, emit less carbon, during the build and, more importantly, throughout the lifespan of the building. The use of passive design considerations, such as the orientation of building, glazing and roof can maximise the benefit of 'free' elements of sustainable design such as access to sunlight, natural ventilation and optimum orientation for technology. The successes lie in meeting the targets through energy conservation as far as possible, building a fabric which is airtight and reduces heat losses, rather than by compensating with renewable technologies.

Two other significant elements of passive design are common throughout all case studies featured and given the highest priority: good daylighting and natural ventilation. Getting these right improves conditions for the children, and staff, and has been demonstrated to allow them to concentrate more easily and be more productive, especially during the typically 'drowsy' period after lunch.

Systems

Increasingly, the community aspects of school or campus developments mean systems must be designed and costed to operate outside of normal school hours. The CHP schemes demonstrated at Blaenavon Community Campus and Coleg Cymunedol Y Dderwen show how other facilities within the local authority client's ownership can benefit from the school's capital investment, whether immediately or in the future through the additional infrastructure.

It is apparent that the larger schools require a number of renewables in conjunction with other passive systems where the fabric efficiencies, however good, can not compensate enough over the larger floor area and complex uses. Early costings and design integration of these systems from the outset is critical and it is clear the benefits that BIM has brought to this.

Although it is unfortunate that little monitoring has so far been carried out on these case studies, it is clear the importance of client understanding of the systems to ensure efficent future operation and building management.

Procurement and working as a team

All the projects were delivered by strong partnerships between contractor, client, architect, services consultants and sub-contractors. This can result in an integrated solution from the outset, with all parties taking ownership of the project and clearly knowing the parameters.

Although the contract types and size of school varies, the approach has been similar in using BIM, thermal modelling software or PHPP to acurately model and predict the building performance, proving to be successful in the cases demonstrated. It would be interesting to develop further the budgets for monitoring to determine the status of performance after 12 months, 2 years, 5 years and so on, especially where future flexibility, pupil numbers and equipment changes make additional demands upon the building.

Initially, the promotion of a soft landings approach looks to be of great benefit during handover, ensuring efficiencies are monitored and systems are fully understood by staff. Allowance should be made during programming stage to incorporate the time and cost investment required for this post-occupancy involvement.

Community engagement and consumer attitudes

In most cases, an aspirational client has been the key element in maintaining the low carbon agenda throughout the design, contract arrangement and construction of these schemes, despite cost pressures. The importance placed on capital costs often endangers the longer term benefits and savings generated by a less demanding building. Incorporation of other community projects in the proposals has been shown to be a beneficial way of generating additional income and improving other assets, not least rooting the school firmly within the ownership of the community.

A common factor amongst many of the examples noted here is the didactic nature of the buiding itself, through its form and exposure to performance indicators such as energy use, carbon emissions, temperature and rainwater use. This is an important learning tool which engages the children and other users and instills an environmental consciousness in to the next generation.

Retrofit and extend

In the first instance, we should look to reuse our current building stock, wherever possible, and assess existing build quality and suitability for adaptation against complex criteria. Significant embodied carbon savings are made by reusing buildings, as well as waste reduction, and this should be considered as a priority. The success of a partial or full school refurbishment rests in making good decisions at strategic level. Refurbishment projects work well were the retrofitted building/s form part of a greater masterplan considering the building in a site-wide context. Refurbishment projects make Low Carbon sense where the existing building has the flexibility to adapt the floor plan (ie non load bearing internal walls); the flexibility to incorporate replacement services; and a fabric suitable for enhancement.

A successfully conceived retrofit can see significant cost reductions – our case study demonstrated a £300 per m² reduction over the new-build equivalent, giving the client a full retrofit including reconfiguration of the floor plan, full services replacement and complete fabric upgrade, achieving significant performance U-values. The build programme for retrofit schools typically needs to fall intensively within school holidays, limiting scope and restricting programming. However because of this requirement they are often less disruptive to the school.

Typically 70% of embodied carbon is wrapped up in the materials and construction processes that form the sub and super-structure of a new school building. Therefore retrofit projects can make significant embodied carbon savings – savings that could equal the first 20 years of operational carbon load. Perhaps lessons should be taken from what makes a building successful to retrofit and fed into how we design new buildings. Should we be designing new-build or 'retrofit for the future'?

Passivhaus

The introduction of Passivhaus to the educational construction market has been shown to be a successful addition in the UK. Currently, completed schemes are relatively small and it would be interesting to see this demonstrated at a larger, secondary school scale. Projects in Europe indicate that there should be no reason why this would not also be successful.

Achieving Passivhaus certification involves processes and a team structure that are not dissimilar from other schemes, such as BIM, considered material selection and, in these case studies, an element of modular prefabrication. Passivhaus buildings benefit from being compact and the resulting simple layout and clear hierarchy make for an easily understood and controlled environment which maximises the potential of the floor area.

Initial reports say that the environment created has had a positive impact upon the children's behaviour and wellbeing and further monitoring and study of this would be intetresting, if not crucial. This being the case, this principle should be inseparable from the energy agenda.

Standardisation

This approach fits with current central government thinking and the approach adopted through 'baseline designs', whereby the Education Funding Agency sees a need to:
Significantly cut design stage time and costs;
Reduce and simplify procurement process;
Remove cost uncertainly from procurement process.

Standardisation offers these objectives by engaging the client in the process a stage further on from usual – with a fully designed, costed offering.

Who makes these choices in absence of an early stage client? In our case study example, the standardised Paxton design is based on learning from projects with significant engagement from previous client teams. Both client teams made a big investment in the design process, bringing low carbon commitment, knowledge and rigorous thinking to shape what was for them the perfect school. The standardised design could be seen to offer this past client engagement 'bottled', an attractive outcome for a clients with limited resources and a tight time frame. The standardised school in this instance could include 'design and procurement done well' as a bi-product of the process.

However, standardisation could be criticised for failing to capitalise on the low carbon benefits of locality and 'specialness' a particular school offers. Where there is a particular desire to stretch the boundaries, produce an exemplary scheme or exceed expectations, client teams may find standardised options restrictive. There is also the question of how a fully standardised system may be of benefit to clients with a tight or difficult site, which in reality is often the case.

Teams designing schools on a one-off basis are usually under intense pressure from commissioners to move quickly through design and procurement stages. However, teams preparing a standardised school design are not under this pressure, as they are undertaking the work in preparation for offering it as a product at a later date. This therefore gives opportunity to explore and incorporate past research, innovative construction techniques, off-site production options, perfect construction and fabrication details and provide a solution that best meets low carbon criteria.

Whether standardisation proves successful comes down to many factors, including marketing. In a construction culture that celebrates individuality, this may prove the methods biggest challenge.

Cost

The current difficulty is to safeguard the budget for the capital cost of improved fabric measures with the lifecycle savings made through a less demanding building, while on-site pressures test the resolve of the client's 'optional' low carbon aspirations. Schools such as Coleg Cymunedol Y Dderwen, at around £1790m^2, and Oakmeadow Primary at £1754m^2 (building only cost) have proven that exceptionally high energy targets can be met with a budget no greater than a typical new-build school meeting minimum standards.

The Government's new baseline school designs look to achieve a cost of around £1113m^2 for an average 1200 place secondary school. Even the Sunesis Paxton 2 form-entry primary is advertised at an average of over £2000m^2, so it would be interesting to see how the new era of baseline schools meet this demand, especially with any additional site specific requirements and variation of systems and renewable technologies.

Of course, there is potential for design quality to be neglected in the race to achieve green credentials and competitive costs per m^2, but this report demonstrates that a high quality building design and user environment can be achieved and is integral to the success of a low carbon school.

This report is published to correspond with our conference 'Low Carbon Learning: Lessons from Practice'. A roadmap to procurement and further detailed cost analysis will be developed and discussed during this event.

This report is the second output of the Low Carbon Research Institute's (LCRI) Low Carbon Built Environment programme work package, 'Design of Low/Zero Carbon Buildings.' The objective of the project is to provide design teams involved in the delivery of low/zero carbon buildings with clear but non-prescriptive design guidance based on current best practice.

The LCRI was set up to unite and promote energy research in Wales, UK to help deliver a low carbon future. The multidisciplinary LCRI aims to support the energy sector, UK and globally, to develop low carbon generation, storage, distribution and end use technologies, and to offer policy advice.

The Higher Education Funding Council For Wales (HEFCW) granted £5.1 million to develop the LCRI for 5 years from April 2008. LCRI's research is also supported by contracts from the Research Councils, Industry and Government.

In 2010 LCRI secured £15 million from the Welsh European Funding Office, a contribution to a £34 million programme to enable Wales and its industry partners to lead the way in research to cut carbon emissions, as part of the European Research Development Fund's Convergence, Regional Competitiveness and Employment programmes.

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