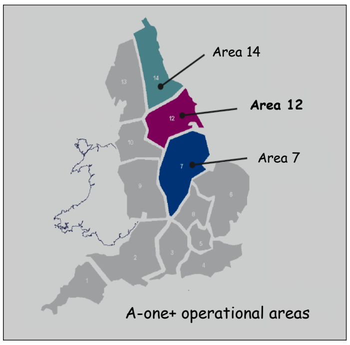
A-one+ Integrated Highway Services

We Deliver Sustainable Solutions

Area12—Biomass

A currant national debate is how to create a more resilient natural environment that supports our society in the context of climate change. Management of the land owned by Highways England beyond the edge of the carriageway can contribute to this goal.

A-one+ maintain the motorway and trunk road network for Highways England in Area 12 and are exploring opportunities to use the 1,800 hectares (ha) of soft estate to create a biomass resource. We have converted low grade timber into wood chip to provide sustainable low carbon fuel for heat production. This has been achieved whilst still maintaining this significant ecological asset often undisturbed by human intervention.



Project Aims

- Harvest existing Area 12 soft estate to produce wood chip biomass.
- Reduce fossil fuel dependence and work towards mitigation of the effects of climate change.
- Reduce CO_2 of our operation and energy production.
- Manage land for environmental benefit.
- Provide income from sale of product.
- Produce a model for biomass harvesting that can be adopted throughout the UK on the Highway England network.
- Positive impact on flora and fauna.
- Sustainable delivery.
- Increase road safety.
- Create canopy gaps for ground flora and sheltered woodland edge.
- Contribute to the Humberhead Levels Nature Improvement Area .

Area12—Biomass

The project team determined the minimum woodland size required to warrant biomass harvesting and identified 150 plots larger than 1 ha. These sites are predicted to generate 18,000 tonnes of biomass on the basis of a 50% thin. A large scale trial on a representative selection of plots was undertaken to determine production and confirm estimated yield rates.

The layout of the biomass production had to be carefully considered. Felled timber was extracted to the verge where it was separated into firewood or timber for chipping. A temporary hard standing was created in the verge where a 'whole tree chipper' was located, enabling every part of the tree to be chipped. The layout enabled chipping to be undertaken directly into the wagon whilst maintaining the compact production layout established within the site.

The work on the motorway and trunk road network and tree felling are both high risk activities that usually occur remotely from each other. The project brought both distinctively hazardous environments together with a unique mix of specialist individuals. Site staff from both disciplines worked closely together to ensure that this interaction was safe.

Biomass is a growing market for all wood products, driven by government subsidies. A-one+ has demonstrated that biomass harvesting is a sustainable model that can be implemented nationally. The local small/medium scale biomass heat market (firewood, woodchip and pellets) is one which will grow in significance and provide an important market for the timber coming out of England's undermanaged woodland resource.

Roger Wantling, Highway England ***'There is a genuine commitment within A-one+ Area 12 to be an exemplar with regards to improving sustainability whilst still offering viable solutions to meet customer and business needs.'***

Key statistics from biomass trial 2015

Woodchip harvested:	1440 tonnes
Firewood harvested:	216 tonnes
Total biomass:	1656 tonnes
Area of woodland thinned by 50%:	194,000m^2
Total area of Area 12 woodland plots greater than 1ha:	212ha
Projected tonnage from Area 12 suitable woodland plots:	18,000tonnes
Approximate value of biomass in Area 12 assuming £30/t=	£540,000

At £30/t there is £7.5m of biomass held within the Highway England network if the projected tonnage is matched nationally.

Life Cycle Cost of Building Services Dashboard

Category 4: Design, Innovation & creativity

Name: Haniyeh Mohammadpourkarbasi
Email: Haniyeh@bcmconsulting.co.uk
Tel: 0161 831 7900

BCM SUSTAINABLE BUILDING SERVICES DESIGN

Innovate UK Technology Strategy Board

LIVERPOOL JOHN MOORES UNIVERSITY

Summary

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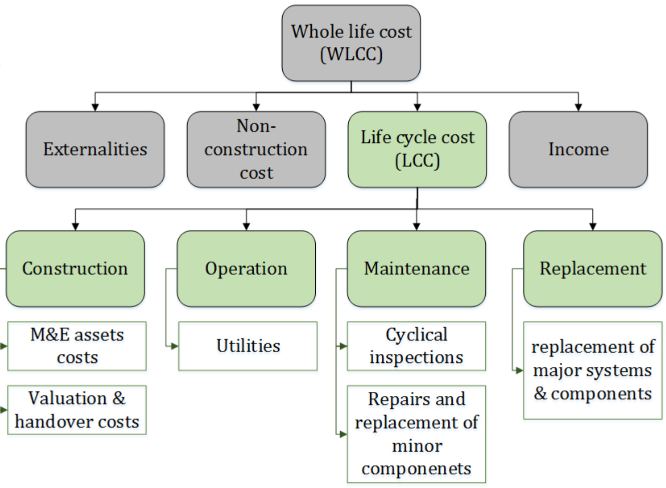
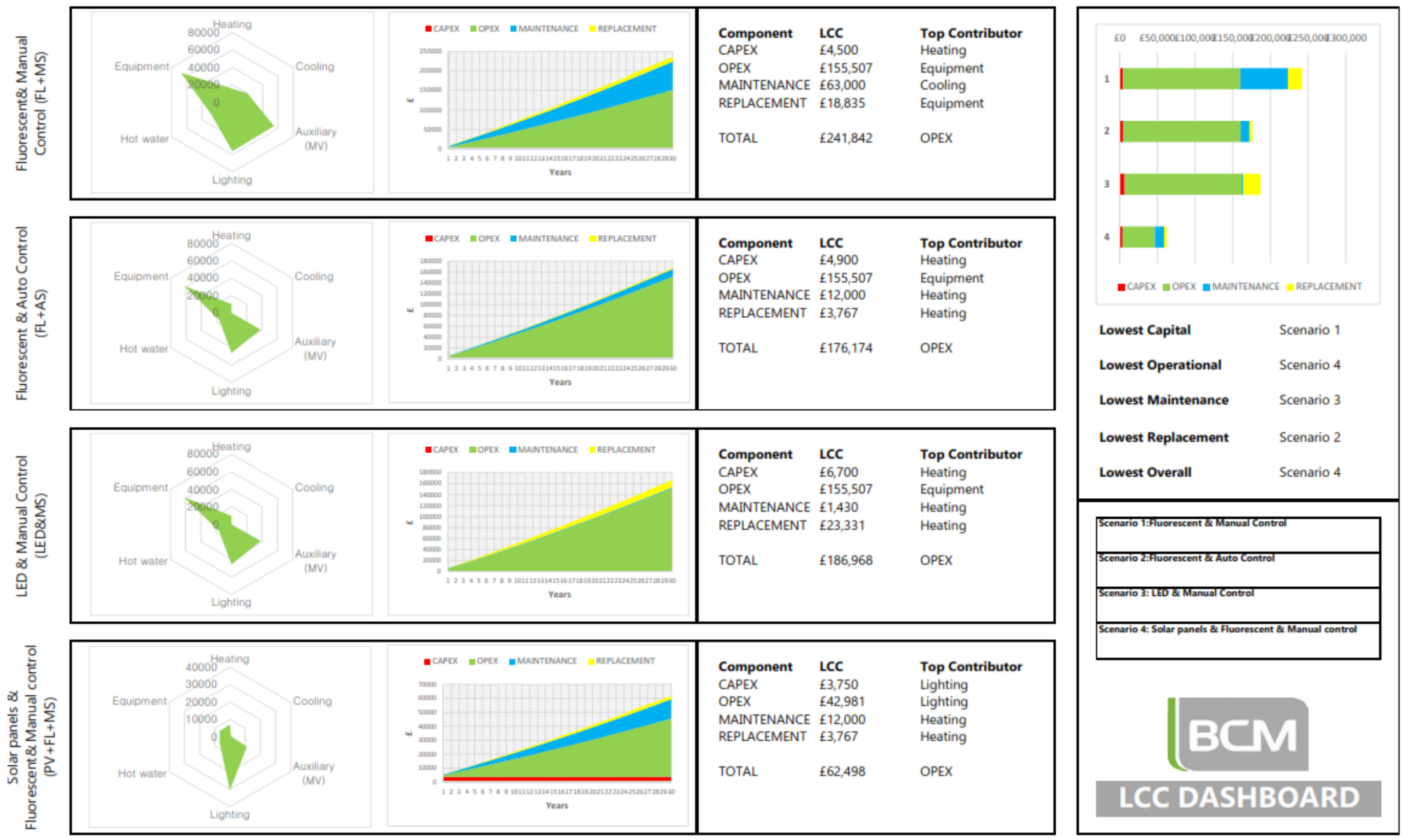


Fig.1. BS ISO 15686-5:2008 WLCC framework

BCM LCC CALCULATOR



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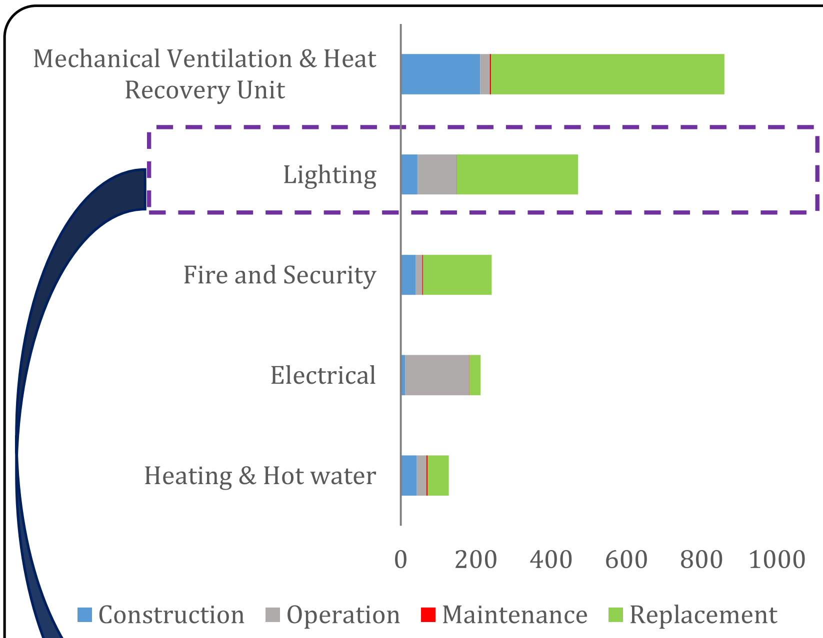

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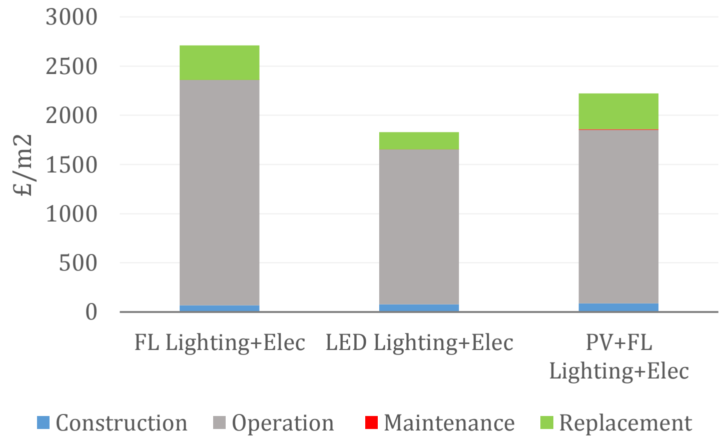

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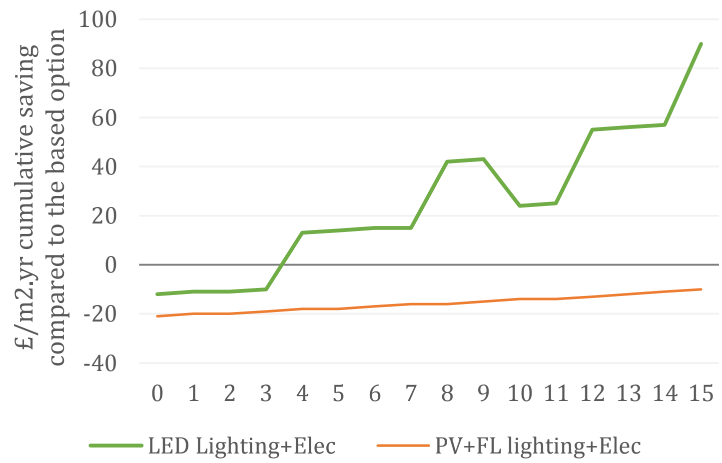

Fig.5. Cumulative savings from different options compared to FL Lighting+Elec

Life Cycle Cost of Building Services Dashboard

Category 7: Behavioural change

Name: Haniyeh Mohammadpourkarbasi
Email: Haniyeh@bcmconsulting.co.uk
Tel: 0161 831 7900

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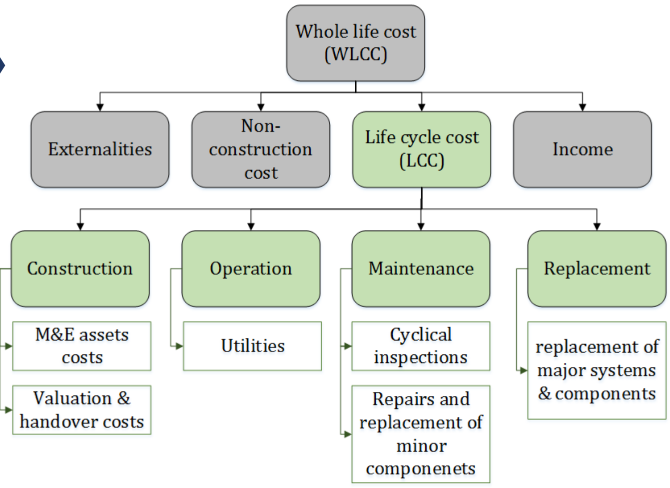

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BCM LCC CALCULATOR

Fig.2. BCM LCC Calculator

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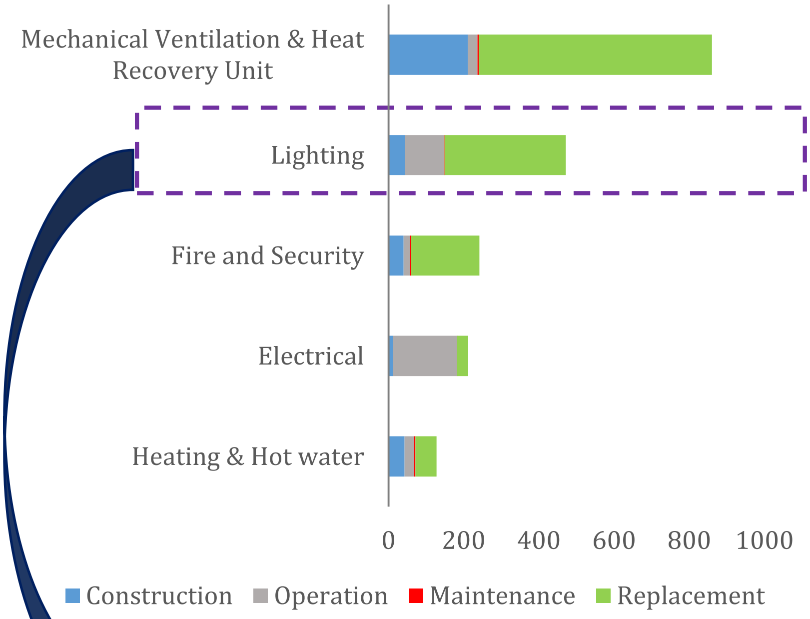

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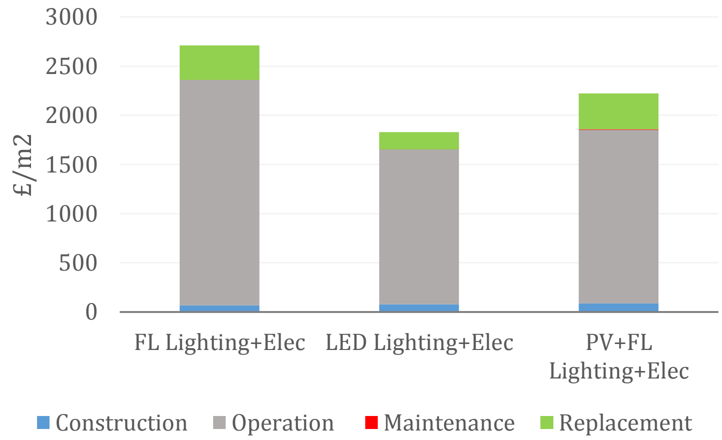

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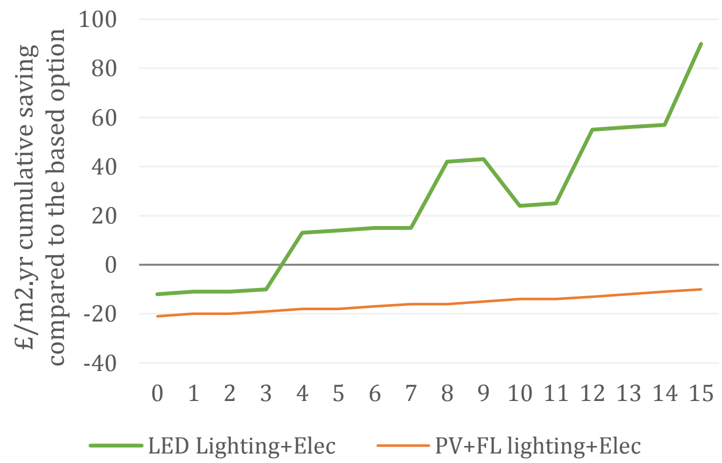

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Life Cycle Cost of Building Services Dashboard

Category 8: Enterprise

Name: Haniyeh Mohammadpourkarbasi
Email: Haniyeh@bcmconsulting.co.uk
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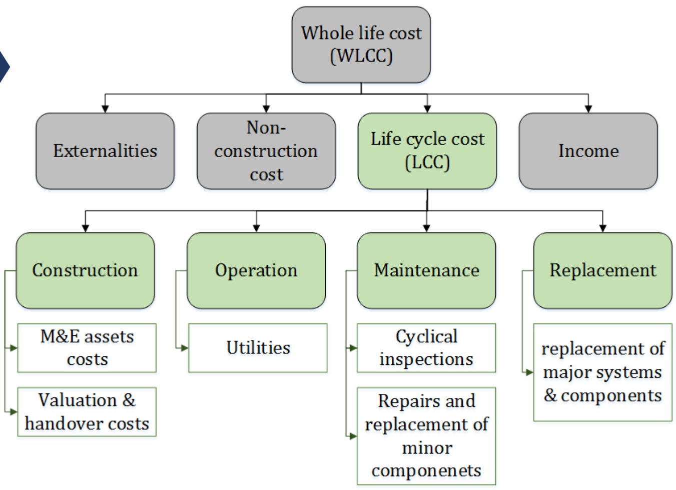

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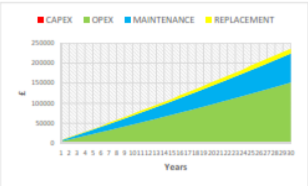
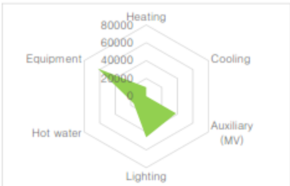
BCM LCC CALCULATOR

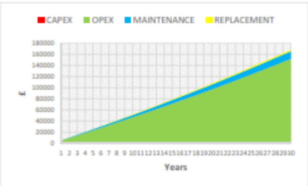
Fluorescent& Manual Control (FL+MS)



Component	LCC	Top Contributor
CAPEX	£4,500	Heating
OPEX	£155,507	Equipment
MAINTENANCE	£63,000	Cooling
REPLACEMENT	£18,835	Equipment
TOTAL	£241,842	OPEX

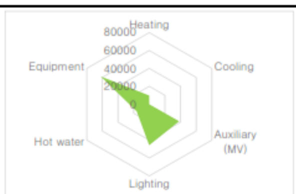
Fluorescent & Auto Control (FL+AS)

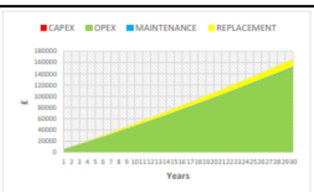




Component	LCC	Top Contributor
CAPEX	£4,900	Heating
OPEX	£155,507	Equipment
MAINTENANCE	£12,000	Heating
REPLACEMENT	£3,767	Heating
TOTAL	£176,174	OPEX

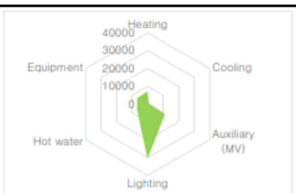
LED & Manual Control (LED&MS)

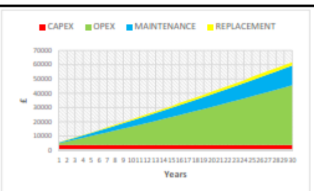




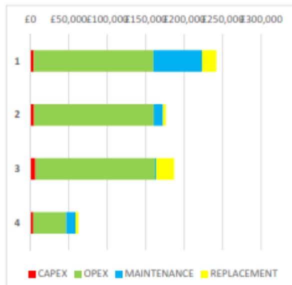
Component	LCC	Top Contributor
CAPEX	£6,700	Heating
OPEX	£155,507	Equipment
MAINTENANCE	£1,430	Heating
REPLACEMENT	£23,331	Heating
TOTAL	£186,968	OPEX

Solar panels & Fluorescent& Manual control (PV+FL+MS)





Component	LCC	Top Contributor
CAPEX	£3,750	Lighting
OPEX	£42,981	Lighting
MAINTENANCE	£12,000	Heating
REPLACEMENT	£3,767	Heating
TOTAL	£62,498	OPEX



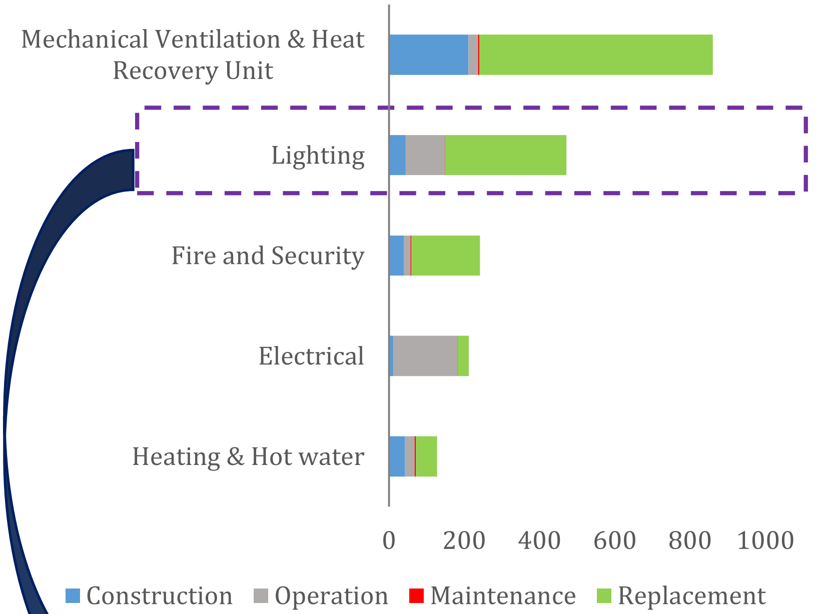
Lowest Capital	Scenario 1
Lowest Operational	Scenario 4
Lowest Maintenance	Scenario 3
Lowest Replacement	Scenario 2
Lowest Overall	Scenario 4

Scenario 1:Fluorescent & Manual Control
Scenario 2:Fluorescent & Auto Control
Scenario 3: LED & Manual Control
Scenario 4: Solar panels & Fluorescent & Manual control

LCC DASHBOARD

Fig.2. BCM LCC Calculator

RISE AWARDS 2015



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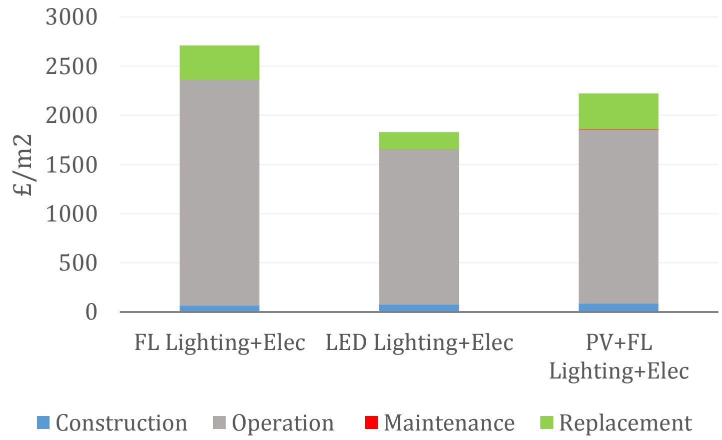

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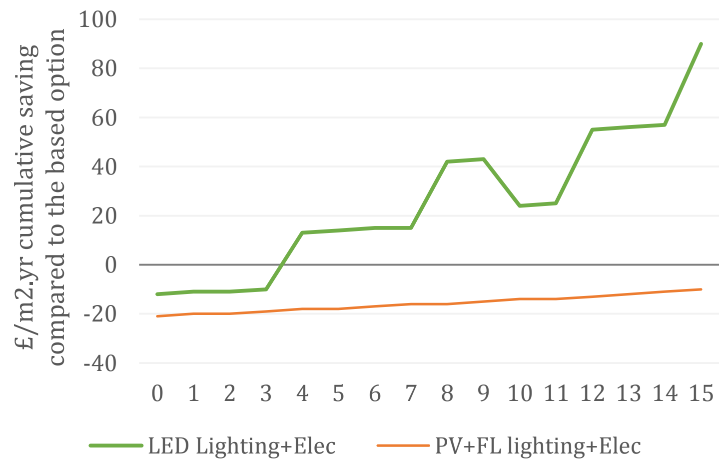

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RISE Awards 2015

Low carbon geopolymer bed joint anode material for the durable corrosion protection of heritage buildings

Strategic aims:

- *Create a more cost efficient method of repairing and restoring historic steel framed structures and their façades compared to traditional approaches.*
- *Reduce the carbon footprint of such restorations.*
- *Extend and predict the life of structures through protection against corrosion.*
- *Actively and remotely monitor, control and report on future performance for the portfolio management of properties without disruption to tenants.*

Overview:

C-Probe Systems Ltd, working with Sheffield Hallam University and Mott MacDonald, has developed a new method for repairing historic buildings suffering from structural damage and associated façade degradation due to the corrosion of the structural steel frames, which support them.

This new technology derives from synthetic stone arising from recycled and industrial by-products. These are combined in a blending process that requires no additional heat therefore has a low energy consumption. Low water content within the wet mix design completes the achievement of an ecologically sustainable and low carbon product.

It also eliminates most of the deconstruction and reconstruction required to the façade with associated and significant cost and environmental impact savings. The solution goes much further than this though.

C-Probe Systems has taken the well-proven concept of impressed current cathodic protection (ICCP), which passes a low direct current between the structure and anodes drilled into the masonry and improved it with a reduced carbon innovation that more closely dovetails with conventional site repair methods.

As these repairs, normally, include the need to re-point the façade blockwork which would traditionally be done using Portland or lime cement based mortars; the new system has substituted these with the geopolymer bed joint mortar anode containing recycled carbon fibre strands. Architectural aesthetic finishes to the joints with traditional materials is still possible for conservation compliance. The combination of the carbon fibre and the geopolymer mortar formulation enables the system to conduct extra low voltage electricity and hence become the stable anode material for durable corrosion protection of the steelframe.

Contract Benefits:

- *Conservation compliance by eliminating the need for façade reconstruction.*
- *Cost-effectiveness of both repair and ICCP method.*
- *Efficiency by quickening site production timescales.*
- *Sustainability by reducing carbon emissions of the mortar by around 80%.*

Furthermore, the resulting extra low voltage electrical circuits and monitoring tools can be connected to its remote control and online data management system.

Long-term Benefits:

- *Active remote control of corrosion.*
- *Asset life extension.*
- *Property life tracking.*
- *Online performance reporting on a continuous basis.*
- *Low level disruption to operation of the building.*

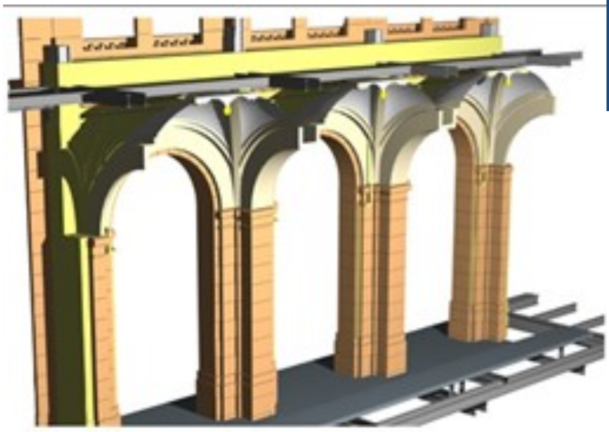
Proof of Performance in the Field:

Having developed the concept in the laboratory, the first trial project was carried out in conjunction with Leeds City Council with a section of the Civic Hall being restored permanently using this system.

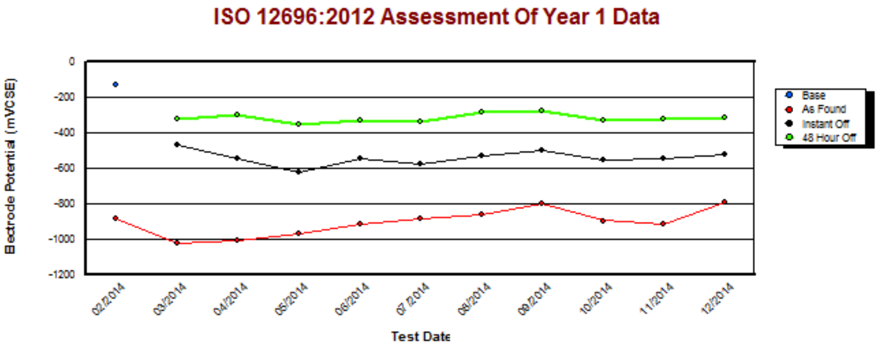
This enabled the concept to be refined and proven resulting in a significant contract in the USA for the repair and corrosion control of a heritage bank building in Kansas City.

The design was created in 2D CAD and 3D formats for ease of representation for installation by the local US contractor in Kansas City. The picture below represents the anode positioning internally (in yellow) whereas the actual installation activities were performed entirely externally.

A significant added feature was the inherent thermal stability of the new material allowing mixing and setting at external air temperatures as low as -15C for all year round working.



Assessment of the completed ICCP system was performed by C-Probe in accordance with the international standard for design and operation of ICCP systems. Additional corrosion rate monitoring allows the tracking of service life by data manipulation of the on site rate measurements as accumulated corrosion information. In turn this allows the calculation and graphical representation of PCorr values that can be directly correlated with Tuutti's model for estimation of the extension of service life of the property.



To quote an industry corrosion expert and the project system designer:

"By preserving the life of historic steel-framed structures, this new material and method of work will ensure that buildings continue to fulfil their functional purpose and re-affirm their place in our local and national cultures. Without this innovative work, structural deterioration will occur and result in major maintenance works, disruptive to occupants and negatively impacting the look and feel of our cities. In addition, the cost of major maintenance or traditional CP applications far outweighs the benefits of preventative measures through this innovative, non-disruptive approach"

Professor Paul Lambert, Mott MacDonald, 2014.

Company Contact Details:

C-Probe Systems Limited

Unit 2, Sherdley Road Industrial Estate, Wharton Street, St Helens WA9 5AA United Kingdom

Tel: 01744 611555 (Graeme Jones)

Email: gjones@c-probe.com

C-PROBE

RISE Awards 2015

Development of a Low Carbon, Fire Resistant Tunnel Ring

Strategic aims:

- *Create a binder material for precast concrete applications from recycled industrial by-product materials.*
- *Provide integral fire and chemical resistance to save on the cost of infrastructure build through the removal of construction processes.*
- *Reduce the carbon footprint of such structures.*
- *Meet the requirements of EN206 and BS8500.*
- *Provide a long-term durable material for construction.*

Contract Benefits:

- *Efficiency by quickening site production timescales through Build Offsite practices.*
- *Removal of the need to provide additional fireproof lining to tunnels by integration of precast material and jointing grouts in single technology.*
- *Lower the risk to contract warranties.*

Sustainability:

C-Probe Systems Ltd, working with Sheffield Hallam University, has developed a new material that has wide implications on the construction of civil engineering structures.

This new technology has been developed from synthetic stone derived from recycled and industrial by-products combined in an ambient blending process that requires no additional heat. This manufacturing process therefore has ultra-low energy consumption.

In addition, the mix designs require low water as they are alkali-activated with dilution of the liquid activator being the only use of water yielding a water: binder ratio of 0.2.

All these features of the manufacturing process provides an ecologically sustainable and low carbon product with 80% CO_2e savings compared to ordinary Portland cement equivalents (oPc) achievable.

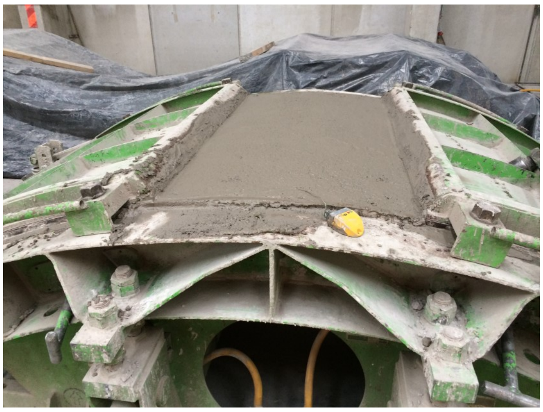
Segmental tunnel tubes are designed to bend by rotating the position of the keystone. The initial task for this test was to form a single full ring.

The Development Project:

Having developed the concept and binder formulations in the laboratory, the first trial project to construct a trial tunnel ring comprising 6 segments was carried out in conjunction with Shay Murtagh Precast in Ireland.

This enabled the geopolymer concrete design to be tested in a full scale mixer with steel fibres in the mix then cast within moulds previously used for the precast construction of tunnel segments for Crossrail in London.

Trial cubes were performed in June 2014 before the final mix design was decided for the tunnel ring construction in November 2014. Additional cubes, cylinders and beams were retained for testing as well as assessment of demoulding times.



Material Features:

- *Reduced carbon emissions of the mortar by over 80%.*
- *Fireproof to at least 1100C for over 4 hrs*
- *Chemical resistance to sulfates.*
- *Freeze-thaw resistance*
- *Alkali Silica Reaction resistance*

The lifting, handling and construction sequence followed normal precasting protocols successfully:

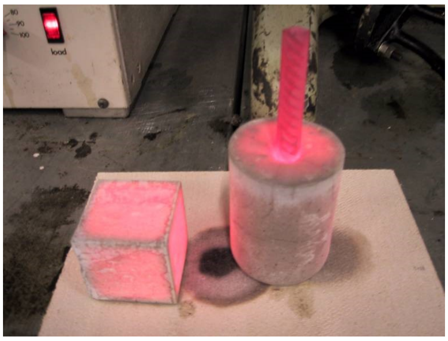
Proof of Performance:

Demoulding was achieved within 24hours with reduced times possible through control of retarder content.

Typically the density of the geopolymer concrete was comparable to oPc mixes measured at 2280kg/m^3 with minimal slump.

Curing temperatures are low (15-17C) through depth of segment as logged using “tiny tags”.

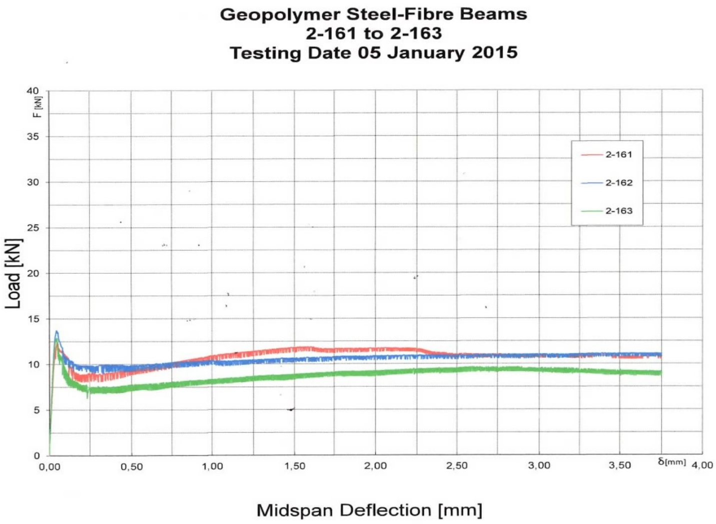
Compressive strengths were typically over 50MPa after 28 days and still rising to 60MPa up to 56 days therefore comparable with C50/60 oPc concretes.



At high temperatures of at least 1100C the concrete keeps its form and doesn’t crack or explode as one would expect with oPc concretes (see photograph right).

Tensile splitting strengths of 3.5-3.8MPa were measured.

The graph below demonstrates a good level of ductility shown by geopolymer beams tested to 3.5mm mid span deflection.



Long-term Testing:

Industry acceptance of alkali-activated binder materials is underway and it is anticipated that close correlation with existing concrete test standards will be required. The C-Probe geopolymer binder is undergoing a wide range of durability testing with rigorous Failure Mode and Effects Analyses (FMEA) for a range of applications so as to ensure appropriate formulations are proven.

Data will be published in due course as information is generated from the development.

Company Contact Details:

C-Probe Systems Limited

Unit 2, Sherdley Road Industrial Estate,
Wharton Street, St Helens WA9 5AA
United Kingdom

Tel: 01744 611555 (Graeme Jones)

Email: gjones@c-probe.com

C-PROBE

RISE Awards 2015

Research | Innovation | Sustainability | Enterprise

Award Catagory: Sustainable developments

Entry: Saint-Gobain My Comfort multi sector building concept

my comfort
by Saint-Gobain

Introducing the idea of Multi-Comfort

When we typically spend 90% of our time indoors or in vehicles, it's fair to say that the buildings we live, work or play in every day, can have a significant impact on our comfort, health and wellbeing.

Buildings should provide us with a comfortable, healthy habitat in which to be successful, efficient and safe as we set about our daily routines.

Imagine a building that's not just good for the environment, but good for you – and for all the other people who live, work or play in it too. Imagine a building that combines the highest level of thermal performance with excellent acoustics, visual comfort, superb indoor air quality and outstanding energy efficiency.

Imagine a Multi-Comfort building...

There are five main considerations that affect people's perception of comfort inside buildings:

- ***Thermal comfort:*** *determined by air temperature, humidity, draughts, etc.*
- ***Audio comfort:*** *determined by parameters such as noise from outdoors, vibrations, clarity of hearing, intelligibility of speech, etc.*
- ***Visual comfort:*** *determined by factors such as view, light quality, luminosity, glare, etc.*
- ***Indoor Air comfort:*** *determined by indoor air quality parameters such as fresh air supply, pollutants, odours, etc.*
- ***Economic comfort:*** *determined by the affordability of constructing, running and maintaining the building.*

The four factors of thermal, audio, visual and indoor air comfort in buildings are better understood today than ever before. However, in combination, these factors become powerful tools for designing happy, healthy, energy-efficient buildings that deliver considerable economic benefits – as well as all-round positive wellbeing effects for everyone.

THERMAL comfort | AUDIO comfort | VISUAL comfort | INDOOR AIR comfort | ECONOMIC comfort

SAINT-GOBAIN

My Comfort performance parameters

my comfort by Saint-Gobain			RESIDENTIAL New-Build	RESIDENTIAL Renovation	NON-RESIDENTIAL New-Build	NON-RESIDENTIAL Renovation
THERMAL	Heating & Cooling Energy Demand	PH	15kWh/m^2/p.a ***or*** 10W/m^2	25kWh/m^2/p.a	15kWh/m^2/p.a ***or*** 10W/m^2	25kWh/m^2/p.a
THERMAL	Relative Humidity [12]		40-60%		40-70% [11]	
THERMAL	Overheating Prevention [2]	PH	Limit Value: 10%		Limit Value: 10% [3]	
THERMAL	Thermal Bridging	PH	0.01 W/mK	0.01 W/mK [9]	0.01 W/mK	0.01 W/mK [9]
AUDIO	Acoustic Sound Insulation (Design Values)		+3dB of current acoustic regulation level for building type [4]		+3-6dB of current acoustic regulation and/or guidance level for building type [4]	
AUDIO	Acoustic Absorption		N/A in most cases [5]		In line with currect reverberation control regulation and/or guidance level for building type	
AUDIO	Speech Clarity/ Intelligibility (c50)		N/A		In line with currect regulation and/or guidance level for building type	
AUDIO	Harmonious Resonance		Due consideration to be given to frequency transfer of noise based on selection of structural materials			
VISUAL	Daylight Autonomy [13]		8am - 6pm DA 60% at 300lux	Optimise existing openings through glazing spec. [1]	BREEAM [16]	Optimise existing openings through glazing spec. [1]
INDOOR AIR	Airtightness (n50)	PH	0.6 V/h @ 50pa	Limit: <1.0V/h@50pa Target: <0.6V/h@50pa	0.6 V/h @ 50pa	Limit: <1.0V/h@50pa Target: <0.6V/h@50pa
INDOOR AIR	Ventilation [14, 15]	PH	30m^3/hr/person [8]	30m^3/hr/person [8]	To be agreed with Passivhaus Institute (PHI) based on a review of planned occupany patterns/ratios [8]	
INDOOR AIR	Control of VOC's (3 routes to compliance)		Use of EN15616 tested materials ***or*** [18]			
INDOOR AIR			Internal materials finishes that remove VOC concentration ***or*** [19]			
INDOOR AIR			Total VOC Concentration <300µg/m^3 + Formaldehyde levels <100µg/m^3 [17]		Total VOC Concentration <150µg/m^3 + Formaldehyde levels <100µg/m^3 [17]	
ECONOMIC	Primary Energy Demand	PH	120kWh/m^2/p.a		To be agreed with Passivhaus Institute (PHI) based on a review of electrical appliances & equipment planned	
ECONOMIC	Fabric U-Values		0.08 - 0.15 W/m^2K [6]			
ECONOMIC	Window U-Value Installed Value		1.1 Uw DGW and 0.8 Uw TGW [7]			
ECONOMIC	OPEX vs CAPEX Analysis		Provision of design statement used for planning that accounts for potential future building use and adaptability (Includes: Maintenance costs, standard build cost comparison with Multi-Comfort build cost, ROI based on running costs)			
ECONOMIC	Embodied Energy Analysis		Using Type III EPD Verified (EN15804 Compliant) LCA/EPD Data of all Fabric and M&E components to inform specification [10]			

The Passive House Standard & the Multi-Comfort building concept

The Passive House (or Passivhaus) standard represents today's highest energy standard for buildings. It was developed from the belief that the most inexpensive and environmentally friendly energy is that which is not consumed in the first place.

The Saint-Gobain Multi-Comfort concept builds on the Passive House principles of delivering the highest thermal comfort and reducing CO_2 emissions by also combining excellent audio and visual comfort with superb internal air quality, fire protection and safety.

Criteria from the Multi-Comfort concept that is in line with the Passive House standard is denoted in the previous table by PH.

Multi-Comfort building accreditation

Having independent verification of the performance of your building is a key part of demonstrating your building's performance and a good way to demonstrate the value it offers current and future users. Whilst having your building assessed and accredited for Passive House compliance, you can have your building accredited as a Multi-Comfort building with the aid of Saint-Gobain.

Visit **www.multicomfort.co.uk** for more details.

SAINT-GOBAIN

RISE Awards 2015

Research | Innovation | Sustainability | Enterprise

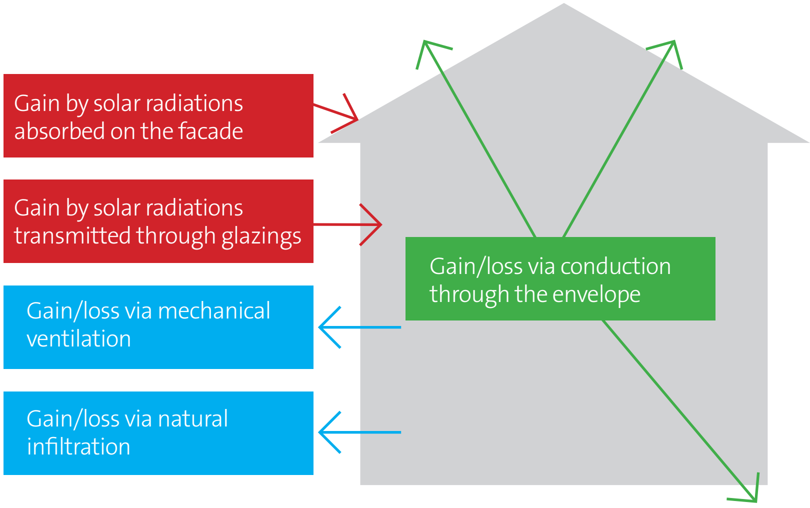
Award Category: New Technologies

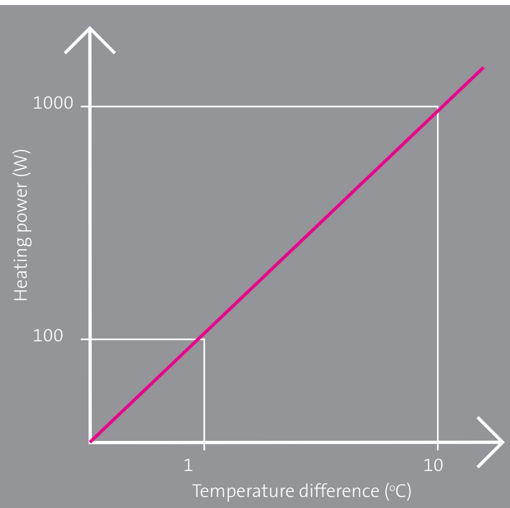
Entry: Saint-Gobain Research QUB Heat Loss measurements

QUB: Quick U-value of Buildings

Heat Loss Coefficient (HLC)

The product of the whole building U-value times the deperditive area.

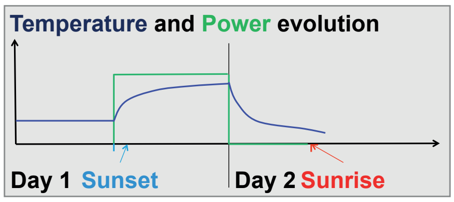




Building	R [m²-K/W]	U [W/m²-K]
To be retrofitted	0,3 - 0,7	1,4-3,3
New (RT2012)	3,0-4,0	0,25-0,33

Saint Gobain Quick U-value of Buildings (QUB)

- A quick dynamic measurement

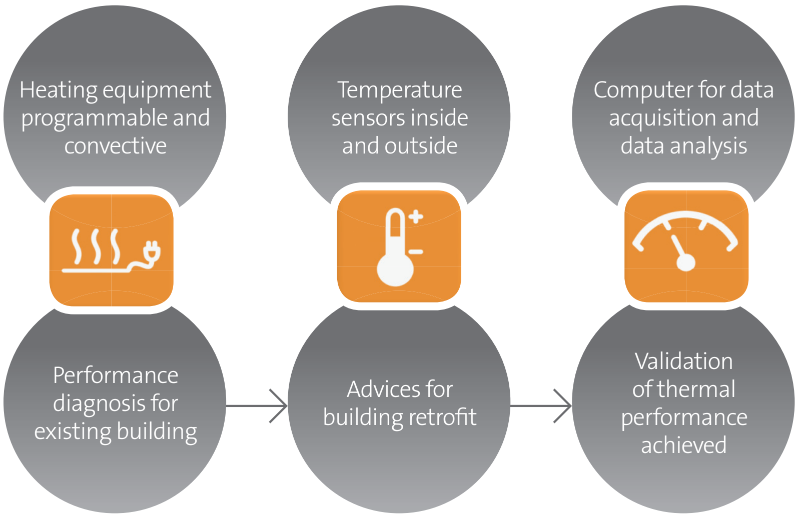


- Temperature analysis from a simple model
  - Without occupancy
  - During the night

$$P = K_0 \left(T_{IN} - T_{EXT}\right) + C\,\frac{\Delta T_{IN}}{\Delta t}$$

Loss by transmission and infiltration

Internal mass storage



SAINT-GOBAIN

QUB: Quick U-value of Buildings

Validated results

Validation summary

Building	Duration	Trials	Result (W/K)	Reference (W/K)
Saint-Gobain Research Bungalow	1 hour	35	32 ± 5	33 ± 2 (Coheating)
	2 hours	15	30 ± 2	
	4 hours	27	32 ± 4	
	8 hours	18	32 ± 3	
Saint-Gobain House	2 hours	10	90 ± 18	109 ± 8 (Coheating)
	8 hours	21	93 ± 12	
	2 nights	6	107 ± 9	
Saint-Gobain Energy House	1 hour	8	183 ± 16	228 ± 20 (Static)
	4 hours	4	202 ± 23	
TRNSYS simulation	8 hours	57	142 ± 8	143 (Static)
	2 nights	44	146 ± 5	

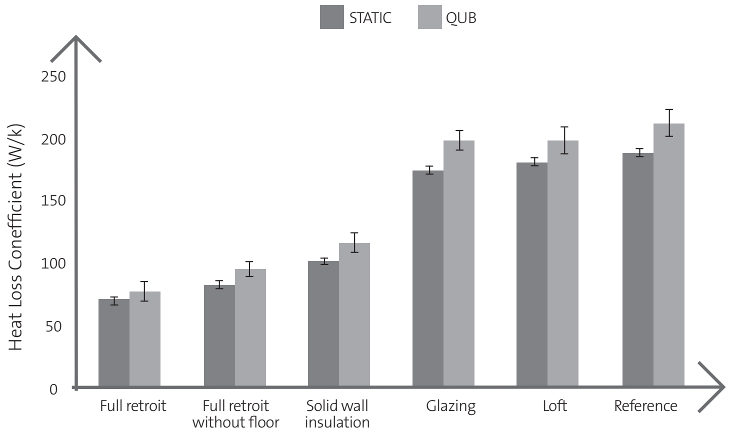
Saint-Gobain Energy House retrofit scenarios

- Full Retrofit
- Full Retrofit without Floor Insulation
- Solid Wall Insulation
- Performance Glazing
- Loft Insulation
- Reference

Outcomes to date

- 2 Patents
- 6 Scientific papers
- 4 Talks in conferences
- 4 Academic collaborations

Static Vs QUB testing



SAINT-GOBAIN

RISE Awards 2015

Research | Innovation | Sustainability | Enterprise

Award Category: Product and Element Interface

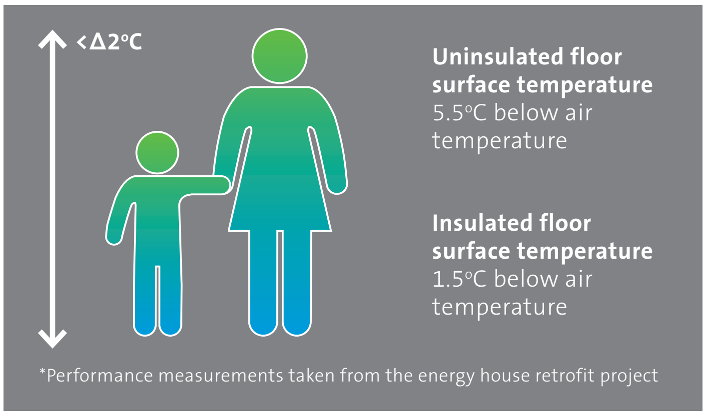
Entry: Saint-Gobain Isover suspended timber floor application

Thermal airtightness and comfort solution

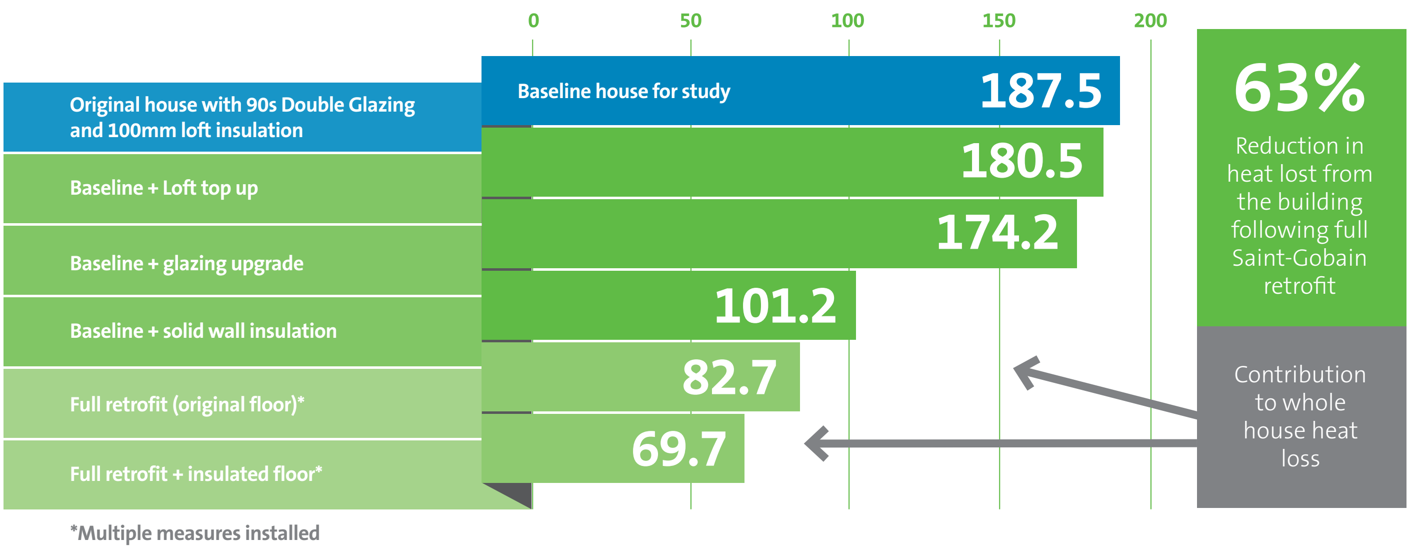
Comfort

A temperature differential of greater than 2 degrees can cause a feeling of discomfort, installation of a well insulated floor with incorporated airtightness properties can maintain a temperature differential of less than 2 degrees.

In addition the structure retains its moisture permeability (utilising open cell Isover mineral wool insulation and the variable vapour permeability properties of the Isover Vario Climate Membrane) mitigating potential moisture issues whilst controlling uncomfortable draughts.

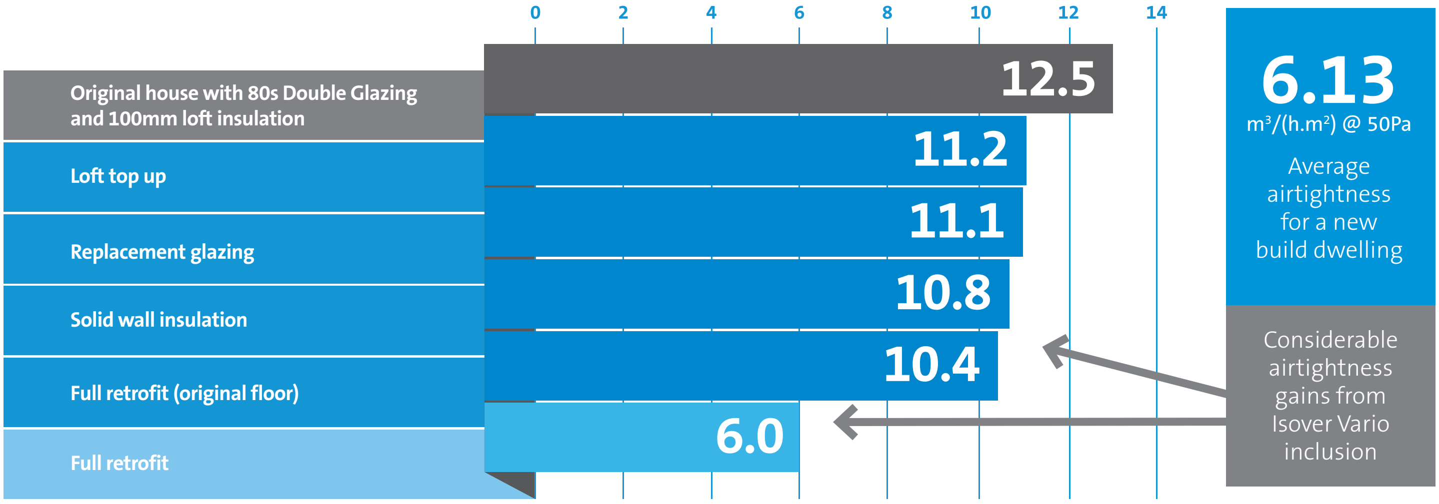


Thermal: Whole house performance – Heat Loss



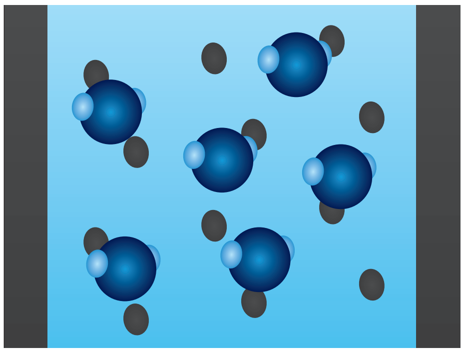
As part of a whole house retrofit insulated and airtight flooring contributes significantly to reducing the overall heat loss.

Airtightness: Whole house performance

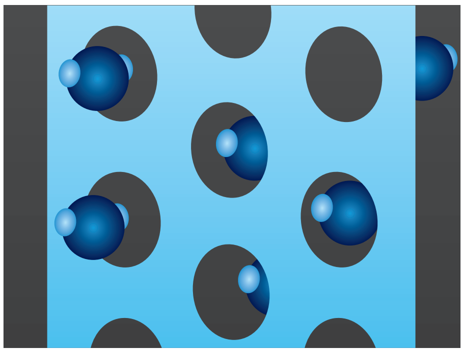


By incorporating an airtight membrane with variable moisture permeability properties, considerable gains can be made in terms of airtightness whilst considering and mitigating potential consequential moisture issues within the structure.

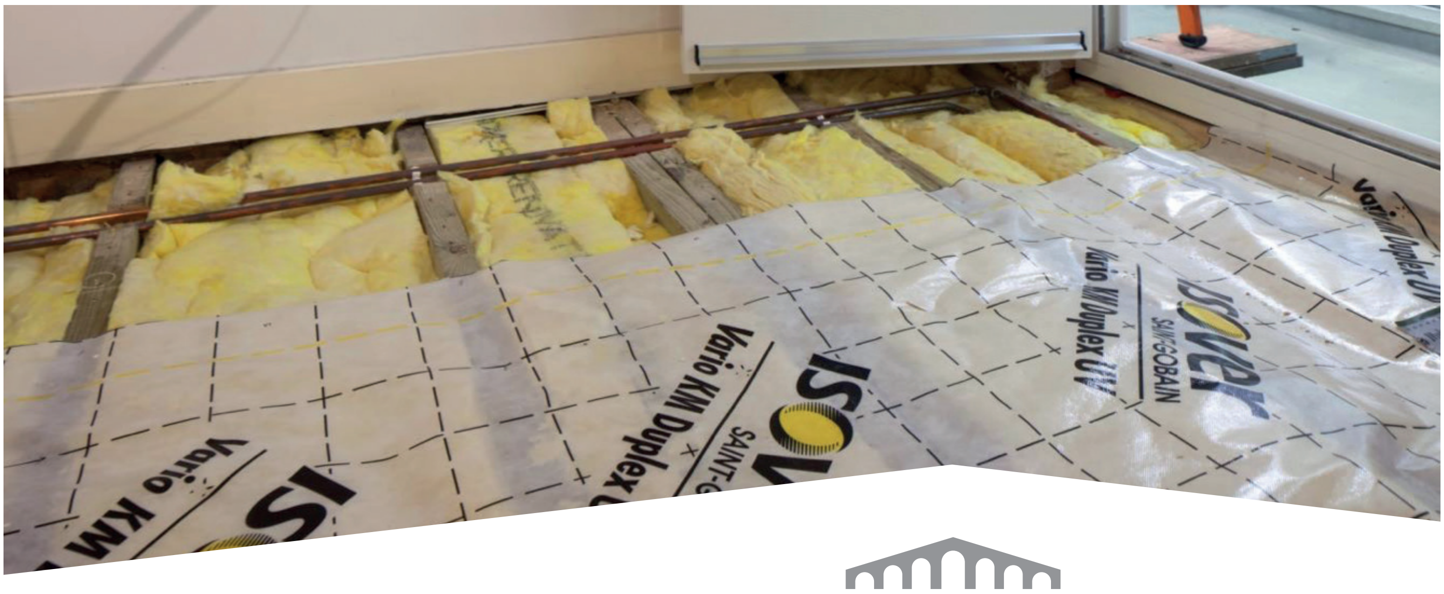
The functionality of “Smart Vapour Retarders”: Isover Vario



40% – 50% relative humidity
=> Vapour retarder
S_d value ˜5,0m



70% – 80% relative humidity
=> Water vapour diffusion open
S_d value = 0,3m



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RISE Awards 2015

Research | Innovation | Sustainability | Enterprise

Award Category: Field and Laboratory Research

Entry: Zero Carbon Hub Overheating Project

What problem is the project addressing

There is now a significant body of evidence to suggest that overheating in homes in England and Wales is happening and is likely to become more commonplace in the coming decades. Up to 20% of homes in England may already be overheating, even in relatively cool summers.

Overheating, in this context, is the term used to describe situations where the conditions in a building become uncomfortably warm or excessively hot because the design of the building makes it more difficult to keep unwanted heat out or effectively remove it - especially during warmer weather.

The critical question raised by stakeholders with the Zero Carbon Hub in early 2014 is whether enough is being done by government and the housing sector to adequately address the issue. If not, then what specific changes to current levels of awareness, processes and legal frameworks will be needed to protect consumers and the industry from the health and financial impacts of overheating?

Strong stakeholder participation and consultation

With the backing and support of six government departments and agencies and 100+ industry and academic stakeholders, this ambitious and exciting project seeks to answer these questions, and in doing so will help to shape the future for overheating policy in England and Wales towards outcomes which are cost-effective and feasible for the industry to deliver.

Building up the big picture

The first Phase of the project which was completed in June 2015 sought to gain an understanding of the scale and severity of overheating at a national level, and to what extent the industry is already gearing up to address the issue.

Questions we asked Housing Providers included:

- How do you define overheating within your organisation?
- Have you had any instances of overheating in the last five years? If so, how did you find out you had an issue? What seemed to be the cause? How was the issue resolved? What was the impact on your organisation?
- Does your organisation have a process in place to assess the risk of your stock overheating the future?
- What motivated your organisation to take action on overheating?
- What changes do you plan to make to your processes in the future to mitigate overheating risk?
- What support do you need from government to manage this issue effectively?

Outputs and impact (so far)

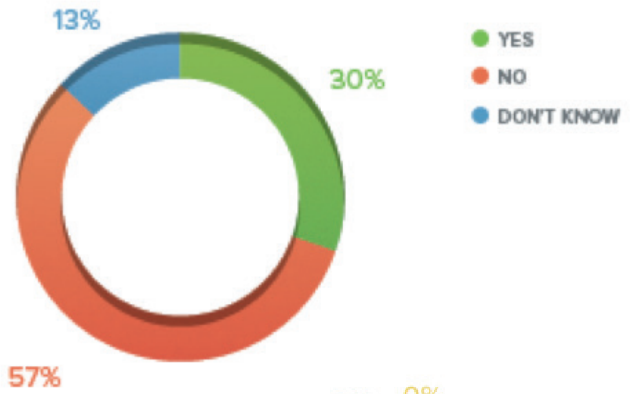
The Zero Carbon Hub is only half way through the project and has already achieved a huge amount of interest and engagement on the issue in both the housing and health sectors, surpassing even our own expectations:

- **Literature review** – Reviewed over 400 research papers and project reports to gain a solid technical understanding of the issue and build on known issues.
- **Industry survey** – Surveyed 75 Housing Providers across England and Wales representing 207,728 homes (with partners Sustainable Homes) to ascertain their level of concern and preparations to address overheating.
- **In-depth interviews** - Interviewed 33 Housing Providers and technical experts to gain a detailed understanding of their processes, barriers to action, and ambitions for the future.
- **Workshops and events** – Raised awareness with hundreds of organisations through 3 industry workshops and events hosted by the Zero Carbon Hub, plus over 20 presentations and webinars. Hundreds of copies of our reports were disseminated at Ecobuild in 2015 alone.
- **Evidence reviews** – Increased the sector's technical understanding of the issue by producing 5 detailed evidence reviews with experts on: defining overheating, assessing overheating risk, overheating risk mapping, impacts of overheating, and (still to be published) technical solutions to overheating (see pg 29 of the Overheating in Homes. – The Big Picture report for the list of partner authors)

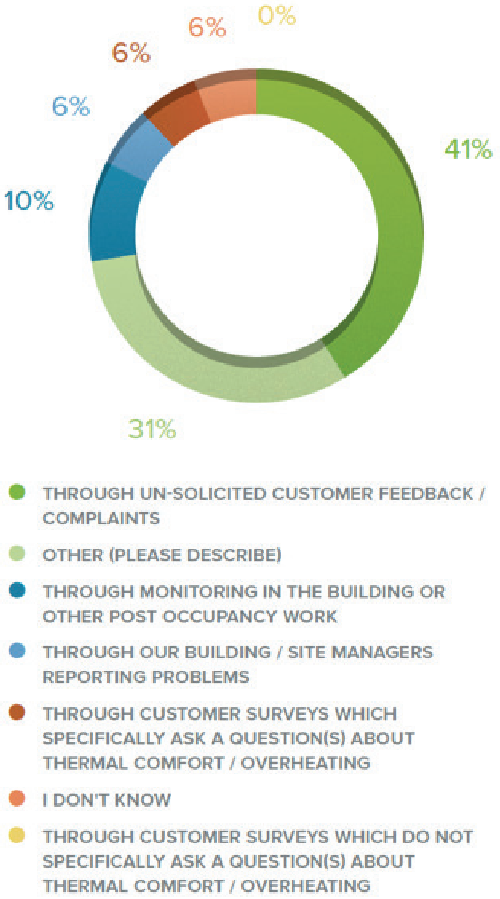
- **Assessment of the big picture** – Overheating in Homes – The Big Picture report was published in June 2015 (www.zerocarbonhub.org/recent-publications). This provides a comprehensive summary of the current position on overheating, including the extent and overall level of preparedness providing a solid baseline for the second phase of the project.

- **Booklets and leaflets** – 3 booklets produced which were tailored towards particular audiences and have been widely disseminated by partners: Overheating Drivers of Change, Monitoring Overheating in Homes, and Local Authorities – Tackling Overheating in Homes.
- **Significant engagement with decision-makers and standard setters** – Including DCLG, DECC, Defra, Department of Health, Environment Agency, Public Health England, Greater London Authority, the Committee on Climate Change, the Environmental Audit Committee, the London Assembly, the NHBC, LABC and CIBSE.

Does your organisation currently specify overheating related requirements in your contracts with architects / designers?



For those who reported experiencing overheating problems in their stock, how did they find out there was a problem?



Next steps

Following this first phase of the project, the industry is very much looking to the Zero Carbon Hub to work with them and with government to move this issue forward and get into a more secure position where the risk of overheating can be truly classed as 'managed' at a national level.

The next, and most important stage, is to focus on solutions – to analyse potential policy responses with the aim of demonstrating to government how it could lower overheating risk exposure for consumers and for Housing Providers in a cost-effective way.

Phase Two of the project (expected to start in December 2015) will for example consider what definition of overheating could be used by the industry as a whole, whether a policy to identify and treat the high risk homes first is feasible, and the pros and cons of a mandatory standard on overheating. The Zero Carbon Hub will also use the learnings from Phase One to produce materials that directly support Housing Providers in deciding how to strengthen their own risk management strategies.

Examples of policy questions we intend to ask in the second phase of the project:

- How can SAP Appendix P be used more effectively to flag up properties with a high risk of overheating?
- How to encourage modeling of overheating risk to be carried out early enough in construction and retrofit projects to influence outcomes?
- How the current body of evidence on the causes of overheating and risk factors can be better utilised in policy frameworks?
- What changes could be needed to current requirements in Part L and F of Building Regulations to provide greater clarity for the sector?
- What might a 'standard' on overheating look like, as being called for by the Committee on Climate Change?
- How can conflicts in requirements and standards which are leading to confusion and potential liabilities for Housing Providers be overcome?
- How can planning policy be used more effectively to prevent overheating cases?

Company Name – Zero Carbon Hub

Contact – Rob Pannell (Managing Director)
or Nicola O'Connor (Project Manager)

Email – rob.pannell@zerocarbonhub.org /
nicola.oconnor@zerocarbonhub.org

ZERO CARBON HUB

SAINT-GOBAIN

RISE Awards 2015

Research | Innovation | Sustainability | Enterprise

Sustainable Developments & Energy

Building a future in energy efficient sustainable housing

Hill is committed to designing and building homes that offer their occupants stylish and contemporary living environments and that help to create appealing and sustainable local communities.

Hill's growth and success since its formation in 1999 has been impressive. The company has been at the forefront of housing innovation and sustainability, constantly striving to improve processes in order to deliver the best possible product for each individual development.

Hill understand that building homes is about far more than just construction and fully embrace their responsibility to enhance landscapes and contribute positively to the lives of the communities in which they work through local initiatives and sponsorships.

Hill has delivered over 200 homes to the highest standard of the Code for Sustainable Homes – level 5. The company can design, build and sign off homes to the standard. However, the company recognizes the need for real post-completion data to validate that the building actually performs as designed, which requires new skills and capability.

The KTP Project in partnership with Leeds Beckett University was implemented in December 2014 to assist in acquiring a specialist in-house sustainability capability. The Project is designed as a mechanism to develop and embed this in-house capability, with a view to working towards a zero carbon target, as required by Government policy by 2016.

The project is being part-funded under a Knowledge Transfer Partnership from Innovate UK and is based at the company's offices in Ickleton, Cambridge. Led by Alex Rice the project is receiving academic support and guidance from the Leeds Sustainability Institute at Leeds Beckett University.

Project Outcomes

- Projected 10% increase in profits
- Reduced costs in external consultancy

Hill
Email: info@hill.co.uk
Phone: 0208 527 1400

Hill

LEEDS BECKETT UNIVERSITY

Leeds Sustainability Institute

SEEDS CONFERENCE
Growth through Collaboration
Sustainable / Ecological / Engineering / Design

Aerial Thermography: Utilising UAV Technology for Thermal Survey Applications

Infrared thermography is a well established technique in building forensics, and is based on the measurement of the radiant thermal energy distribution which is emitted from a target (i.e. a building). If there are any non-homogeneities in the near-surface region of a structural element, the IR camera will show measurable temperature differences, allowing the researcher to locate thermal anomalies in the building fabric (Kylili, Fokaides et al., 2014).

With multiple practical applications, the non-destructive nature of thermography makes it an attractive option for the assessment of buildings, and it is one that the research team at Leeds Beckett have utilised for over a decade.

SkyJib-X4 Test Flight (LBU, 2015)

The development of increasingly smaller, more accurate thermal cameras combined with advances in Unmanned Aerial Vehicles (UAV) has meant that it is now possible to obtain high quality thermal images from a camera the size of a mobile phone, 50m above the ground. This provides a previously unavailable perspective to researchers, enabling both thermal and visual building assessment from an aerial vantage point.

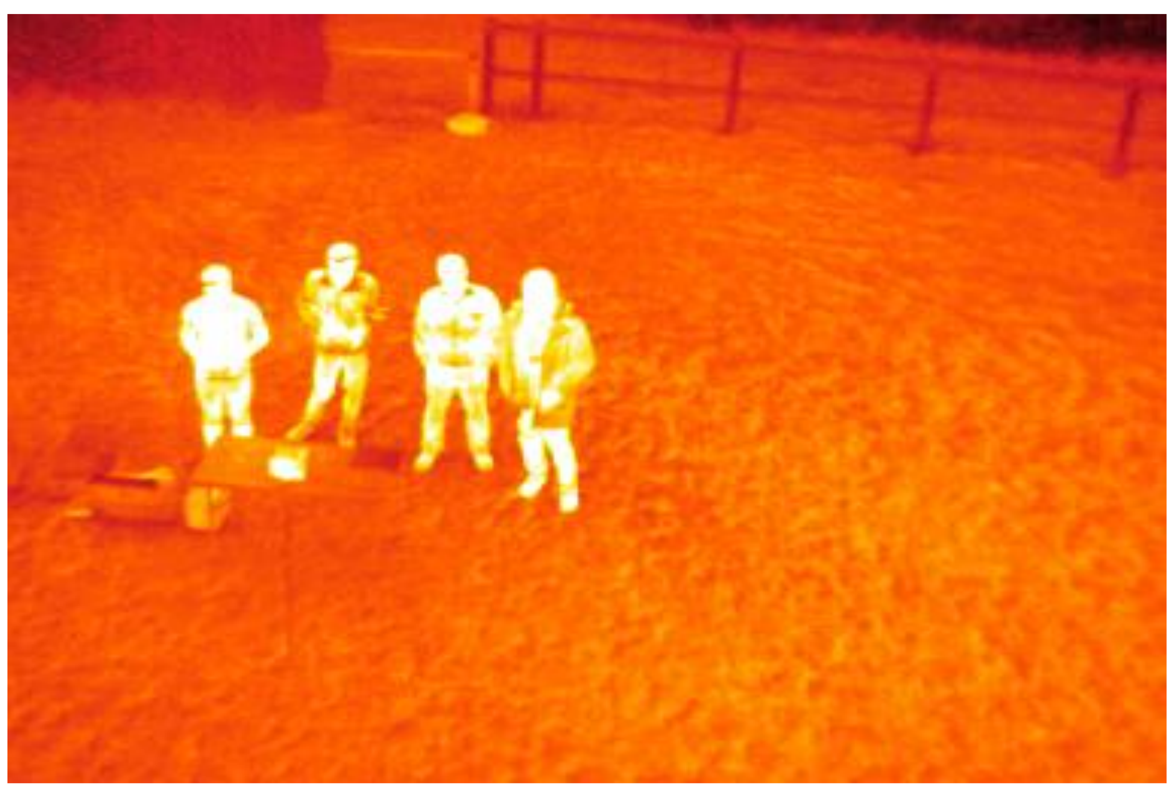
Leeds Beckett have recently procured an Aeronavics SkyJib-X4 drone complete with an Optris Pi450 IR camera. The Pi450 is the smallest thermal camera of its class, but despite its small size is comparable to larger handheld cameras, being thermally sensitive to 40mK and returning a thermal video at 80Hz with an accuracy of ± 2°C (Optris, 2015). The SkyJib-X4 UAV system features an 8 motor coaxial arrangement which gives outstanding stability even in windy conditions (Aeronavics, 2015), and with retractable landing gear and an auto-levelling gimbal allows the researcher to obtain a stable image through a 360° range of motion. The camera and UAV are operated independently of each other and feature separate transmitters, with the pilot controlling the UAV flight and the cameraman controlling the camera gimbal across both horizontal and vertical motion range.

SkyJib-X4 Test Flight (LBU, 2015)

Live thermal and visual video is streamed simultaneously to separate screens on the ground, in addition to being saved locally on the integrated Raspberry Pi computer on-board the UAV.

The system not only allows for thermal anomalies in previously unreachable areas to be detected, but also facilitates the comparison of several buildings within the same thermal image, with feasibly whole housing estates able to be surveyed in one flight.

Drone Equipment (LBU, 2015)



SkyJib-X4 Test Flight (LBU, 2015)

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Kylili, A., et al. (2014). "Infrared thermography (IRT) applications for building diagnostics: A review." Applied Energy **134**: 531-549.
Optris (2015) "Pi450 Technical Specifications" www.Optris.com

Martin Fletcher
Leeds Beckett University
M.F.Fletcher@leedsbeckett.ac.uk

RISE Awards 2015: Design, Innovation & Creativity

Innovations in delivery of Low carbon, high energy efficiency solutions for housing retrofit of Leeds Victorian housing stock

BEGINNINGS

In 2012 LEDA co-wrote the Very Low Carbon Building Improvements Guide for Leeds Victorian Terrace Homes. This was a collaboration between LEDA (architects and building services engineers), Leeds Action to Create Homes (specialist social housing providers carrying out housing improvement with an in-house team and volunteers), and SURE Solid Wall Insulation (specialist installers). It arose out of a collective desire to achieve much higher standards for retrofit of Victorian properties using internal wall insulation (IWI) within tight budgetary constraints. IWI was favoured as it allowed a piecemeal, phased approach that was suited to LATCH's programming restrictions which were dictated by funding for the improvement of new and existing properties.

The guide addresses the process of prioritising measures depending on the particular constraints and gives indications of the likely benefits and costs of the range of measures considered.

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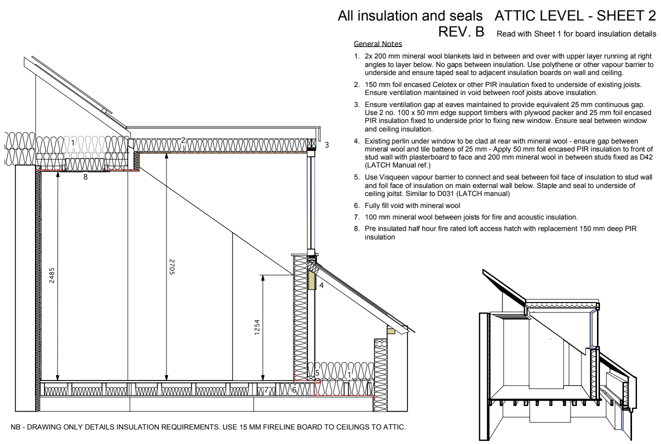

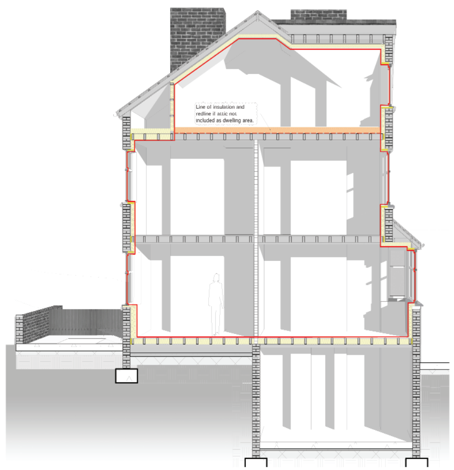

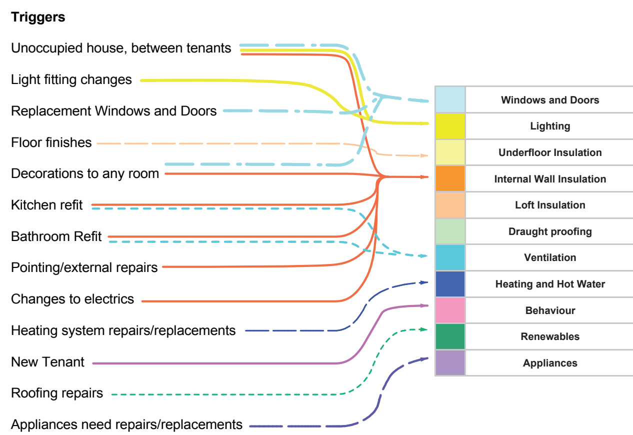

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As well as confirming the moisture build-up as a potential cause of deterioration in any timber within the wall, the modelling yielded some interesting results regarding the effect of insulation on party walls. We found that neighbouring properties with no insulation could be adversely affected by the reduction in temperature of the untreated property's wall surface, leading to possible condensation and mould growth.

Monitoring carried out on similar dwellings also noted the amount of air movement in the 'solid' wall that could have implications for calculations and realtime results.

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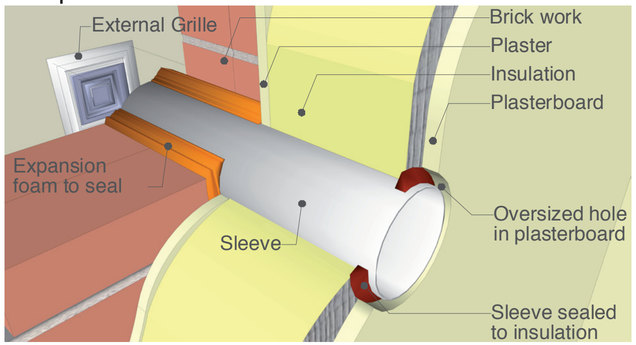

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Thermal Bridging Calculations

Detail:	Party Wall 150 mm Insulation Single Side						
Calc No:	TM/07	**Rev:**	A	**Date:**	Jun-13	**Calc By:**	MP

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Material:	λ:	Source:
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Bricks Inner Leaves	0.560	BR 443
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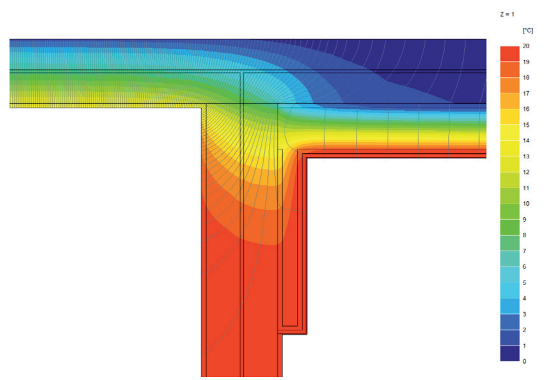

Q:	51.3992	ℓ_j:	1.000	U_w:	0.129	T_{si}:	19.40
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RISE Awards 2015: Sustainable Developments & Energy

Innovations in delivery of Low carbon, high energy efficiency solutions for housing retrofit of Leeds Victorian housing stock

BEGINNINGS

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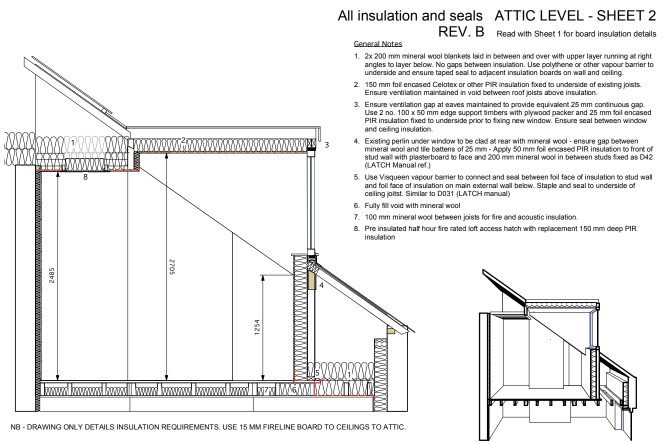

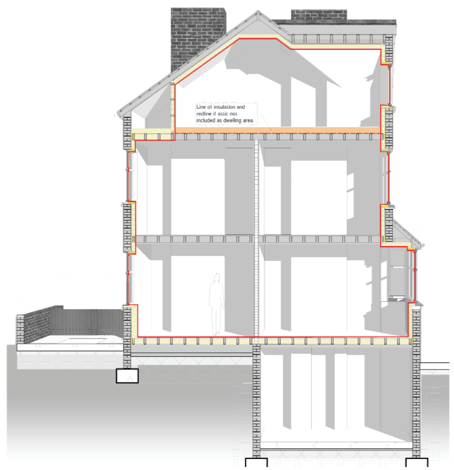

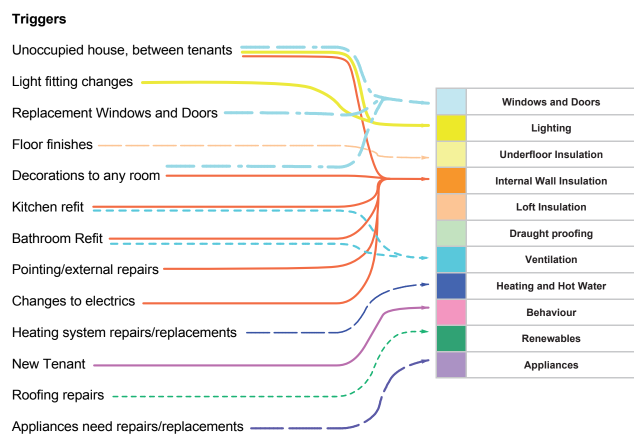

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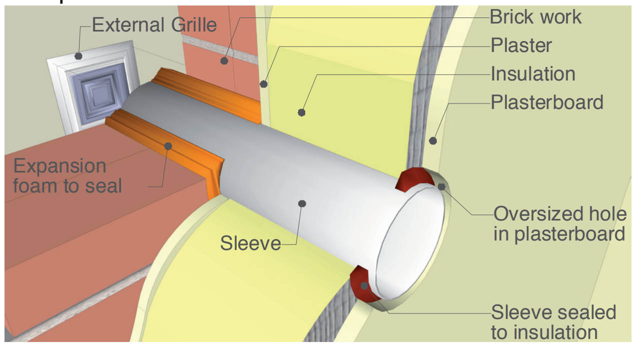

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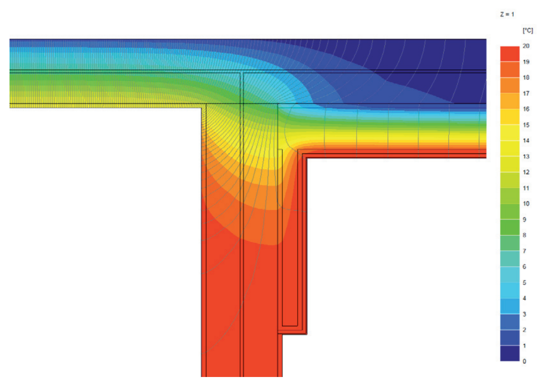

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RISE Awards 2015
Sustainability

Award category: **Behavioural change**

Reducing energy consumption and carbon emissions of our commercial fleet by understanding drivers habits and changing drivers behaviours.

As a major UK construction and infrastructure company, Morgan Sindall is clear in the role that we must undertake to be a sustainable business. Our sustainability strategy is embodied in our six Total Commitments and through these, we aim to continue to deliver against and positively influence the UK's sustainability agenda.

Our Total Commitments are split into three pillars People, Planet and Profit and under each pillar, we have two specific objectives.

Under our People pillar, we have a commitment to reduce energy consumption and carbon emissions and have targeted our commercial vehicle fleet as a way to achieve this commitment.

In 2014, we recorded that our commercial vehicle fleet used nearly 2.4 million litres of diesel per annum and emitted around 6 million tonnes of CO_2. Our initial step towards this commitment was to ensure we were making use of the greenest vehicles possible, whilst still meeting the operational requirements of our business.

PEOPLE

Total commitment to

- a safe environment
- developing talented employees

PLANET

Total commitment to

- reducing energy consumption and carbon emmissions
- reducing waste

PROFIT

Total commitment to

- improving sustainable procurement
- supporting local economic growth

This has gone some way to reducing fuel usage and CO_2e, we have identified that the manner in which a vehicle is driven has a much greater impact.

By utilising telematics data, we found that there was a considerable difference in vehicle utilisation and how they were being driven across the business.

With a new workforce servicing a recently won contract for Western Power Distribution and making up 25% of our commercial vehicle fleet, we targeted this team with a view to improving their driving behaviours and reducing work related road risk, CO_2e and fuel usage.

The first step was to raise awareness of the Telematics system within the driver base and explain how it showed the different types of driver behaviours. This was achieved via talk box talks and the setting up of an automated weekly driving style analysis, mailed directly to each driver.

This was supplemented with a weekly one-to-one with the poorest performing drivers, to discuss their driving style and what they could do to improve it. Vehicles were also fitted with a visual display unit in the cab, to allow drivers to immediately see when they had triggered an event that could increase a road risk to them and other users.

Upto **14%** improvement on **mpg** per annum

Reduced CO_2e by **140 tonnes** per annum

Ongoing saving of **53,000 litres** of fuel per annum

In addition, a league table for each depot was created and posted at each site. This became a talking point amongst drivers, as they were all keen to see their position improve.

League table for group 'Multi' for the period of Aug

Rank	Name	HH:MM	Distance	Event Pattern	Score	Improvement
1	KP64MWX - Roy Shaw	72:54	689.73MI		22	
2	KP64NCX - Liam O' Toole	64:10	1540.92MI		27	
3	KP64NAU - David Clarke	75:48	1073.1MI		32	
4	KP64MWW - Garry Stretton	66:20	1012.09MI		70	
5	KP64MZL Stuart Morgan	78:18	1491.17MI		71	
6	NA13KRX Kevin Blackwell	153:42	2575.79MI		81	
7	KP64MVE James Blacknell	113:59	3930.79MI		92	
8	KP64NCZ - Michael Enright	45:13	747.75MI		201	
9	DV64LFE Darren Reeve	54:22	1086.83MI		240	
10	DV64LFF Glenn Coombes	38:38	1059.32MI		263	

Speeding Cornering Braking Acceleration

A quarterly Tracker Challenge was also initiated with the aim of developing and rewarding best practice on the road. Instances of speeding, harsh braking and acceleration, and severe cornering, for example are scored as well as extended periods of engine idling.

At the end of each quarter, each driver gets a score and the driver with the lowest score is the winner receiving a cash prize and certificates to mark their achievements.

Michael McHugh, team leader on the Western Power Distribution won our quarter one tracker challenge. Michael was also recognised by Mercedes-Benzes for his efforts as he regularly drives a Mercedes-Benz Sprinter.

The results have been very positive. Our overall miles per gallon (mpg) statistics have improved by up to 14% on our three key vehicle types. We have reduced our on-going fuel usage by 53,000 litres per annum and our CO_2e by 140 tonnes. A reduction in vehicle idling time, which is also measured by the telematics system, has further reduced CO_2e by 1.6 tonnes per annum.

These initiatives are now being rolled out to the wider fleet across Morgan Sindall.

EVERYTHING DiSC®

We know that changing behaviours to improve performance requires continually development. Most recently, we have been utilising a behavioural self-development tool called Everything DiSC. The tool provides the employee with a bespoke report that identifies their behavioural characteristics to increase self-awareness. It also defines others behavioural characteristics and how the individual can identify those characteristics understanding where and when they may need to modify their behaviours to increase their workplace effectiveness. Through this tool we are able to identify the qualities of a High Performing Team in each business function and continually drive our cultural development programme.

> "We plan to apply our best practice findings to other contract right across Morgan Sindall. The fleet for this project comprises over 120 vehicles but as the business we have more than 600 vehicles, we believe that huge savings can also be made elsewhere."

John Stephenson
Senior Operations Manager
Western Power Distribution Term Contract
Morgan Sindall Utility Services

Morgan Sindall is a UK construction, infrastructure and design business with a network of local offices. The company works for private and public sector customers on projects and frameworks from £50,000 to over £1 billion. Activities range from small works and repair and maintenance, to the design and delivery of complex construction and engineering projects where it is able to provide specialist design, tunnelling, utilities, building, civil engineering and mechanical and electrical services. The company operates across the commercial, defence, education, energy, healthcare, industrial, leisure, retail, transport and water markets. Morgan Sindall is part of Morgan Sindall Group plc, a leading UK construction and regeneration group with revenue of over £2 billion and which operates through five divisions of construction and infrastructure, fit out, affordable housing, urban regeneration and investments.

John Stephenson, Senior Operations Manager - Morgan Sindall
john.stephenson@morgansindall.com
07887 840 838

THE FORMER DIPLOMAT HOTEL

When Yeme Architects found this derelict former pub for their new home in Bradford, it was a woeful sight. Years of neglect had led to dry rot, vandalism and dereliction.

The design of this total refurbishment aimed to achieve a distinctive, efficient office space at minimal cost, through recycling existing fixtures, sourcing low cost replacement fittings and using recycled parts where possible. The original timber beams and brick chimney walls are complimented by exposed copper piping, reclaimed scaffold board doors and a hand made OSB board chill-out kitchen space.

But this refurbishment was not all about aesthetics, a state of the art AIR SOURCE HEAT PUMP provides heating and hot water, minimising the building's carbon footprint. High thermal mass and double glazed aluminium windows were carefully calculated to help minimise heat loss.

Saving and reusing everything possible from the original entrance doors to the original grand piano is not only good for the environment, it's also a tribute to the building's heritage. The rescue of an RAF TORNADO fighter jet tail fin from the scrapyard and installing it in the reception was possibly a touch indulgent, but as a testimony to British engineering and achievement, we love it.

RISE AWARDS 2015
RESEARCH | INNOVATION | SUSTAINABILITY | ENTERPRISE

AWARD CATEGORY: RISE - COLLYHURST - NEW FACADE DESIGN TECHNOLOGY

Name of Regeneration scheme:
Collyhurst - Northwards Housing

Location of scheme: Rochdale Road, Manchester

Partners involved in scheme: Northwards Housing, ROCKPANEL, ROCKWOOL, Mears Group, Astley Facades Ltd, Vivalda Ltd., Manchester Working Ltd

Value of scheme: £3m

Completion date: June 2015 (6 months on site)

Lying to the north east of the city centre, Collyhurst is one of the most densely populated areas in Manchester, and houses some of the most deprived communities in the country. A major PFI regeneration scheme for the area was scrapped in 2010 and has now been replaced by a more modest plan which will still provide a considerable boost for the local environment and residents. This part of the overall regeneration scheme comprises the refurbishment of four 13 storey tower blocks: Humphries, Roach, Mossbrook and Vauxhall Court.

The council-owned 1960s tower blocks are managed by social landlords Northwards Housing, and funding was secured through the Decent Homes programme and ECO. The refurbishment includes upgrading the thermal performance of the building envelopes to current building regulations, adding insulation, new windows, a new roof covering, and carrying out structural repairs, as well as improving the aesthetic appearance of the blocks with external cladding.

The ROCKPANEL Chameleon boards which have been used on the project have a 6 prism colour base with colours flipping from blues to purples to greens to pinks and to yellows in various lights; changing as the weather does over the course of the day, and as it is viewed from different points. The boards have also been routed with the names of the tower blocks giving an identity to each of the tower blocks with the lettering 'falling' down the sides of the facades over three storeys deep.

The tenants now feel a sense of pride and ownership of the place they live in and the striking effect the ROCKPANEL boards now give to this area of Manchester. The refurbishment has also decreased the cost of fuel bills massively for tenants, thanks to the ROCKWOOL insulation used behind the ROCKPANEL boards, making homes warmer places to be.   On a few facades, solar panels have been used, again to assist in driving down costs of fuel.

The newly refurbished blocks have also revived demand, bringing vacant bedsit flats back into use and helping to ease some of the issues caused by changes to the benefits system.

The social housing in the area had been neglected for decades. By taking tenants views into account, and allowing them to choose the finish of their blocks, it provided an opportunity for them to come together as a community, and to share in the regeneration of their local environment. In turn this gives them an investment in how the area is perceived, and ownership of the improvement in that perception. The improvement will also help to attract more business and greater interest in the area, potentially providing more jobs and a boost to the local economy.

Contact Details:
Jenni Muston, - ROCKPANEL
07824 848916
jenni.muston@rockpanel.co.uk

RISE AWARDS 2015
RESEARCH | INNOVATION | SUSTAINABILITY | ENTERPRISE

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RISE Awards 2015

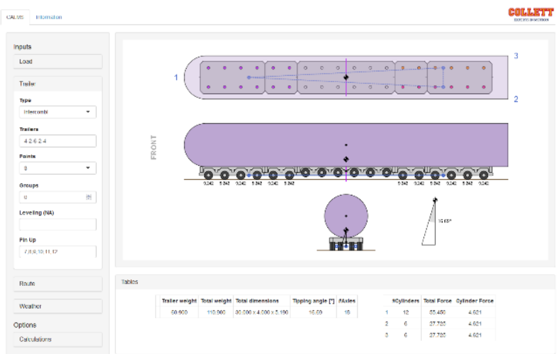
Research | Innovation | Sustainability | Enterprise

Innovation

Designing and developing an integrated system for transportation of abnormal loads

Established in 1928, Collett & Sons is a successful family owned company. Originally a transport company, Collett has developed into a specialist multi-modal logistics operator and has a wealth of experience in transporting and moving difficult loads throughout the UK, Europe and Worldwide.

Through an innovative partnership with Leeds Beckett University the company is embedding new integrated solutions for the movement of abnormal loads. By utilizing mechanical engineering knowledge and expertise in software development the company is developing an integrated system that optimizes the configuration of modular trailers.



The project represents a step change in company capability and is providing:

- Introduction of new technology;
- Enhancement of workforce skills creating increased capacity and associated cost savings;
- Development and embedding of new processes;
- Enhanced technical content for sales proposals that strengthens the company's credibility leading to increased sales;
- Opportunities to provide larger value transport solutions to existing clients.

The project is being part-funded under a Knowledge Transfer Partnership from Innovate UK and is based at the company's offices in Goole. Led by Dr Ruben Escribano the project is receiving academic support and guidance from Dr Andrew Platten and Dr Nick Cope from the Arts, Environment & Technology faculty at Leeds Beckett University.

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PREDICTING THE ACTUAL ENERGY PERFORMANCE OF LOW CARBON BUILDINGS: A CASE STUDY APPROACH

Edward Murphy, Mott MacDonald; Holly Castleton University of Sheffield

ABSTRACT

Recent publicity has highlighted a significant gap between predictions of energy use at the building design stage, and measured results once operational [1]. This so called 'energy performance gap' erodes the credibility of the construction industry in the eyes of its clients, and leads to general public scepticism of new high performance building concepts. A case study approach has compared outturn energy monitoring of a completed speculative air-conditioned office building for comparison with its earlier design stage thermal models in an attempt to discover where the major causes in errors of accuracy in the design and building regulatory compliance processes lie. Verification of the actual energy use of the case study building came after extensive and detailed post occupancy energy monitoring was conducted; to understand how the building performed in practice and how the building's operation compared to its design stage thermal simulation predictions.

The authors of this paper have been working on a test case building in an attempt to understand the key parameters that influence the accuracy of building energy model simulations at the design stage with a view to developing and verifying a more robust building energy prediction methodology. Mott MacDonald (herein known as 'Designer') undertook the design energy use predictions of the building in 2009 for a government client. Since handover of the building in June 2010, a research team, comprising the Designer, The University of Sheffield, and a client representative, have been able to collect two years' worth of half-hourly metered data from 53 energy meters located through the new building for direct comparison with the original concept design thermal model simulation data. The data has been mapped so that each of the metered sub-systems of regulated (use determined by building plant systems and controls) and unregulated (use by determined by occupant's use of office equipment and lifts) can be directly compared.

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The test case building is a modern 10,483 m^2 (GIA) stand alone, comfort cooled, speculative office located in the city centre of Sheffield.

The UK government purchased the modern office building of eight floors over a car-park basement outright from a speculative developer as a Category A shell (see Figure 1). The client then contracted a team of professionals, which included the Designer, to undertake a major fit out to install all partitions, fixtures, and fittings.

Figure 1 Image of case study building

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The building is the second of three major office buildings that form a new modern commercial office district at the city centre of Sheffield. The elevations (see Figure 1) comprise large floor to ceiling argon filled glazed panels set in a steel frame which itself is cladded in Portland stone. Oblique brise soleil is purely of architectural décor value and offers little by way of effective thermal shading to the interior offices.

There are six floors of offices sitting on top of a double height reception. A double height car parking space at basement level and a smaller floor plate café/restaurant and library at roof level "sandwiches" the 6 office floors.

PV panels (see Figure 2) cover approximately 40% of the roof area. Additionally solar thermal hot water producing panels are also located at the southern end of the flat roof.

Figure 2 Image PV array on roof of case study building

DESIGN SIMULATION

Over the timeline of the project from inception in Year 1 to the end of the Post Occupancy Evaluation (POE) in Year 4, three major thermal simulation models were constructed. For the purposes of identification we have come to identify them as Models A, B and C.

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Profile input data for lighting, power, and occupancy was given to the LCA by the POE team and is considered similar to that of Model A and Model C.

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Finally, for the purposes of the most recent Technology Strategy Board (TSB) two year post occupancy research study [4], a substantial update of Model A was undertaken in an attempt to arrive at a model that was a closer reflection of the completed "as-built" building. The updates of Model A to arrive at a more detail Model C included:

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- Update all occupation profiles closely reflect actual occupation of the building.

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Fabric, Plant and Equipment Profile

As mentioned above all models drew from similar base building fabric, plant and equipment profiles. The fabric and unregulated occupancy data included in the models is outlined in summary below. Full detailed data can be found at Appendix A. Table 1 and Table 2 below highlight the key headline data used within the models. The same or similar data was also used in the IES SBEM Model B.

Table 1 Fabric Data

Fabric Data	Description	U-Value (W m^{-2} K^{-1})
Area weighted U-Value	Average weighted area. U-Value	1.9911
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Item	Value	Comment
Lighting Load	16.5 (W m^{-2})	16mm T5 high frequency with PIR and daylight controls
Occupancy Density	0.11 persons m^{-2}	Floor provision can accept 10.7 m^2 per desk
Office Gains	15 W m^{-2}	PC/phones/Tanberg units (150W connected load)
Fresh Air	10 l s^{-1} person^{-1}	CIBSE Norm

Software Upgrade

In Year 3 just as the TSB POE study commenced, DesignBuilder EnergyPlus V2.0.04 was upgraded to a new generation Version 3.02.07 which included the latest EnergyPlus engine V7.3. When run in the new environment, the older version Model A concept stage simulation files were automatically upgraded to run on the updated software; in the process the results were also updated and modified to those obtained when initially run under the older version of the software. Upgrade "readme" notes with the later version of EnergyPlus suggest that the "adaptive comfort" algorithms were modified. Results illustrate that resultant thermal heating and cooling energy totals are slightly higher than those of Model A. For the purposes of this paper all EnergyPlus simulations Model A results are run on the later version of the software to achieve a consensus for comparison across both sets of data.

Post Occupancy Evaluation Study

The post occupancy study was undertaken as part of a wider two-year Technology Strategy Board (TSB) post occupancy evaluation process. The main purpose of the study was to understand where energy was being principally consumed, at what time of day it was consumed and how much energy was used out of hours. The study also looked at the effects of interventions by the FM team on annual energy and to understand user behaviour in response to the building and its design comfort. The study was based upon data downloads of half-hourly energy data from 53 building meters and using CIBSE Technical Manual 22 [5] as a tool to structure the recorded data.

Energy meters were placed on-

- all tenant sub-distribution power boards at each floor level (serving power and fan coils).
- all lighting distribution boards at each floor level
- each plant controls and BMS system distribution panel
- all lift power supplies
- each main chiller
- power supplies to the separable data centre
- cooling supplies to the separable data centre
- photovoltaic array
- sub distribution boards serving the above items
- the main incoming electrical
- incoming district heat meter
- domestic hot water heat meter (non operational)

All meters were connected to an energy monitoring system (EMS). Half-hourly data from each meter was downloaded in CSV format from the EMS system to CIBSE TM22 for analysis yielding a fully authenticated data set with full systematic breakdowns of regulated and unregulated energy use.

DISCUSSION AND RESULT ANALYSIS

Regulated Energy

Figure 3 presents the comparative regulated (dependent on building fabric and comfort systems design) energy outputs for each of modelled scenarios and actual measured in-use data described above. We see that the Model B: EPC SBEM whole building data is substantially lower than the comparative Model A: Stage C Concept thermal model (which as we have seen is not inclusive of the basement area). Closer analysis of the regulatory Model B: EPC SBEM data shows that the breakdown figures are based on a floor area of 19,642 m^2 (which as we have seen is due to the inclusion of ceiling voids as spaces), but air conditioned space is confirmed as just 9996 m^2 which is the correct floor area. Review of Appendix A totals suggest that Model B uses the larger total floor area, and not air conditioned area to arrive at its benchmark total kWh m^{-2} yr^{-1} which is incorrect.

To correct the obvious error in benchmark totals, a new SBEM EPC model was produced by simply using the correct treated (air-conditioned) floor area in lieu of total floor area to generate a corrected model which we labelled as Model B1. Making these changes also serves to put the Model B1 SBEM model on the same or similar footing to our Model A: Stage C thermal model.

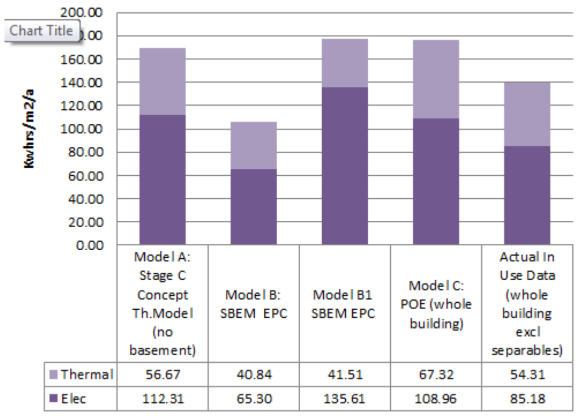

Figure 3 Thermal/Electricity Regulated Energy

Figure 3 illustrates a clear performance gap exists between Model B: the SBEM used to generate the EPC and measured in-use data. The gap is typical of that which is reported to exist across the industry. However, when a correction was made for what was found to be an incorrect floor building area is applied as per Model B1, the energy performance gap is eliminated. Whether this error in floor area was a user or software error is difficult to establish.

Comparisons of Model A at concept (part building), corrected Model B compiled during design (whole building), and updated Model C post occupancy (whole building) all yield good consensus at least in total predicted energy. All are based on the same input data sets and do not give rise to an underestimated energy performance gap.

Scrutiny of the energy splits between thermal heating and electricity illustrates that there is perhaps an issue for the corrected B1 SBEM to address. The B1 SBEM model has significantly underestimated thermal energy and overestimated electricity consumption (Figure 3).

In contrast, Model C, the detailed POE EnergyPlus model is of equal proportion (61% electricity, 39% heating) in its energy splits between thermal and electricity loads to ratio of actual in use energy. This would appear to indicate greater robustness of Model C: POE as a predictor of the actual building performance. In an attempt to provide further validation of the above finding, Figure 4 below looks at the thermal and electricity splits at a granular systematic level.

The chart shows that the performance gap in Model B1 appears to originate in its handling of direct heating and cooling energy. Lighting, Auxiliary and DHW splits all appear to be reasonable. Heating is too small indicating cooling is too large. This could infer that the SBEM model is not aware of the external shading provided externally by tall buildings on three of its four aspects, and/or it is not handling unregulated occupant loads correctly.

As indicated above, the detailed Model C: POE illustrating splits in all energy sectors that are in proportion, though higher than that of the actual measured building.

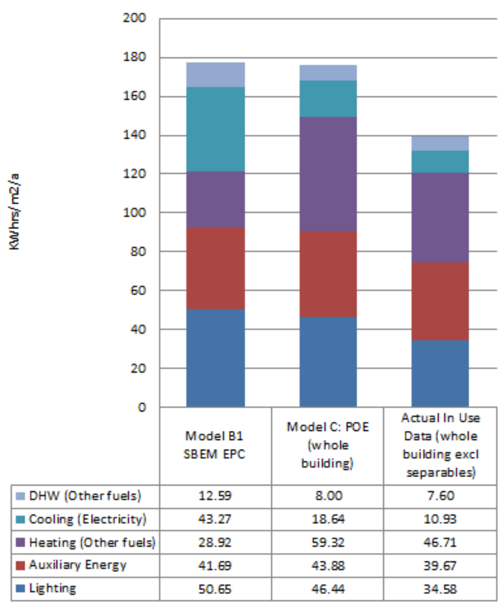

Figure 4 Comparative Thermal Model Regulated Energy showing system sub totals

Unregulated Energy

For Model B1 SBEM or Model A and C: Thermal Models to be completely accurate in predicting actual energy use, both need to include a simulation of user driven "unregulated" energy to add to that of the regulated or building specific energy loads.

This unregulated energy component is purposely omitted from SBEM and EPC published results. To include it is declared by DCLG to detract from the methodology's ability to compare the fabric and installed plant efficiency credentials of similar building types on an equal basis. However, from a building owner's perspective, the absence of likely in-use energy is likely to be an omission, one that contributes to the perceived energy "performance gap".

To determine the degree to which unregulated energy can contribute to the performance gap, Figure 5 below was prepared. The chart includes Model A and Model C thermal model unregulated energy (i.e. that component derived by the occupants in using the buildings facilities, e.g. pcs, lifts, small power, telephones etc.) components.

The unregulated energy components do not include the "separable" data centre energy which is deducted from the total building metered energy totals.

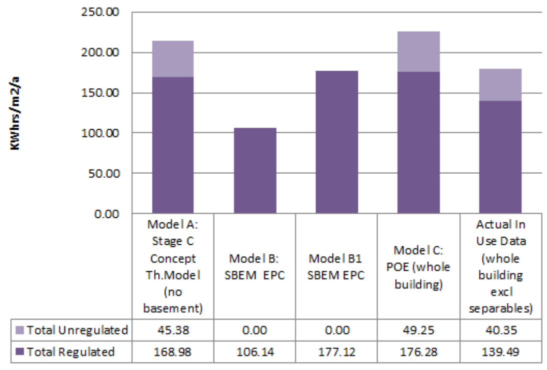

Figure 5 Comparative Thermal Model Regulated and Unregulated Energy

Figure 5 shows that Model B SBEM variants do not include unregulated energy and so can never realistically be deemed to yield a complete prediction of actual energy in use.

Model A the initial "rough and dirty" model yielded a good approximation, even though it was only an estimated representation of the final building. When the model was updated to include the whole of the building, accuracy was increased and the proportions of energy use in each of the systematic splits including unregulated loads increased. Both A and C models as it turned out where conservative. Actual energy use is considerably lower than expected. The reason for this is we believe, solely down to how well the building is managed by the incumbent FM team to include the following items which are not fully represented in Model A or C. The key differences between the model input data and the actual on site situation are:

- Unregulated loads from desktop pc, lifts, telephones, video communications etc. is lower than expected. This is believed to be due to rolling out "thin-client" pc terminals, which reduce installed desktop pc loads by 50%. The client has also introduced "multifunction devices" (MFD) to bring together printing, photocopying and scanning functions into one low energy machine rather than having separate devices each consuming their own individual standby power.
- The reduced unregulated loads also have a knock on impact in reducing cooling energy, and this is reflected in the reduced metered cooling figures. Additionally an intervention to control fresh air volume on return CO_2 levels is not included in the POE model, and this too introduces further significant savings on that predicted. Finally, a decision to turn off the chillers from October to April, has yielded good reduction in energy, albeit at the expense of comfort during some unseasonably warm days in March and October.
- The reduction in fan speed together with close control on hours of operation of heating helps to explain the differential between the POE model and the in-use thermal energy.
- Auxiliary energy from main plant systems is lower due to lower air moving energy than that included in the model, again partially due to the inclusion of CO_2 control.
- Finally, lighting energy in-use is lower than predicted. This is explained by the fact that large parts of the basement, third floor and kitchen are unoccupied for long periods and switched off. This was not anticipated by the thermal model input profiles.

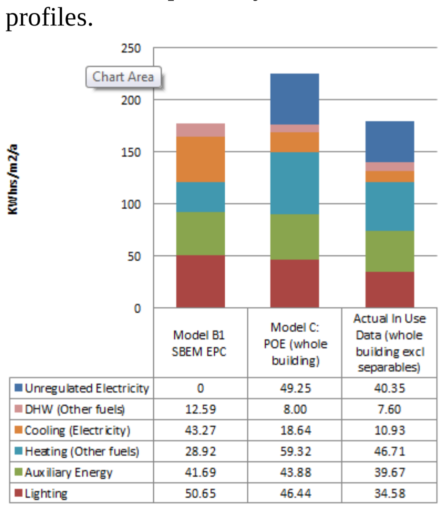

Figure 6 Comparative Thermal Model Regulated and Unregulated Energy showing system sub totals

It is clear therefore that unregulated loads (user defined) are a key component and that failure to understand them properly has impacts on both regulated and unregulated components in predictions of final outturn energy.

Additionally the competency of the management of energy use within the building also has an impact. It could be postulated that without good management practices, energy at the case study building would be close or equal to that indicated in Model C. Thus, good husbandry has reduced energy by up to 20% in the case study building. Conversely, poor husbandry, failure to curtail operating hours, monitor temperature set points, ignore failures in control routines could result in higher energy use than predicted. It is apparent therefore that design energy predictions assume that the building will be operated within the design parameters set for it.

DISCUSSION

In review of the data presented, it is evident that the process of predicting the energy of a building is complex. Buildings by their nature are their own prototypes which introduce many variables that can contribute to the final outturn energy calculation. However, it is also clear, at least in this case study, that regulatory EPCs and SBEM were not conceived to provide complete representations of actual energy use, and so to expect them to fulfil that role is mistaken.

The question therefore is what can be done to close the performance gap and to offer better and more accurate information at the point of procurement or design of a new or refurbishment of an existing building? In attempting to answer this question, this case study has demonstrated that:

- there is a place for introducing full thermal modelling as early as possible. The model should include regulated and unregulated load profiles at the initial concept stage of design. The case study has demonstrated good alignment and management of the design process between the early stage thermal model as defined at Stage C and that measured at final handover and occupation of the building.
- to produce even better accuracy, thermal models need to be better informed by a knowledge of how well the building will be managed when in use. It is perhaps prudent therefore that designers do not offer a single figure value as a predictor of building energy performance. It is postulated that a value with error bars is produced based on a statistical analysis, to reflect the parameters and extents of good or bad building operational management, and that this would be a more appropriate representation format.
- in order to better inform models, more POE research is needed to compile the data necessary to close the gap between design and actual building occupancy profiles.
- To bring about closure of the performance gap, every building should have its own compliance virtual thermal model which is continually adapted and updated from inception to end of life, into EPC and through to DEC.

CONCLUSION

This paper has been prepared to address the reasons for the so called 'energy performance gap', a modern feature of the property and construction industry which erodes the credibility of the industry in the eyes of its clients, leading to some concerns that it cannot deliver on its low carbon promises.

There is a need within the industry to understand the degree of sophistication required in order to bring more accuracy to the whole process of predicting the final energy use and carbon emissions of the proposed building. The so-called "Simplified Building Model" approach does not include the level of sophistication necessary to meet the challenges presented by even simple prototype buildings. What is required is a methodology that employs full dynamic simulation and is updated through design and into post occupancy.

Thermal modelling software tools such as Designbuilder/EnergyPlus and others can provide closer virtual representations of the proposed building and have been proven to generate the levels of accuracy that are acceptable not only to designers but also to vendors and occupants.

The construction of a thermal model is only ever as good as the quality of the inputted information. The key variables are those of occupancy, controls and usage profiles. To assist in creating a level of "accuracy" for this unregulated data input, the case study recommends that thermal models are continually updated to include actual in use profiles of the building and that this then becomes the benchmark energy target for the building EPC and DEC compliance documentation.

Design energy benchmarks should also include error bars to represent the variation in outturn energy expected for good and poor maintenance and operation of the building. More post occupancy evaluation is essential in order to better inform thermal model in use profiles.

ACKNOWLEDGEMENTS

This paper has been produced based on research funded by the Technology Strategy Board Building Performance Evaluation Programme in conjunction with EPSRC funded research as part of the Energy Futures Doctoral Training Centre at the University of Sheffield. The authors give additional thanks to Craig Ellin at the case study building and to Michelle O'Neil at Mott MacDonald for their vital assistance in this research.

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CONTACT DETAILS

Eddie Murphy
Mott MacDonald
Mott MacDonald House
111 St Mary's Road
Sheffield
S2 4AP
T: 0114 2283923
E: edward.murphy@mottmac.com

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In Year 3 just as the TSB POE study commenced, DesignBuilder EnergyPlus V2.0.04 was upgraded to a new generation Version 3.02.07 which included the latest EnergyPlus engine V7.3. When run in the new environment, the older version Model A concept stage simulation files were automatically upgraded to run on the updated software; in the process the results were also updated and modified to those obtained when initially run under the older version of the software. Upgrade “readme” notes with the later version of EnergyPlus suggest that the “adaptive comfort” algorithms were modified. Results illustrate that resultant thermal heating and cooling energy totals are slightly higher than those of Model A. For the purposes of this paper all EnergyPlus simulations Model A results are run on the later version of the software to achieve a consensus for comparison across both sets of data.

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- all tenant sub-distribution power boards at each floor level (serving power and fan coils).
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- power supplies to the separable data centre
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- domestic hot water heat meter (non operational)

All meters were connected to an energy monitoring system (EMS). Half-hourly data from each meter was downloaded in CSV format from the EMS system to CIBSE TM22 for analysis yielding a fully authenticated data set with full systematic breakdowns of regulated and unregulated energy use.

DISCUSSION AND RESULT ANALYSIS

Regulated Energy

Figure 3 presents the comparative regulated (dependent on building fabric and comfort systems design) energy outputs for each of modelled scenarios and actual measured in-use data described above. We see that the Model B: EPC SBEM whole building data is substantially lower than the comparative Model A: Stage C Concept thermal model (which as we have seen is not inclusive of the basement area). Closer analysis of the regulatory Model B: EPC SBEM data shows that the breakdown figures are based on a floor area of 19,642 m^2 (which as we have seen is due to the inclusion of ceiling voids as spaces), but air conditioned space is confirmed as just 9996 m^2 which is the correct floor area. Review of Appendix A totals suggest that Model B uses the larger total floor area, and not air conditioned area to arrive at its benchmark total kWh m^{-2} yr^{-1} which is incorrect.

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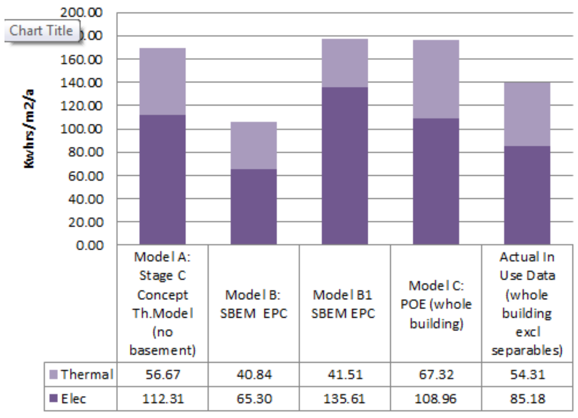

Figure 3 Thermal/Electricity Regulated Energy

Figure 3 illustrates a clear performance gap exists between Model B: the SBEM used to generate the EPC and measured in-use data. The gap is typical of that which is reported to exist across the industry. However, when a correction was made for what was found to be an incorrect floor building area is applied as per Model B1, the energy performance gap is eliminated. Whether this error in floor area was a user or software error is difficult to establish.

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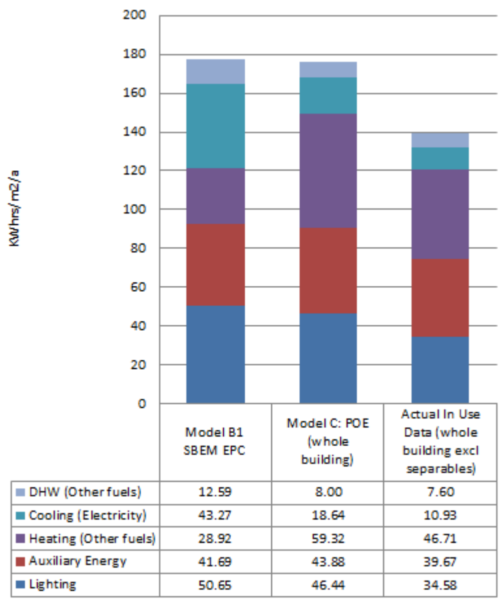

Figure 4 Comparative Thermal Model Regulated Energy showing system sub totals

Unregulated Energy

For Model B1 SBEM or Model A and C: Thermal Models to be completely accurate in predicting actual energy use, both need to include a simulation of user driven “unregulated” energy to add to that of the regulated or building specific energy loads.

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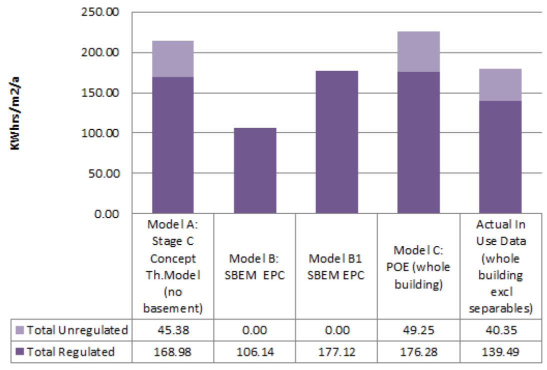

Figure 5 Comparative Thermal Model Regulated and Unregulated Energy

Figure 5 shows that Model B SBEM variants do not include unregulated energy and so can never realistically be deemed to yield a complete prediction of actual energy in use.

Model A the initial "rough and dirty" model yielded a good approximation, even though it was only an estimated representation of the final building. When the model was updated to include the whole of the building, accuracy was increased and the proportions of energy use in each of the systematic splits including unregulated loads increased. Both A and C models as it turned out where conservative. Actual energy use is considerably lower than expected. The reason for this is we believe, solely down to how well the building is managed by the incumbent FM team to include the following items which are not fully represented in Model A or C. The key differences between the model input data and the actual on site situation are:

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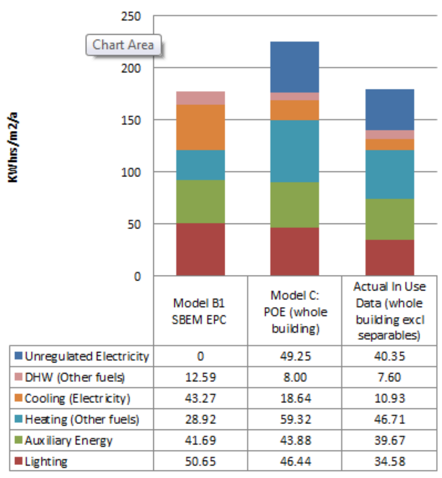

Figure 6 Comparative Thermal Model Regulated and Unregulated Energy showing system sub totals

It is clear therefore that unregulated loads (user defined) are a key component and that failure to understand them properly has impacts on both regulated and unregulated components in predictions of final outturn energy.

Additionally the competency of the management of energy use within the building also has an impact. It could be postulated that without good management practices, energy at the case study building would be close or equal to that indicated in Model C. Thus, good husbandry has reduced energy by up to 20% in the case study building. Conversely, poor husbandry, failure to curtail operating hours, monitor temperature set points, ignore failures in control routines could result in higher energy use than predicted. It is apparent therefore that design energy predictions assume that the building will be operated within the design parameters set for it.

DISCUSSION

In review of the data presented, it is evident that the process of predicting the energy of a building is complex. Buildings by their nature are their own prototypes which introduce many variables that can contribute to the final outturn energy calculation. However, it is also clear, at least in this case study, that regulatory EPCs and SBEM were not conceived to provide complete representations of actual energy use, and so to expect them to fulfil that role is mistaken.

The question therefore is what can be done to close the performance gap and to offer better and more accurate information at the point of procurement or design of a new or refurbishment of an existing building? In attempting to answer this question, this case study has demonstrated that:

- there is a place for introducing full thermal modelling as early as possible. The model should include regulated and unregulated load profiles at the initial concept stage of design. The case study has demonstrated good alignment and management of the design process between the early stage thermal model as defined at Stage C and that measured at final handover and occupation of the building.
- to produce even better accuracy, thermal models need to be better informed by a knowledge of how well the building will be managed when in use. It is perhaps prudent therefore that designers do not offer a single figure value as a predictor of building energy performance. It is postulated that a value with error bars is produced based on a statistical analysis, to reflect the parameters and extents of good or bad building operational management, and that this would be a more appropriate representation format.
- in order to better inform models, more POE research is needed to compile the data necessary to close the gap between design and actual building occupancy profiles.
- To bring about closure of the performance gap, every building should have its own compliance virtual thermal model which is continually adapted and updated from inception to end of life, into EPC and through to DEC.

CONCLUSION

This paper has been prepared to address the reasons for the so called 'energy performance gap', a modern feature of the property and construction industry which erodes the credibility of the industry in the eyes of its clients, leading to some concerns that it cannot deliver on its low carbon promises.

There is a need within the industry to understand the degree of sophistication required in order to bring more accuracy to the whole process of predicting the final energy use and carbon emissions of the proposed building. The so-called "Simplified Building Model" approach does not include the level of sophistication necessary to meet the challenges presented by even simple prototype buildings. What is required is a methodology that employs full dynamic simulation and is updated through design and into post occupancy.

Thermal modelling software tools such as Designbuilder/EnergyPlus and others can provide closer virtual representations of the proposed building and have been proven to generate the levels of accuracy that are acceptable not only to designers but also to vendors and occupants.

The construction of a thermal model is only ever as good as the quality of the inputted information. The key variables are those of occupancy, controls and usage profiles. To assist in creating a level of "accuracy" for this unregulated data input, the case study recommends that thermal models are continually updated to include actual in use profiles of the building and that this then becomes the benchmark energy target for the building EPC and DEC compliance documentation.

Design energy benchmarks should also include error bars to represent the variation in outturn energy expected for good and poor maintenance and operation of the building. More post occupancy evaluation is essential in order to better inform thermal model in use profiles.

ACKNOWLEDGEMENTS

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CONTACT DETAILS

Eddie Murphy
Mott MacDonald
Mott MacDonald House
111 St Mary's Road
Sheffield
S2 4AP
T: 0114 2283923
E: edward.murphy@mottmac.com

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PREDICTING THE ACTUAL ENERGY PERFORMANCE OF LOW CARBON BUILDINGS: A CASE STUDY APPROACH

Edward Murphy, Mott MacDonald; Holly Castleton University of Sheffield

ABSTRACT

Recent publicity has highlighted a significant gap between predictions of energy use at the building design stage, and measured results once operational [1]. This so called 'energy performance gap' erodes the credibility of the construction industry in the eyes of its clients, and leads to general public scepticism of new high performance building concepts. A case study approach has compared outturn energy monitoring of a completed speculative air-conditioned office building for comparison with its earlier design stage thermal models in an attempt to discover where the major causes in errors of accuracy in the design and building regulatory compliance processes lie. Verification of the actual energy use of the case study building came after extensive and detailed post occupancy energy monitoring was conducted; to understand how the building performed in practice and how the building's operation compared to its design stage thermal simulation predictions.

The authors of this paper have been working on a test case building in an attempt to understand the key parameters that influence the accuracy of building energy model simulations at the design stage with a view to developing and verifying a more robust building energy prediction methodology. Mott MacDonald (herein known as 'Designer') undertook the design energy use predictions of the building in 2009 for a government client. Since handover of the building in June 2010, a research team, comprising the Designer, The University of Sheffield, and a client representative, have been able to collect two years' worth of half-hourly metered data from 53 energy meters located through the new building for direct comparison with the original concept design thermal model simulation data. The data has been mapped so that each of the metered sub-systems of regulated (use determined by building plant systems and controls) and unregulated (use by determined by occupant's use of office equipment and lifts) can be directly compared.

BUILDING DESCRIPTION

The test case building is a modern 10,483 m^2 (GIA) stand alone, comfort cooled, speculative office located in the city centre of Sheffield.

The UK government purchased the modern office building of eight floors over a car-park basement outright from a speculative developer as a Category A shell (see Figure 1). The client then contracted a team of professionals, which included the Designer, to undertake a major fit out to install all partitions, fixtures, and fittings.

Figure 1 Image of case study building

Architecture and Layout

The building is the second of three major office buildings that form a new modern commercial office district at the city centre of Sheffield. The elevations (see Figure 1) comprise large floor to ceiling argon filled glazed panels set in a steel frame which itself is cladded in Portland stone. Oblique brise soleil is purely of architectural décor value and offers little by way of effective thermal shading to the interior offices.

There are six floors of offices sitting on top of a double height reception. A double height car parking space at basement level and a smaller floor plate café/restaurant and library at roof level "sandwiches" the 6 office floors.

PV panels (see Figure 2) cover approximately 40% of the roof area. Additionally solar thermal hot water producing panels are also located at the southern end of the flat roof.

Figure 2 Image PV array on roof of case study building

DESIGN SIMULATION

Over the timeline of the project from inception in Year 1 to the end of the Post Occupancy Evaluation (POE) in Year 4, three major thermal simulation models were constructed. For the purposes of identification we have come to identify them as Models A, B and C.

Model A: Concept Stage Model

The first virtual building thermal model simulation was constructed at concept stage shortly after the commencement of the Designer's design commission in Year 1. The simulation established the likely in-use energy consumption patterns of the purchased building. The model formed a benchmark comparator for the testing of several energy efficiency options appraisals undertaken as part of the early concept design and optioneering process.

The initial concept stage "quick and dirty" model was constructed over the period of just two days, performed a fast assessment of the building's behaviour and the life cycle costs of a number of fabric and renewables options.

The thermal model was built in EnergyPlus with a Designbuilder interface which includes drop down menus as a means of inputting Construction, Openings, Activity, Lighting and HVAC profiles. Within the software, operational profiles can be set at building, zone or room level. Screen shots of the settings are included in Appendix A together with a screen shot of the model.

Model B: Building Regulations Part L: NCM SBEM Model

The second model was a regulation Simplified Building Model (SBEM) for demonstration of compliance with building regulation and BREEAM rating purposes. The model constructed to run the National Calculation Methodology algorithm was constructed in the approved software of IES Virtual Environment VE SBEM.

To gain statutory approval the software is required to perform data handling and calculations in a prescriptive manner as outlined by the UK Government Department of Communities and Local Government (DCLG). The prescriptive calculation is referred to as a Simplified Building Energy Model or SBEM. Full details of the algorithm and the methodology by which the software arrives at energy and carbon prediction is outlined in *DCLG technical manual for SBEM* [3].

The case study building when subjected to the SBEM calculation achieved an EPC rating of B at 44. The calculated building emission rate is **27.63 $kgCO_2\ m^{-2}\ yr^{-1}$** against a typical of **64 $kgCO_2\ m^{-2}\ yr^{-1}$** if notionally built.

The model was constructed by an approved Low Carbon Assessor (LCA) who was not part of the design team. For this reason, access to interrogate the key parameters behind the compliance SBEM model is not available to the authors of this paper. However, a hard copy of the energy breakdowns taken from the model shows that the modelled building area for EPC purposes is 9996.4 m^2.

All of the retail spaces as well as the basement area (with relevant assumptions for energy use) are included in the SBEM calculation. Separable energy for the IT and cooling of the data centre in the basement is excluded. Lighting load in the data centre and adjoining occupied areas of the basement is included.

Profile input data for lighting, power, and occupancy was given to the LCA by the POE team and is considered similar to that of Model A and Model C.

Model C: Post Occupancy Evaluation (POE)

Finally, for the purposes of the most recent Technology Strategy Board (TSB) two year post occupancy research study [4], a substantial update of Model A was undertaken in an attempt to arrive at a model that was a closer reflection of the completed "as-built" building. The updates of Model A to arrive at a more detail Model C included:

- addition of the basement areas including the data centre, plant rooms, stores, and occupied areas
- updates to the third floor to include the large meeting spaces and conferencing suite zones.
- addition of kitchen, library spaces, and level 7 ventilation plantroom as distinct control zones.
- improve the zoning of offices to suit sub meter zoning, allowing modelled zone energy data to be directly compared with sub meter data
- remove the adjacent 14-story building included in Model A, to reflect the fact that its planned construction has not yet taken place due to the 2007/2008 property recession.

- Update all occupation profiles closely reflect actual occupation of the building.

The design team were aware that the client had a desire to roll-out the installation of low energy “thin client” IT desktop terminal on levels 3 to 6 of the building. However, this was not included in the updated models as it was considered at the time of construction of the model to have not been representative of the current “as-fitted” installation. Subsequently however, the rollout was implemented such that by the end of the two-year study three offices floors included the “thin client” desktop technology.

Fabric, Plant and Equipment Profile

As mentioned above all models drew from similar base building fabric, plant and equipment profiles. The fabric and unregulated occupancy data included in the models is outlined in summary below. Full detailed data can be found at Appendix A. Table 1 and Table 2 below highlight the key headline data used within the models. The same or similar data was also used in the IES SBEM Model B.

Table 1 Fabric Data

Fabric Data	Description	U-Value (W m^{-2} K^{-1})
Area weighted U-Value	Average weighted area. U-Value	1.9911
Wall	87mm Portland Stone, 100 mm insulation, 102mm block, plaster	0.214
Glass	87% 4mm clear glass, argon, 4 mm k-glass in aluminium frame	2.2
Floor	Concrete slab on 100 mm phenolic foam.	0.217
Roof	Metal deck supporting 150 mm concrete, 100 mm phenolic block and 50 mm concrete tiles	0.35
Airtightness (AC h^{-1})	Specified 10	Achieved 8.77

Table 2 Unregulated Profile Data

Item	Value	Comment
Lighting Load	16.5 (W m^{-2})	16mm T5 high frequency with PIR and daylight controls
Occupancy Density	0.11 persons m^{-2}	Floor provision can accept 10.7 m^2 per desk
Office Gains	15 W m^{-2}	PC/phones/Tanberg units (150W connected load)
Fresh Air	10 l s^{-1} $person^{-1}$	CIBSE Norm

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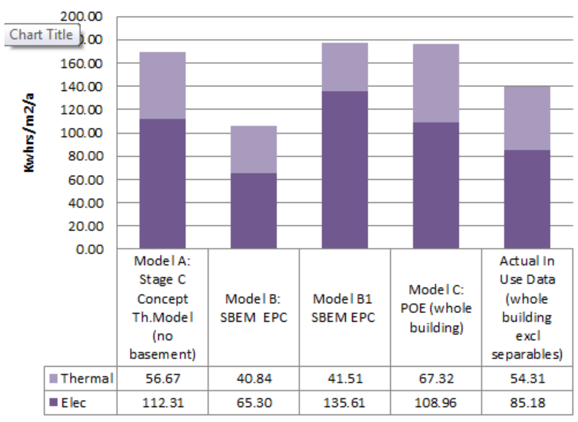

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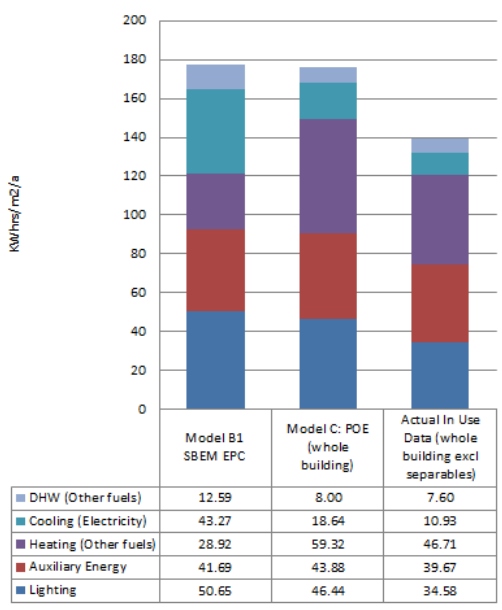

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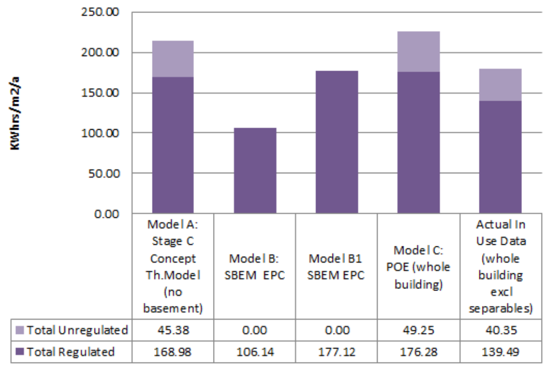

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- Auxiliary energy from main plant systems is lower due to lower air moving energy than that included in the model, again partially due to the inclusion of CO_2 control.
- Finally, lighting energy in-use is lower than predicted. This is explained by the fact that large parts of the basement, third floor and kitchen are unoccupied for long periods and switched off. This was not anticipated by the thermal model input profiles.

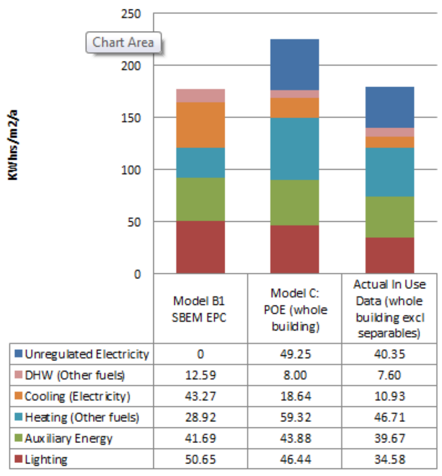

Figure 6 Comparative Thermal Model Regulated and Unregulated Energy showing system sub totals

It is clear therefore that unregulated loads (user defined) are a key component and that failure to understand them properly has impacts on both regulated and unregulated components in predictions of final outturn energy.

Additionally the competency of the management of energy use within the building also has an impact. It could be postulated that without good management practices, energy at the case study building would be close or equal to that indicated in Model C. Thus, good husbandry has reduced energy by up to 20% in the case study building. Conversely, poor husbandry, failure to curtail operating hours, monitor temperature set points, ignore failures in control routines could result in higher energy use than predicted. It is apparent therefore that design energy predictions assume that the building will be operated within the design parameters set for it.

DISCUSSION

In review of the data presented, it is evident that the process of predicting the energy of a building is complex. Buildings by their nature are their own prototypes which introduce many variables that can contribute to the final outturn energy calculation. However, it is also clear, at least in this case study, that regulatory EPCs and SBEM were not conceived to provide complete representations of actual energy use, and so to expect them to fulfil that role is mistaken.

The question therefore is what can be done to close the performance gap and to offer better and more accurate information at the point of procurement or design of a new or refurbishment of an existing building? In attempting to answer this question, this case study has demonstrated that:

- there is a place for introducing full thermal modelling as early as possible. The model should include regulated and unregulated load profiles at the initial concept stage of design. The case study has demonstrated good alignment and management of the design process between the early stage thermal model as defined at Stage C and that measured at final handover and occupation of the building.
- to produce even better accuracy, thermal models need to be better informed by a knowledge of how well the building will be managed when in use. It is perhaps prudent therefore that designers do not offer a single figure value as a predictor of building energy performance. It is postulated that a value with error bars is produced based on a statistical analysis, to reflect the parameters and extents of good or bad building operational management, and that this would be a more appropriate representation format.
- in order to better inform models, more POE research is needed to compile the data necessary to close the gap between design and actual building occupancy profiles.
- To bring about closure of the performance gap, every building should have its own compliance virtual thermal model which is continually adapted and updated from inception to end of life, into EPC and through to DEC.

CONCLUSION

This paper has been prepared to address the reasons for the so called 'energy performance gap', a modern feature of the property and construction industry which erodes the credibility of the industry in the eyes of its clients, leading to some concerns that it cannot deliver on its low carbon promises.

There is a need within the industry to understand the degree of sophistication required in order to bring more accuracy to the whole process of predicting the final energy use and carbon emissions of the proposed building. The so-called "Simplified Building Model" approach does not include the level of sophistication necessary to meet the challenges presented by even simple prototype buildings. What is required is a methodology that employs full dynamic simulation and is updated through design and into post occupancy.

Thermal modelling software tools such as Designbuilder/EnergyPlus and others can provide closer virtual representations of the proposed building and have been proven to generate the levels of accuracy that are acceptable not only to designers but also to vendors and occupants.

The construction of a thermal model is only ever as good as the quality of the inputted information. The key variables are those of occupancy, controls and usage profiles. To assist in creating a level of "accuracy" for this unregulated data input, the case study recommends that thermal models are continually updated to include actual in use profiles of the building and that this then becomes the benchmark energy target for the building EPC and DEC compliance documentation.

Design energy benchmarks should also include error bars to represent the variation in outturn energy expected for good and poor maintenance and operation of the building. More post occupancy evaluation is essential in order to better inform thermal model in use profiles.

ACKNOWLEDGEMENTS

This paper has been produced based on research funded by the Technology Strategy Board Building Performance Evaluation Programme in conjunction with EPSRC funded research as part of the Energy Futures Doctoral Training Centre at the University of Sheffield. The authors give additional thanks to Craig Ellin at the case study building and to Michelle O'Neil at Mott MacDonald for their vital assistance in this research.

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[3] Building Research Establishment (2010), available from: SBEM Manual: http://www.ncm.bre.co.uk/filelibrary/SBEM_Technical_Manual_v3.5.a_01Mar10.pdf. Date accessed: 01/2014

CONTACT DETAILS

Eddie Murphy
Mott MacDonald
Mott MacDonald House
111 St Mary's Road
Sheffield
S2 4AP
T: 0114 2283923
E: edward.murphy@mottmac.com

MassBespoke™

RISE AWARDS 2015
AWARD CATEGORY 2 : WHOLE BUILDING SOLUTIONS

MASSBESPOKE™ OVERVIEW

This project developes a MassBespoke™ construction system, that joins parametric design & digital prefabrication to assist self/custom home builders. MassBespoke™ enables ease of construction & allows distributed fabrication, so those with limited experience can build to a high quality, meeting Passivhaus standards where desired, at a lower cost than traditional building methods.

Whilst discussing prefabricated houses to meet the housing crisis, Design for Homes' David Birkbeck said: *'Prefab works well if you have extensive repetition. But we don't do repetition in the UK because... of oddly shaped pieces of land requiring sensitive responses… we have yet to see a successful example that has broken out from the niche.'* MassBespoke™ addresses this issue by incorporating parametric design into a system that outputs bespoke, modular, prefabricated houses, the issue of varying land shape & form is ameliorated by overcoming the previous constraints of repetition. MassBespoke™ brings increased level of cost/build certainty to early design stages, making building easier to engage with.

Bauman Lyons Architects are leading the proof of concept research working in a multidisciplinary team funded by a research grant from Innovate UK. Bauman Lyons Architects are also leading on a second Innovate UK funded feasibility project, working in partnership with Citu Developments, to integrate other, tier 2 suppliers into the MassBespoke™' design and to develop browser based platform for the system.

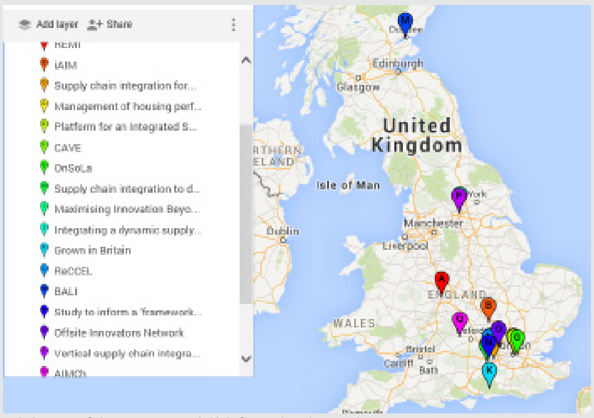
INNOVATE UK FUNDING

MassBespoke™ has recieved two phases of funding:

Innovate UK SMART R&D proof of concept
and
Innovate UK Supply Chain Integration

GOING FORWARD

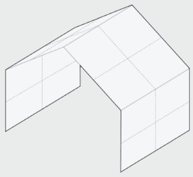
We are planning to apply for SMART R&D grant to build a prototype in 2016 on the Citu owned site in Leeds. We are keen to grow culture of innovation within the construction industry in the North of England as recent statistics show we are lagging significantly behind the south in this respect.



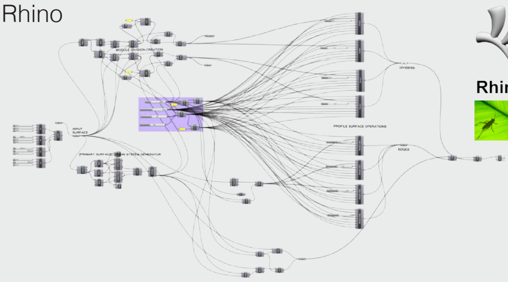
Map of Innovate UK funded projects

SYSTEM OVERVIEW

1) Any given faceted form generated in BIM or other 3D software, such as SketchUp

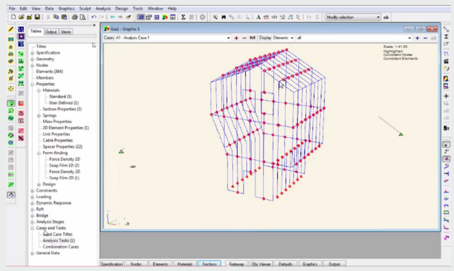


2) Digital design phase using Grasshopper plug-in for Rhino

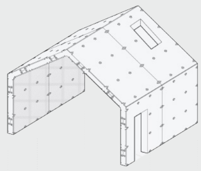


Rhinoceros
Grasshopper

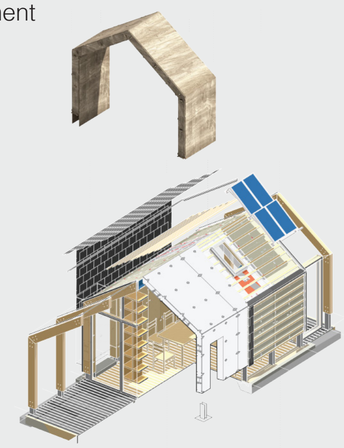
3) Engineering design is processed automatically, including building regulations reports



4) A fabrication model is generated



5) Parts are manufactured and assembled in a factory environment

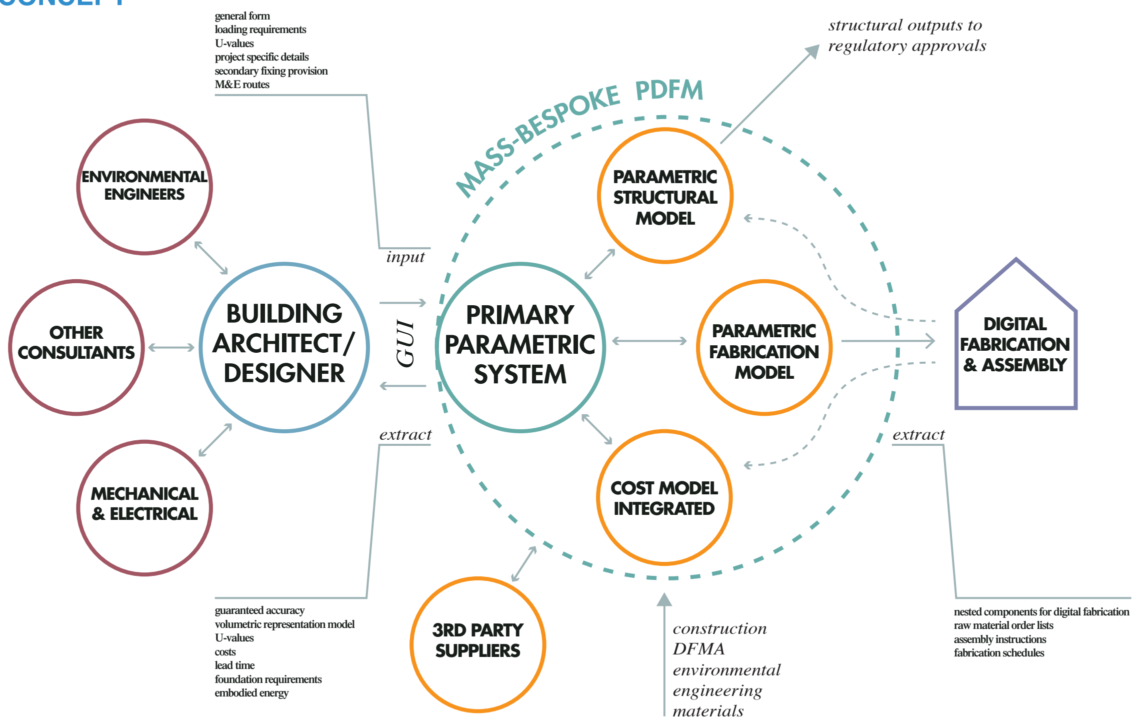


6) Parts are assembled on site

Image of Bauman Lyons Garden Room - Prototype 2

SYSTEM CONCEPT

Mass Bespoke: *System Diagram*



VISION AND AIMS

MassBespoke™ when fully developed will enable users to explore various design iterations rapidly & easily, but with enhanced functionality over that already available by:

1) providing performance, cost & quantity information up-front;

2) outputting files ready for the BIM environment;

3) outputting files ready for 3rd party software conversion into g-code, to enable pre-fabrication of construction components;

4) integration of engineering into MassBespoke™, allowing structural requirements to adapt automatically with changes to geometries and components. MassBespoke™' seeks to automate the output requirements for building regulation approvals.

MassBespoke™' satisfies two Government drivers:

1) a need for increased self-build;

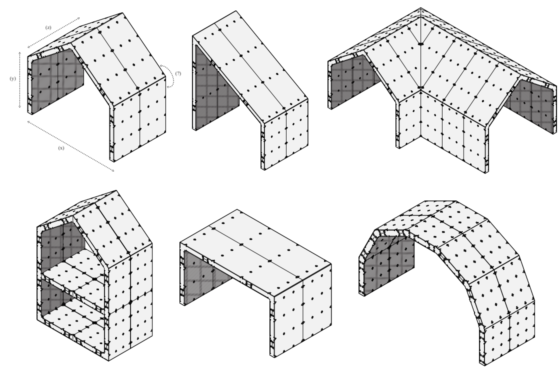
2) a need for smart construction/digital design by 2025. MassBespoke™ will expedite builds, as other components (such as windows) can be ordered at the same as the MassBespoke™' construction system.

RESEARCH CHALLENGES

RESOURCE REQUIRED TO GENERATE
How long does it take to generate full iteration? What level of involvement does that require?

VALIDITY OF OUTPUTS
Is it capable of 4 stories? Is the output valid for building regs ? How robust is it?

CAPABILITY TO MEET VARIANTS
How flexbile is it?



PROTOTYPING

Images of Fridaythorpe Shelter design and fabrication

Prototype 1 - Fridaythorpe Shelter using CNC fabrication

Prototype 2 - Bauman Lyons Garden Room

Prototype 3 - To be carried out in collaboration with Citu

BaumanLyons ARCHITECTS

Black Building
2 Newton Road
Leeds, LS7 4HE

T: 0113 322 3344
E: IrenaB@baumanlyons.co.uk
Website: baumanlyons.co.uk
Twitter: @baumanlyons

RISE Awards 2015

Entrant: BAM CONSTRUCTION
Award category: BEHAVIOURAL CHANGE

The energy performance gap

In recent years the both the construction industry and government have become increasingly concerned with the discrepancy between;

- the intended energy performance of buildings, outlined at design stage, **and**
- the actual energy performance of buildings once built and in everyday use.

Significant evidence suggests that buildings rarely perform as well as predicted during the design phase.

Back in 2002 the PROBE studies conducted post occupancy reviews of 23 buildings, previously featured as 'exemplar designs' in the Building Services Journal. The reviews showed that actual energy consumption was often over twice as much as predicted.

Energy consumption 2x higher than intended

Why is there a performance gap?

Research suggests the performance gap is the result of poor assumptions when predicting energy consumption at design stage, compounded by a lack of monitoring and understanding of energy performance post occupation.

Only sources of energy consumption measured for regulatory compliance are considered during the design phase. Other sources, such as small power loads and server rooms, are rarely considered. Post occupancy evaluations show that in reality, these typically account for more than 30% of energy consumption.

Designs also make standard assumptions about occupancy hours, building use and building maintenance. Post occupancy evaluations show that in reality occupants often struggle to manage their new buildings, in the most energy efficient way.

Contact:
Lucy Booth - Pre-construction Coordinator
BAM Construction, 3125 Century Way, Thorpe Park, Leeds, LS15 8ZB
lbooth@bam.co.uk ~ 0113 290 8800

Changing our behaviour at BAM

In an effort to address this performance gap, BAM has developed a post occupancy evaluation procedure, which is currently being rolled out across projects in our north east region, as a pilot.

We've developed a bespoke, client focussed approach which looks to not only capture information which we can learn from and feed into future designs, but also helps our clients get the best out of their new buildings.

Our post occupancy evaluation procedure goes further than the government's soft landings approach (GSL), which is due to become mandatory next year for public sector projects.

Rather than carrying out just one review, three years after completion, we're conducting annual reviews, gathering incremental data on building performance and supporting our clients in using their new buildings efficiently.

This ongoing commitment to our clients ensures the buildings we leave behind are not only performing as they should be, but are also improving our client's businesses and services.

We have worked with energy and sustainability experts XCo2 and have developed a methodology which allows us to benchmark the performance of our completed buildings, in line with the government's soft landings approach.

> "Post occupancy evaluations are carried out to review the design and construction process and collect information on user satisfaction and building performance. This data can help improve future designs and allows the optimisation of system settings."
>
> Dr Hardip Mann
> BAM's Senior Sustainability Advisor

BOULEVARD ACADEMY

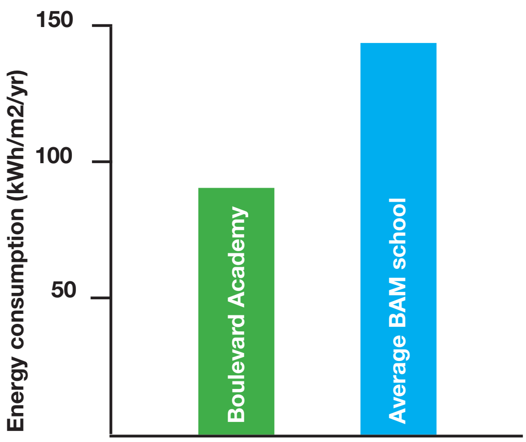
ENERGY COST
PER PUPIL
£263 PER YEAR

BAM's approach in action

BAM built the Boulevard Academy in Hull in 2013. The £8m school features a two-storey entrance building containing sports facilities, a dining room, a learning resource centre and administrative functions. This leads into a three-storey teaching block with modern learning environments and hi-tech IT suites. The school has a capacity for 600 pupils and a floor area of 4,654m2.

We piloted our post occupancy evaluation procedure on Boulevard Academy and we're now rolling this out across further projects in the north east region. We worked with our energy and sustainability experts XCo2 to conduct:

1. A **building use survey** - distributed to the Academy's staff and students. This reached a wide range of user groups and enabled us to benchmark building user satisfaction.
2. A **site visit** - looking at how the Academy is used, movement through its spaces, comfort in different locations and thermal imaging.
3. **Data collection -** including energy and water information, to allow a full analysis of usage. This can take the form of bills at its simplest form, or linking to the buildings full BMS if available.
4. Short 30 minute **interviews** with key users, to discuss the building holistically, explore the positives and the issues and understand potential areas for improvement.



Boulevard energy comparison

What we have learnt

Our post occupancy evaluation highlighted many positives at Boulevard Academy:

- The building has a vibrant, bright, comfortable feel and is displaying above average energy performance.
- The building users enjoy the simplicity of the building management system controls and the natural ventilation.
- The building was delivered within a very low budget and a very tight programme, yet still provides an excellent educational experience.

'The building adds value to the educational experience. It is welcoming, bright, aesthetically pleasing and visually has a collegiate feel to it.'

Andy Grace, Head Teacher, Boulevard Academy

What is more useful however, are the aspects highlighted within the review that we can learn from for future projects, which included:

Building controls can be too complex. Simple building controls and natural ventilation are easier to manage and give users more control over their environment. At Boulevard Academy, budget restrictions forced a simplification of the BMS. The simple system is popular with staff, students and the facilities manager.

During the design phase, early engagement with end-users can help prevent redesign requirements. At Boulevard Academy, end-user engagement workshops resulted in the reception area being modified and this required the installation of an additional air curtain heater.

RISE Awards 2015

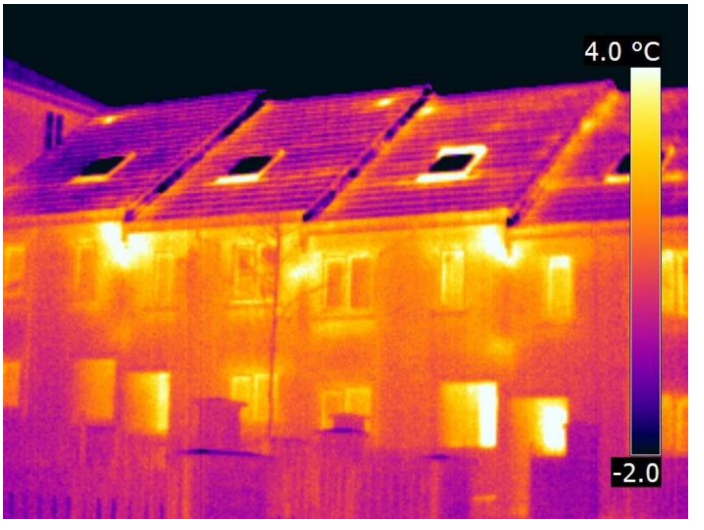
Research Innovation Sustainability Enterprise

Category: 4.) Design, Innovation & Creativity
Entry: ARC T-Barrier®

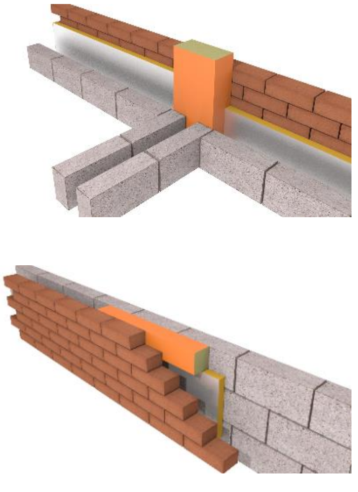
The market requirements for the ARC T-Barrier elevated from the problem of thermal bypass between houses within rows of semi-detached and terraced houses.

Without effective edge sealing, the party wall cavity between two houses allows heat to escape, both from the vertical cavity and at the top of the junction where the party wall cavity meets the external cavity.

Without effective edge sealing, there is limited restriction of the spread of smoke and flames and ineffective reduction of flanking noise pollution between dwellings.

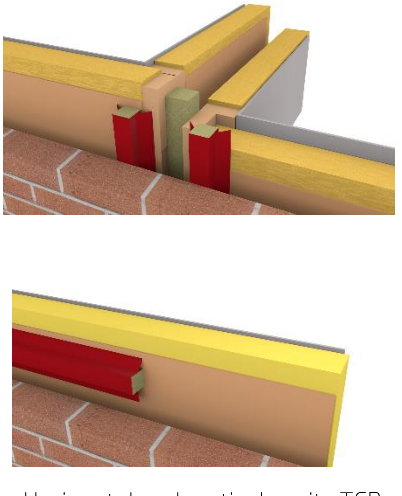


Areas of heat loss between terraced houses

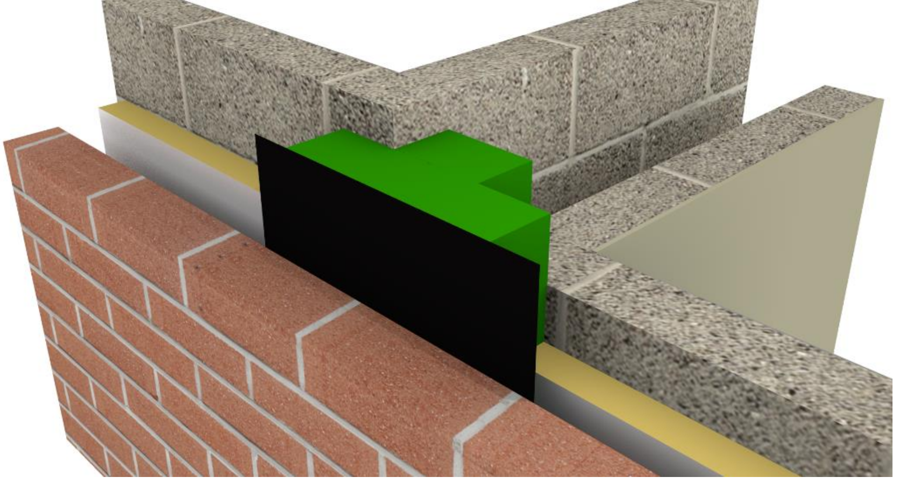


Horizontal and vertical cavity stop socks

Standard products used to reduce thermal bypass provide up to one hour's fire integrity and excellent acoustic properties. However, a combination of three Cavity Stop Socks/TCBs and additional tools and materials are required to seal the cavity effectively at the junction between dwellings. The ARC T-Barrier sought to provide an effective alternative by combining a conventional three piece system in to one product. Strategic aims were that this product should save time on site, as well as out-performing the conventional systems to produce a more effective edge seal.



Horizontal and vertical cavity TCBs



ARC T-Barrier®

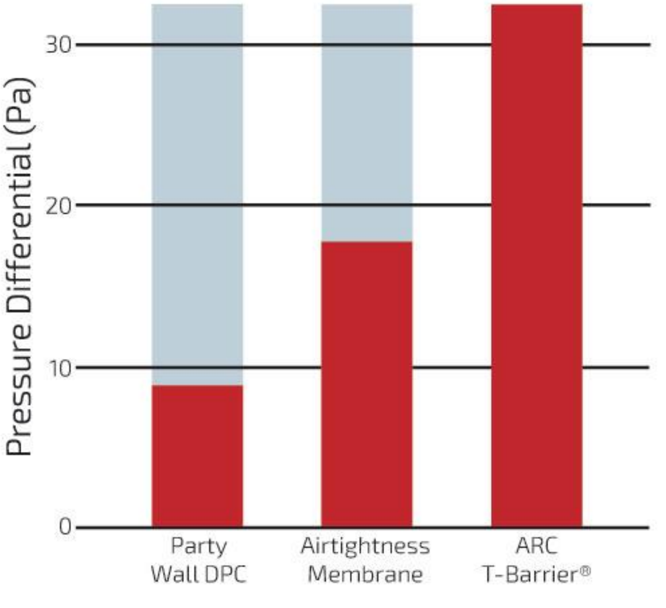
ARC Building Solutions have been working closely with the Centre for the Built Environment department at Leeds Beckett University since March 2013.

Initially, Leeds Beckett assisted ARC Building Solutions in carrying out thermal calculations on the efficiency of the ARC T-Barrier, comparing it to products used in the conventional system. In December 2013, the results of these calculations supported the claims that the ARC T-Barrier performed 20% more efficiently thermally.

On 1st June 2015, Leeds Beckett started an air tight test on the ARC T-Barrier using a timber frame rig set up in ARC's factory. This ground-breaking test is the only test currently available to measure the effectiveness of an edge seal, by replicating real life conditions to measure the differentials between pressurised and non-pressurised cavities. The test also trialled the standard barrier either side of the party wall, comparing this to the ARC T-Barrier.

Air tightness testing at ARC's factory, June 2015

The results of the air tightness test prove that the ARC T-Barrier is an improved solution, and as such performs better for heat loss and the provision of an effective edge seal. The ARC T-Barrier was found to provide three times the pressure differential compared to a conventional cavity barrier system and nearly twice the pressure differential of the airtightness membrane employed by some house builders. Full details of the test results can be supplied on request.
In terms of saving time on site, the ARC T-Barrier is now a specified product by a number of major U.K. house builders, including Bloor Homes, Taylor Wimpey and Persimmon.



Summary results based on 100mm cavity

ARC Building Solutions are an independent manufacturer to the construction industry of products to prevent heat loss, noise pollution and the spread of fire. Established in 2008, ARC specialise in cavity fire barriers and cavity closers, manufactured in accordance with NHBC requirements.
ARC holds ISO 9001 and ISO 14001 accreditation.

ARC Building Solutions, Gildersome Spur, Leeds, LS27 7JZ
www.arcbuildingsolutions.co.uk 0113 252 9428

Category: 1.) Field and Laboratory Research
Entry: ARC Eaves Insulator

The market requirements for the Eaves Insulator elevated from the problem of heat loss through the roof membrane at the junction between the pitched roof and the top of the cavity wall. The nature of the shape of this part of the dwelling lends itself to difficulties in access for construction workers to provide adequate and consistent insulation to prevent heat loss. Traditional methods of filling this 'triangular cavity' are to apply a mineral fibre product manually over the ceiling trusses, forcing it into the narrow gap at this junction. This method of filling this 'triangular cavity' can be problematic for the construction worker. Calculating the amount of mineral fibre required is difficult and knowing how much compression is required to achieve an effective fill achieves inconsistencies in insulation and therefore the heat loss achieved.

Eaves Insulator

ARC Building Solutions have been working with the Centre for the Built Environment at Leeds Beckett University and Knauf Insulation to develop a product that can solve this problem, that benefits both the construction team, and provides an improved method of protecting the property against heat loss. The resulting ARC Eaves Insulator is designed to provide a single, consistent product that is easy to fit, performing better than the conventional manual method of insulating this area. Prototypes of this registered design have undergone rigorous testing by Leeds Beckett University, results and details are as follows;

In March 2015, Leeds Beckett University produced some thermal bridging calculations for the prototype of the ARC Eaves Insulator based on the Building Product Design Limited/Knauf Insulation Ltd UK Patent GB/2430947/B. The geometry of the eaves junction was based upon Figure 2 shown in the patent with a roof pitch of 35 degrees and a 100 mm deep rafter member to the timber trussed rafters. Calculation 9720/TB/01/A includes the product with the 100 mm thick insulation folded down to meet the top of the plasterboard. Calculation 9720/TB/02/A extends the length of the insulation component so that it folds back on itself to reduce the size of the triangular shaped airspace. The calculations demonstrate that extending the length of the insulation component could substantially reduce the thermal bridging. However, both tests at 100mm thickness proved that the product did not meet the approved Ψ-value of 0.060 W/mK.

It was anticipated that the use of a thicker insulation component (e.g. 150 mm) would further reduce the thermal bridging where a deeper rafter member section is used for the trussed rafters. These thermal bridging calculations were repeated using an insulation component of 150mm thickness, the results of which are demonstrated in the following tables.

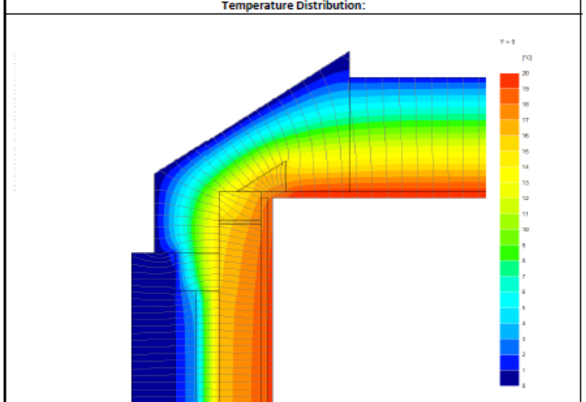
The results of these thermal calculations prove that when this area of the roof is insulated using the Eaves Insulator and 150mm insulation component, it not only reduces the thermal bridging but also achieves a consistent method of insulating this area, which is currently identified as a problem detail in the construction industry, as it is extremely difficult to access once the roof is built. Once in place, it is also easily identifiable by the building inspector, who would previously have had to use thermal imaging equipment.

Leeds Sustainability Institute
Thermal Bridging Calculations

Detail:	Eaves with ARC Eaves Insulator 150 mm						
Calc No:	9720/TB/03	Rev:	A	Date:	Jun-15	Calc By:	MBP
Materials and Thermal Conductivities:							

Material:	λ:	Source:
AAC Blocks	0.190	Manufacturer
Adhesive Dabs (20 % Adhesive, 80 % Air)	0.156	BR 443
Air Spaces	Varies	BS EN ISO 6946
Bricks Outer Leaves	0.770	BR 443
Cavity 50 mm Low-E	0.114	BR 443
Insulation (150 mm) ARC Eaves Insulator	0.044	Manufacturer
Insulation Cavity Closer	0.037	Manufacturer
Insulation Roof (300 mm)	0.044	Manufacturer
Insulation Walls (50 mm)	0.020	Manufacturer
Mortar Protected	0.880	BR 443
Plasterboard	0.210	BR 443
Softwood	0.130	BR 443

Temperature Distribution:



Q:	0.4531	ℓ_j:	0.050	U_w:	0.262	T_{si}:	18.26
T_i:	20.00	ℓ_w:	1.000	U_c:	0.141	L^{2D}:	0.0227
T_e:	0.00	ℓ_c:	1.000			f_{Rsi}:	0.913
T_L:	1.00					Ψ (W/m·K):	0.057

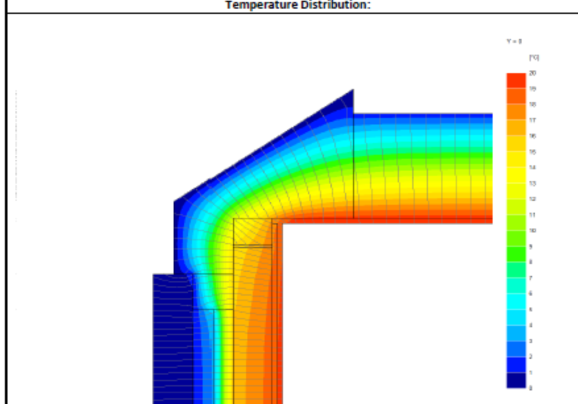
Notes:

Leeds Sustainability Institute
Thermal Bridging Calculations

Detail:	Eaves with ARC Eaves Insulator Extended 150 mm						
Calc No:	9720/TB/04	Rev:	A	Date:	Jun-15	Calc By:	MBP
Materials and Thermal Conductivities:							

Material:	λ:	Source:
AAC Blocks	0.190	Manufacturer
Adhesive Dabs (20 % Adhesive, 80 % Air)	0.156	BR 443
Bricks Outer Leaves	0.770	BR 443
Cavity 50 mm Low-E	0.114	BR 443
Insulation (150 mm) ARC Eaves Insulator	0.044	Manufacturer
Insulation Cavity Closer	0.037	Manufacturer
Insulation Roof (300 mm)	0.044	Manufacturer
Insulation Walls (50 mm)	0.020	Manufacturer
Mortar Protected	0.880	BR 443
Plasterboard	0.210	BR 443
Softwood	0.130	BR 443

Temperature Distribution:



Q:	0.4440	ℓ_j:	0.050	U_w:	0.262	T_{si}:	18.65
T_i:	20.00	ℓ_w:	1.000	U_c:	0.141	L^{2D}:	0.0222
T_e:	0.00	ℓ_c:	1.000			f_{Rsi}:	0.933
T_L:	1.00					Ψ (W/m·K):	0.048

Notes:

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RISE Awards 2015

Research Innovation Sustainability Enterprise

Category: 1.) Field and Laboratory Research
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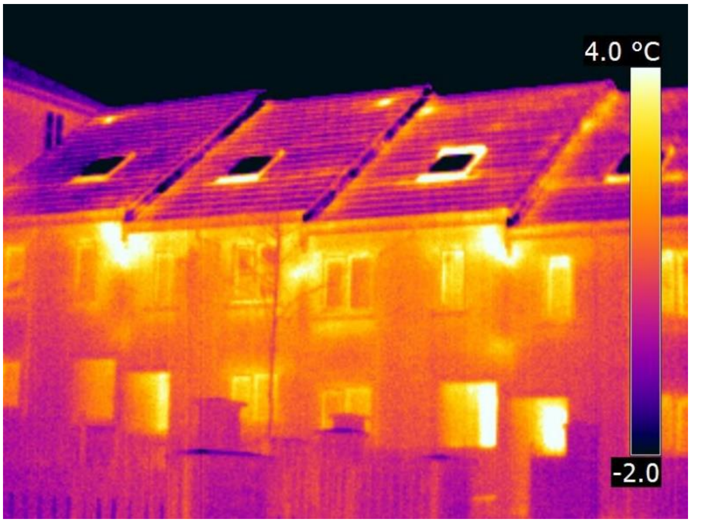
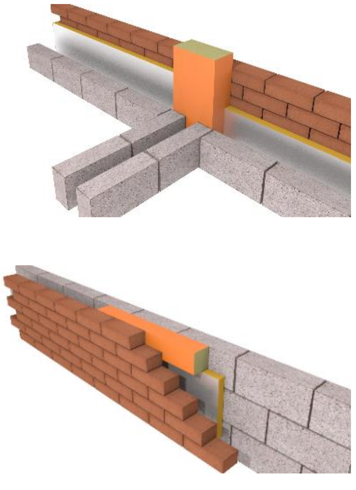


Areas of heat loss between terraced houses



Horizontal and vertical cavity stop socks

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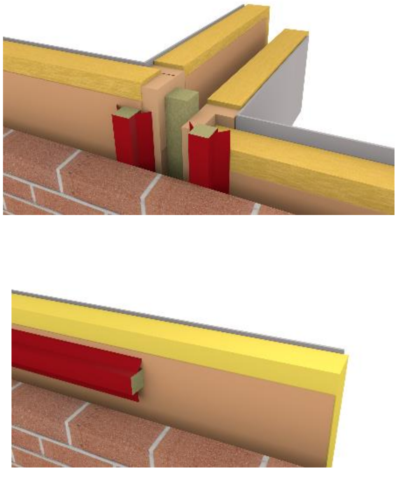

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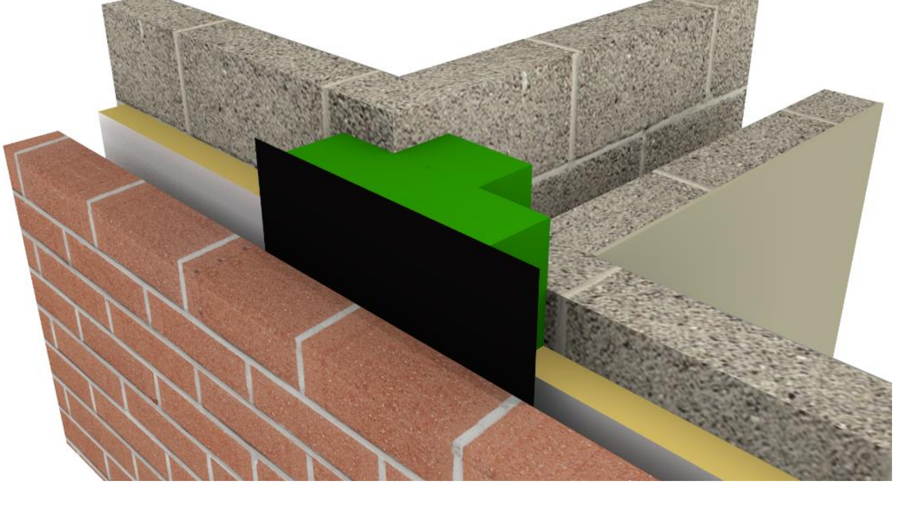

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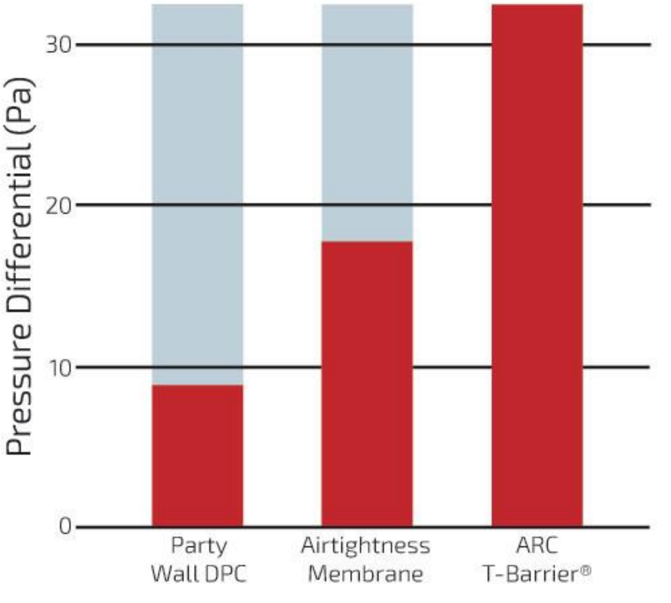

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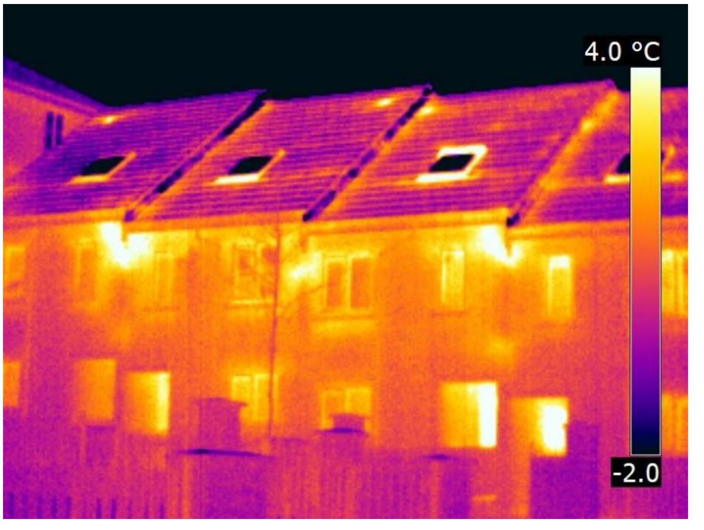
RISE Awards 2015

Research Innovation Sustainability Enterprise

Category: 2.) Product and Element Interface
Entry: ARC T-Barrier®

The market requirements for the ARC T-Barrier elevated from the problem of thermal bypass between houses within rows of semi-detached and terraced houses.
Without effective edge sealing, the party wall cavity between two houses allows heat to escape, both from the vertical cavity and at the top of the junction where the party wall cavity meets the external cavity.
Without effective edge sealing, there is limited restriction of the spread of smoke and flames and ineffective reduction of flanking noise pollution between dwellings.



Areas of heat loss between terraced houses

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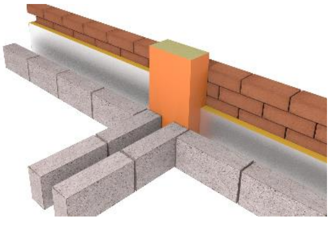

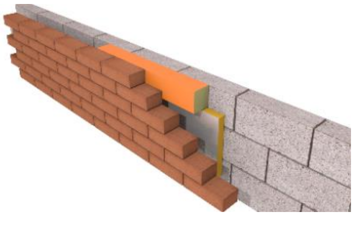

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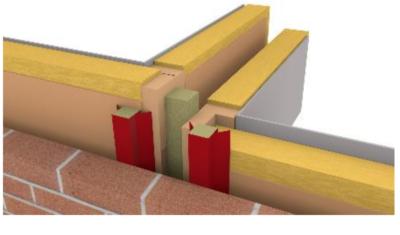

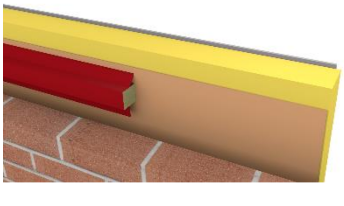

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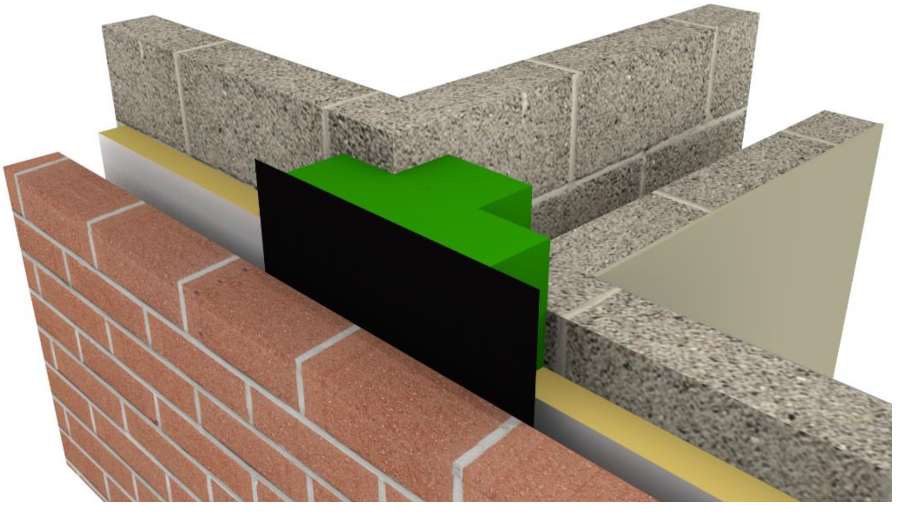

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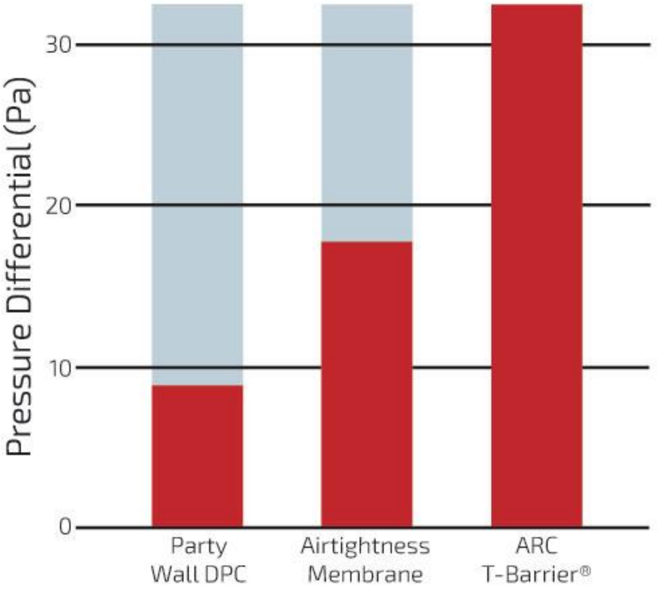

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Leeds Beckett University | Leeds Sustainability Institute

RISE Awards 2015

Research Innovation Sustainability Enterprise

Category: 5.) Sustainable Developments & Energy

Entry: ARC T-Barrier®

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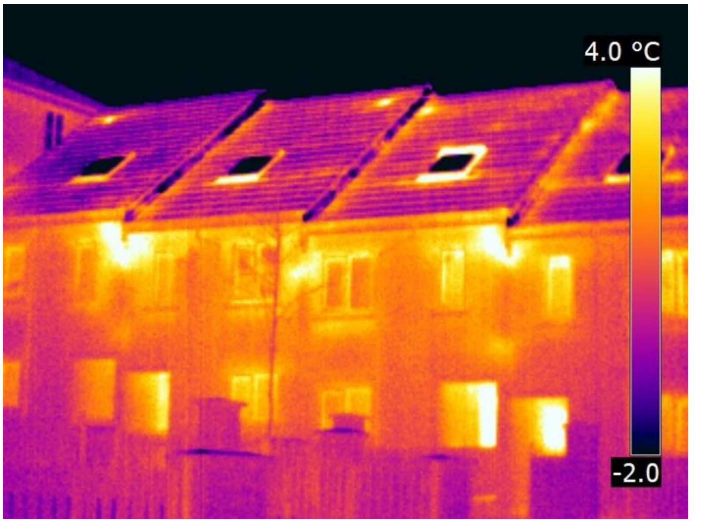

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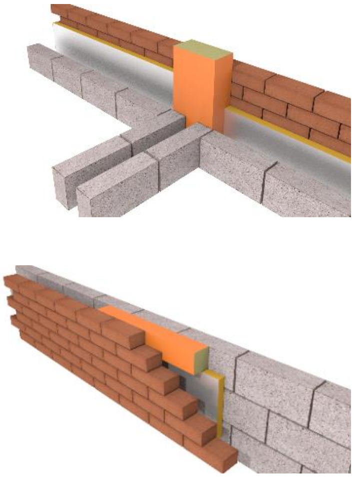

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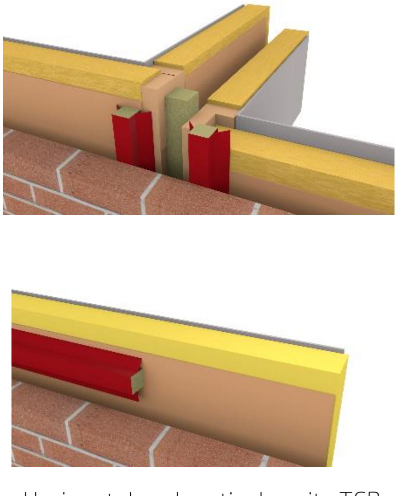

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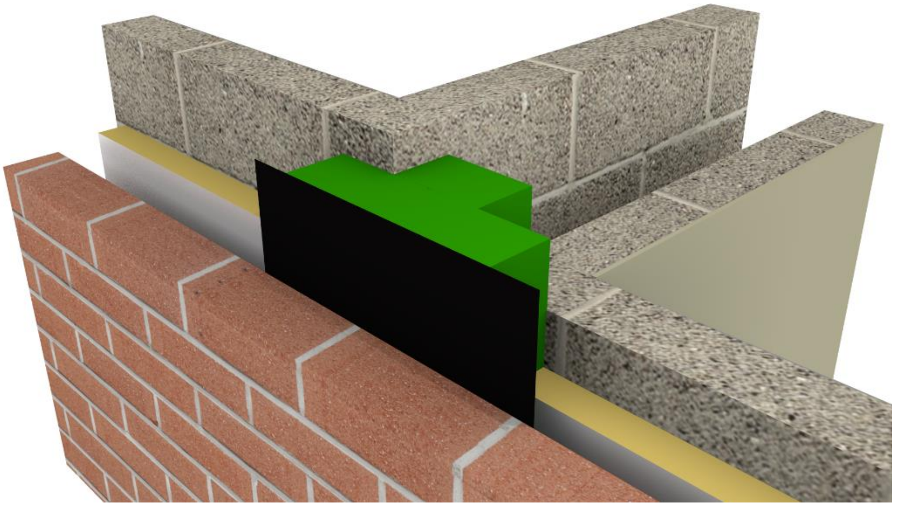

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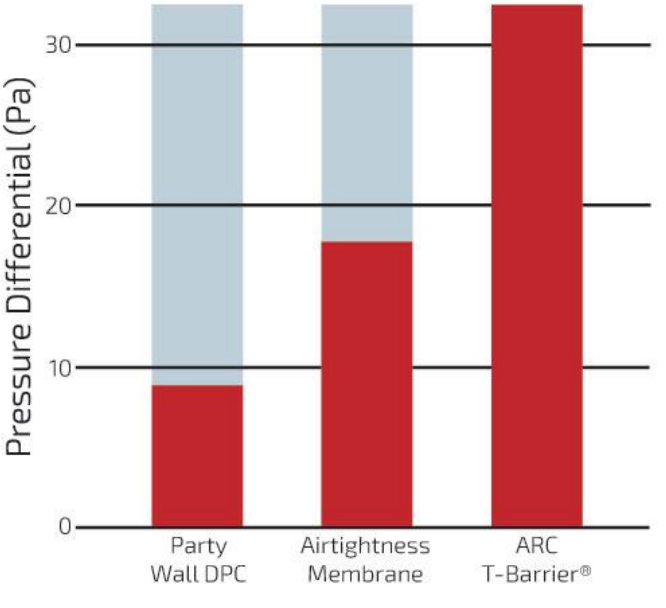

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RISE AWARDS 2015

********** RESEARCH ✳ INNOVATION ✳ SUSTAINABLITY ✳ ENTERPRISE **********

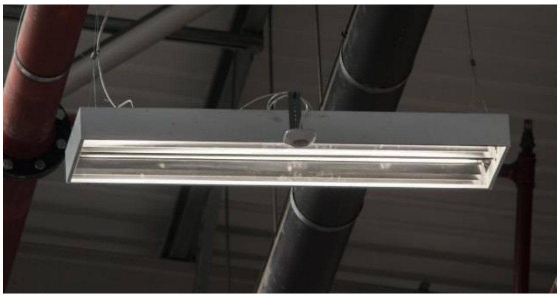
2 x Award Categories:

Innovation – Design, Innovation & Creativity *&* ***Innovation - Sustainable Developments & Energy***

In 2015 Wm Morrison Supermarkets Plc have added innovative lighting controls to 5 more of its Regional Distribution Centres (RDC's). Project & Cost Managed by Rex Procter & Partners (Energy Services) and installed by Data Techniques, the sensors, manufactured by Enlighted, will save Morrisons a minimum of 50% on their electricity consumption from lighting.

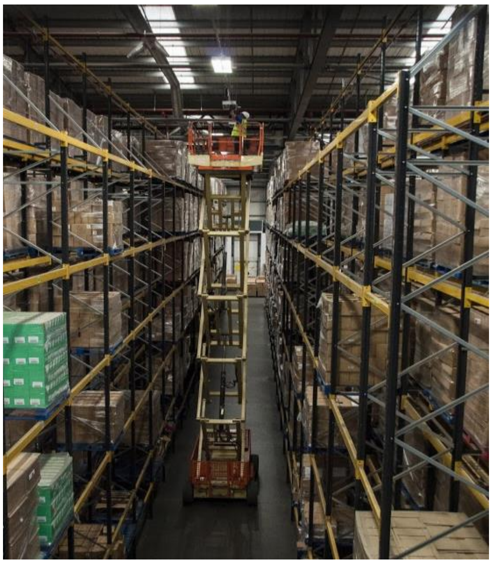
The technology was piloted at the two RDC's at Swan Valley in 2013 and saved an average of 60%, equivalent to over 2 million kWh (1,000 tonnes of CO_2). They are now installed in over 2 million sq ft of UK distribution centre space.

Like other lighting controls in the market place, the technology incorporates combined daylight dimming and PIR movement detection and is wirelessly operated. The added benefit of the Enlighted sensors is their ability to be retrofitted to existing individual light fittings thus increasing the potential for daylight harvesting.



In order to establish a business case for investment, the following criteria had to be satisfied:

- Only RDC's were selected where there was no function to switch the lights off (normal in some larger warehouse environments). This meant there was a strong basis to achieve energy savings on the existing lighting that was on all day, every day, all year round
- It was desirable to install into buildings with roof sky lights because of the natural daylight these offered. This would allow maximum return on daylight harvesting. This however was not possible in all buildings
- A savings guarantee of 50%
- The existing light fittings were T5 fluorescent in ambient temperature areas & 216w (4 x 54w) and 160w (2 x 80w)
- A 2-3 year pay back



The key parts to the installation included:

- Installing a data network infrastructure to link the Enlighted sensors, Gateways and Energy Managers that were strategically positioned around the warehouse
- Removing each individual fitting at high level using a Mobile Elevated Working Platform
- At a workstation bench, retrofitting the sensors to the fitting, swapping the ballast for a dimmable type, cleaning the fitting and replacing the fluorescent tubes
- Re-attaching the light fitting to the ceiling
- Activating the sensor via a laser & commissioning the system based on site specific preferences

Reasons for success of the project included:

- A collaborative team ethos to the installation which had to be undertaken in a live working environment (the distribution centre operates 24 hours a day!). This meant regular communication with management and upmost consideration of the warehouse operations and working around the warehouse pickers
- The project was delivered under a formal construction contract, benefitting both the Data Techniques and Morrisons

Some key challenges to the project included:

- Keeping the MEWPs charged so they could operate
- Ceiling heights, impeding structures (e.g. roof steelwork) & light fitting fixings
- Workstation location
- Connection into the corporate network (IT security)

Some headline figures across the 7 sites include:

- Over **7 million** kWh & **3,500** tonnes of CO_2 saved
- Over **6,000** lighting fixtures retrofitted with sensors
- Over **20,000** fluorescent tubes replaced
- Over **11,000** ballasts replaced

The Technology:

Enlighted is considered one of the most advanced smart sensors on the market and is fast becoming the recognised market leader for the IOT [internet of things] in smart buildings. It can provide the depth of insight for a building and is unrivalled in providing data as rich and detailed within a 10ft radius. It is also scalable for fast implementation & can integrate with other building services

Client: MORRISONS

Project Team:

RP&P Energy Services Ltd

Data Techniques Installing Confidence

enlighted

velocityRDT

Project Contact:

Jim Illingworth, Rex Procter & Partners (Energy Services), 0113 243 3731 / 07711375563

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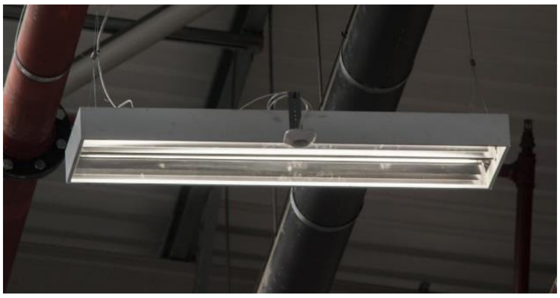

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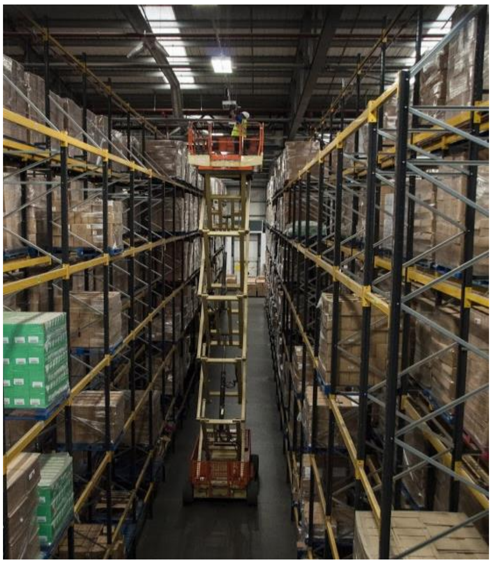

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Research | Innovation | Sustainability | Enterprise

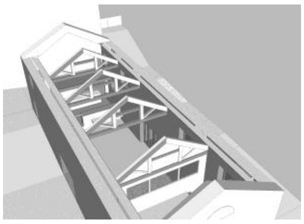
Heritage Award for Restoration/ Retrofit

Cre8 Barn, EnerPHit barn conversion:

achieving high thermal performance & structural stability

An innovative barn conversion project, completed in 2014, was undertaken at Yorkshire Wildlife Trust's Cre8 Barn at Stirley Community Farm, Huddersfield Yorkshire. The client's requirement for low environmental impact for the refurbished building led the team to propose the EnerPHit standard. The project gained EnerPHit certification in 2014 and recently won 'Retrofit category' in the UK Passivhaus Awards 2015.

'Box within a box'

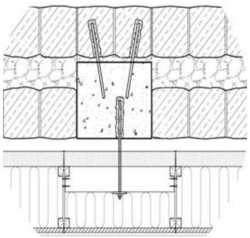


To achieve EnerPHit levels of performance, a super-insulated timber frame structure was constructed inside the existing stone barn, preserving the outward appearance of the barn, while making it easier to achieve high levels of airtightness and continuity of insulation.

The timber frame construction not only ensures thermal performance, but also helps to provide the structural stability to the outer masonry wall. A structural survey revealed that extensive remedial work was needed to stabilize the original stone walls. The internal timber frame structure offered the opportunity to shore up the original stone building, without the extensive and costly rebuilding and some of the associated underpinning required.

Thermal bridge free wall connectors

The inner timber frame braces the original barn masonry walls through a purpose-designed tie system, developed with the project's structural engineers. In situ cast concrete pads set in the outer masonry walls have been tied to the timber frame using adapted basalt fibre wall ties (with low thermal conductivity), set in resin anchors. Care was taken so that the wall connectors did not introduce a significant thermal bridge, and was suitable for Passive House standard construction.



Wall connectors

Ventilated cavity

The design team had to deal with the possibility of solar driven moisture leading to moisture build up within the cavity between the timber frame and masonry walls. Any such interstitial moisture build up could have devastating consequences for the building fabric.

WUFI analysis was undertaken which showed that moisture levels would rise rapidly if the cavity was unventilated. However, with a ventilated cavity, the WUFI graphs show that moisture levels would remain within acceptable parameters over time.

The cavity between the masonry wall and internal structure has been well ventilated utilising 40 ventilation bricks in the top and base of the masonry wall to ensure good circulation. Each air brick has 7500mm^2 free air movement. Researchers at Centre for the Built Environment at Leeds Beckett University have installed moisture measuring probes to measure the moisture content through the wall. It is hoped that this research, when published, will inform the debate about the ventilation of cavities and the dangers of solar driven moisture through masonry walls.

www.greenbuildingstore.co.uk/enerphit

Green Building Store

Heath House Mill, Heath House Lane, Golcar, Huddersfield HD7 4JW,

Tel: +44 484 461705
info@greenbuildingstore.co.uk,
www.greenbuildingstore.co.uk

Sustainable Developments (Domestic & Non Domestic) & Energy

Passivhaus and cavity wall construction

In 2009 Green Building Store embarked on the Denby Dale Passivhaus, a design and build project which pioneered the combination of low energy Passivhaus methodology with standard British cavity wall construction and was the UK's first cavity wall Passivhaus.

The research and development undertaken for the project, and the firm's subsequent Golcar Passivhaus project (completed in 2015), have made a contribution to the wider UK construction industry by developing and improving construction detailing for cavity wall construction for Passivhaus and ultra low energy projects.

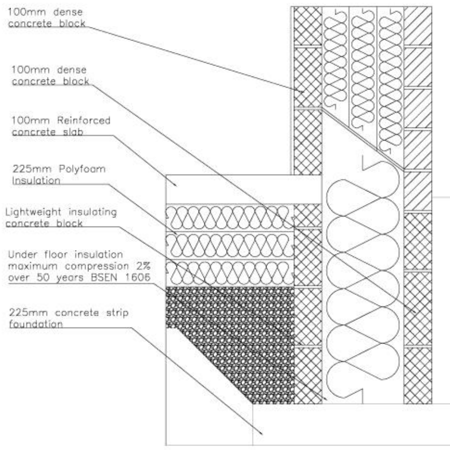
Why cavity wall?

- Most British builders are familiar with the technique and materials could be sourced easily from any builders' merchant.
- Cavity wall met West Yorkshire planning requirements for stone exteriors and was affordable for clients.

Detailing

To get cavity wall to perform to Passivhaus standards the building team had to develop unique design details.

- Use of 300mm insulation in the cavity going right down to the strip foundation, so that any heat lost from the concrete floor slab will have a longer thermal transfer path.
- Use of lightweight aerated block below ground level, which does not transfer heat as readily as standard concrete block.
- Use of basalt and resin cavity wall ties (instead of the usual steel ties).
- Positioning of windows and doors at the centre line of the insulation layer.
- Concrete floor slab is carried across the top of the blockwork of the inner leaf of the wall to minimize shrinkage cracking between the wall and the floor



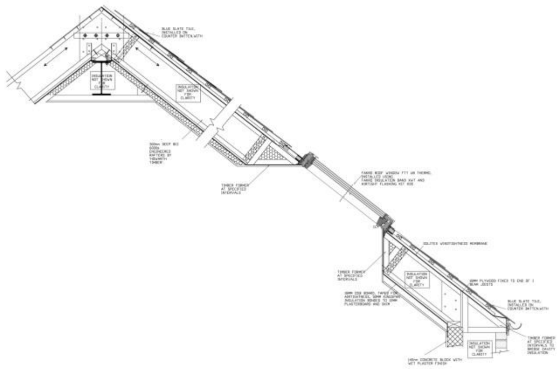
- To improve airtightness around the window opening, a plywood box was set into the wall. An adhesive-backed airtightness tape was then attached to the plywood with a fleece wrapped into the wet plaster, making the junction between the plywood and plaster airtight. Another airtightness tape was used to seal the gap between the window and the plywood box.

- Various details at first floor junction to avoid penetration of the inner leaf blockwork including: use of timber wall plate; parging of the blockwork behind the wall plate; use of-anchored stainless steel threaded bar to carry the 302mm timber I-beam structure. Use of I-Beam for first floor had the added bonus of allowing us to use void for MVHR ducting and all other services, further helping with airtightness (and aesthetics).

Golcar Passivhaus improvements

The recent Golcar Passivhaus project has improved and developed some of the detailing for cavity wall construction:

- Damp proof membrane: Learning lessons from another cavity wall project (Steel Farm), the team took the damp proof membrane around the first course of block below the groundfloor slab, which means the block will stay dry and maintain its lamda value.
- Minimising thermal bridging at thresholds: The team used the Compacfoam rigid insulation on the door thresholds to the doors. Compacfoam was chosen to reduce thermal bridging and because it has excellent compressive strength under the thresholds.
- I-joists: The design team improved the I-joist detailing in the roof by placing polyurethane insulation in both sides of the web of the I-beam so it forms a neat square' unit. This helps minimise thermal bridging through the I-joists and thermal bypass within the web of the I-beam.
- Cathedral roof detailing: Development of construction detailing for a warm roof



- Development of cavity wall closers: The project team has developed an aesthetically-pleasing bespoke aluminium cavity closer, allowing windows to be situated within the cavity wall insulation, helping reduce thermal bridging.

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RISE AWARDS 2015
RESEARCH | INNOVATION | SUSTAINABILITY | ENTERPRISE

AWARD CATEGORY: SUSTAINABILITY - RETROFIT

Name of Regeneration scheme:
Collyhurst - Northwards Housing

Location of scheme: Rochdale Road, Manchester

Partners involved in scheme: Northwards Housing, ROCKPANEL, ROCKWOOL, Mears Group, Astley Facades Ltd, Vivalda Ltd., Manchester Working Ltd

Value of scheme: £3m

Completion date: June 2015 (6 months on site)

Lying to the north east of the city centre, Collyhurst is one of the most densely populated areas in Manchester, and houses some of the most deprived communities in the country. A major PFI regeneration scheme for the area was scrapped in 2010 and has now been replaced by a more modest plan which will still provide a considerable boost for the local environment and residents. This part of the overall regeneration scheme comprises the refurbishment of four 13 storey tower blocks: Humphries, Roach, Mossbrook and Vauxhall Court.

The council-owned 1960s tower blocks are managed by social landlords Northwards Housing, and funding was secured through the Decent Homes programme and ECO. The refurbishment includes upgrading the thermal performance of the building envelopes to current building regulations, adding insulation, new windows, a new roof covering, and carrying out structural repairs, as well as improving the aesthetic appearance of the blocks with external cladding.

The ROCKPANEL Chameleon boards which have been used on the project have a 6 prism colour base with colours flipping from blues to purples to greens to pinks and to yellows in various lights; changing as the weather does over the course of the day, and as it is viewed from different points. The boards have also been routed with the names of the tower blocks giving an identity to each of the tower blocks with the lettering ‘falling’ down the sides of the facades over three storeys deep.

The tenants now feel a sense of pride and ownership of the place they live in and the striking effect the ROCKPANEL boards now give to this area of Manchester. The refurbishment has also decreased the cost of fuel bills massively for tenants, thanks to the ROCKWOOL insulation used behind the ROCKPANEL boards, making homes warmer places to be.   On a few facades, solar panels have been used, again to assist in driving down costs of fuel.

The newly refurbished blocks have also revived demand, bringing vacant bedsit flats back into use and helping to ease some of the issues caused by changes to the benefits system.

The social housing in the area had been neglected for decades. By taking tenants views into account, and allowing them to choose the finish of their blocks, it provided an opportunity for them to come together as a community, and to share in the regeneration of their local environment. In turn this gives them an investment in how the area is perceived, and ownership of the improvement in that perception. The improvement will also help to attract more business and greater interest in the area, potentially providing more jobs and a boost to the local economy.

Contact Details:
Jenni Muston, - ROCKPANEL
07824 848916
jenni.muston@rockpanel.co.uk

LITTLE KELHAM

157 Citu Houses in Kelham Island, Sheffield

Digitally-enabled homes

Little Kelham residents to control and monitor energy usage from a smartphone or tablet. The platform, developed by partners at Actuated Futures, shows in real time information like how much energy is being used, how warm the house is and the time it will take for the house to reach a given temperature. It also allows users to remotely turn off power sockets, boost heat or check their home is secure.

Community-managed

Little Kelham is managed by a Community Interest Company (CIC). Amongst other things, the CIC is able to bulk buy utilities at a heavily discounted price for residents. The CIC is owned, managed and governed by the residents themselves and any profits generated by the CIC will be pumped back into the Little Kelham infrastructure.

This will make sure the development is always improving while ensuring residents get the cheapest energy.

Little Kelham is a development of 157 one to four bedroom low carbon Citu Houses in the Kelham Island area of Sheffield.

Work on the site begun in 2013 and the first residents moved into their homes at the start of 2015. Sales days have seen buyers queuing overnight to secure their homes.

The development of energy efficient and virtually air tight homes is the largest of its type in the UK and residents can expect their energy bills and carbon emissions to be a fraction of that of a conventional property. Little Kelham will also have office, retail and creative workspace, as well as a public square, communal gardens and a boules court.

Little Kelham's Citu Houses only require minimal heating, being warmed passively by the heat given off by domestic appliances, humans and pets. The Citu Houses are insulated to such an extent that the heat created is not lost. Meanwhile the homes use a mechanical heat recovery ventilation (MHRV) system to ensure fresh air circulates around the house without any heat loss.

Little Kelham is built on a brownfield site once occupied by two

The Citu approach

For Citu, sustainability isn't about lifestyle, the environment or politics, it just makes sense to waste less and do things in a more efficient and innovative way. This ethos of minimising waste and seeking out new ways of doing things now applies to everything Citu does, from design, to construction, to the final building and how people use it.

But for a building to waste less and be more efficient, Citu recognises that things need to be done differently. Rooms, houses, streets and communities need to be designed in a more creative and innovative way.

At Citu, we believe that the housing market is broken. Too many modern developments lack creativity or innovation.

We're making use of urban brownfield sites. These areas are often well-connected to city centres and public transport links and can be in fascinating neighbourhoods which are rich in history, fine architecture and a strong community spirit.

CITU

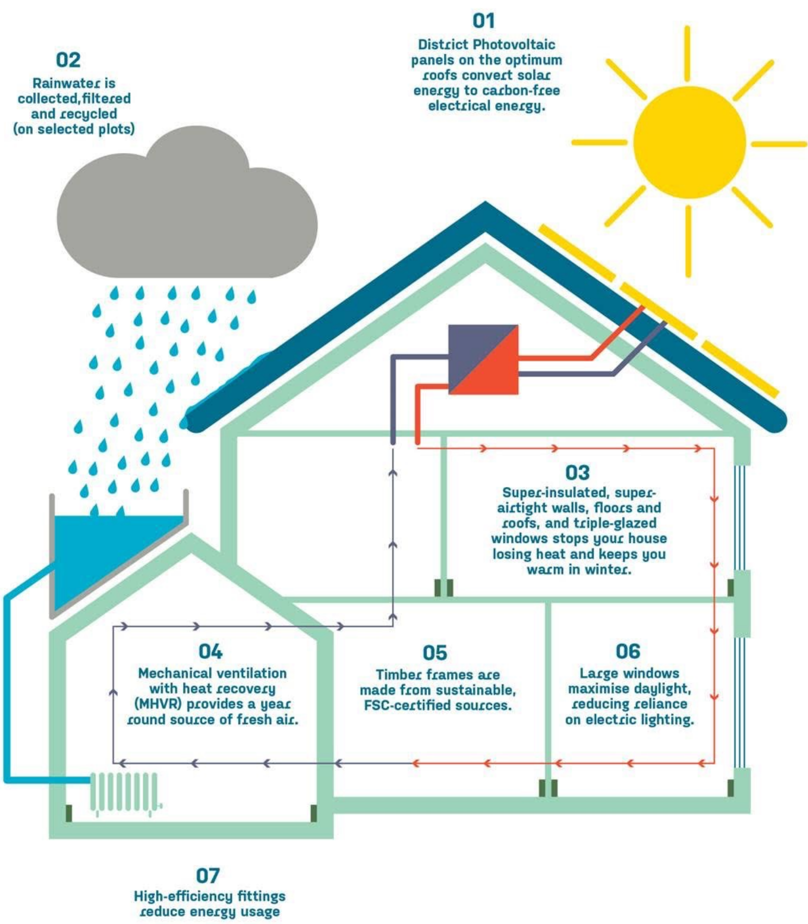
Contact details

Name: Aisling Ramshaw
Email: aisling@citu.co.uk
Phone: 0113-3202350

factories, Eagle Works and Green Lane Works. These important historic buildings, some of which are listed, will form a key part of the Little Kelham development. Historic England have contributed funding towards the restoration of the buildings, which will eventually be used for retail, office and creative space.

Kelham Island has for decades been neglected by investors, landowners and businesses alike. It once was the beating heart of Sheffield's industrial might but until recently it was run-down, with many buildings at falling into dereliction. Little Kelham is the biggest development the area has seen for many years and more recently more and more businesses, restaurants and shops have opened in Kelham Island.

Following on from the success of Little Kelham, there are now plans for a further extension to the scheme at a site adjacent to the existing one. This will see a further 98 Citu Houses being built along with office space and public areas.



Portland Works:
Cold Spots Report by Studio Polpo

Portland Works

Portland Works is a grade II* listed integrated metalwork's building on the edge of Sheffield City Centre. It was the birthplace of stainless steel cutlery and today remains home to metalworkers and craftspeople, as well as artists and musicians who continue a tradition of innovative and collaborative making. Since 2013 the building has been owned and managed by over 500 community shareholders, who together saved the building from being turned into studio flats. Portland Works is managed by an elected steering group and a number of working groups including the 'Building Works Group'.

Studio Polpo

Studio Polpo is an architecture practice based in Sheffield, set up as a social enterprise. Members of Studio Polpo have a longstanding involvement with Portland Works, which includes supporting the campaign to turn it into community ownership, undertaking student projects situated at the Works and using the Works as the focus of PhD research.

Introduction to the Coldspots Report

In 2014 Studio Polpo were asked to put together a report to assist the Building Works Group with collective decision-making and proposals for environmental retrofitting. Studio Polpo used existing studies and surveys as well as new research to produce visual and accessible information about the building fabric, heritage significance and tenant activity. It makes a broad range of considerations visible to the steering group and decision making bodies, so that The Works can maintain its lively active and historic character but operate more energy efficiently, safely and sustainably.

The report proposes a range of costed environmental retrofit strategies and recommendations for implementing them. Retrofit detail drawings (such as *Fig. 3*) are used to show how the thermal performance of the existing fabric can be upgraded, making reference to building products, costs and U Value improvements. This drawing set (which includes wall, floor, roof and tanking details) is cross-referenced with site wide strategies for retaining heritage significance and existing uses/machinery. The report also makes suggestions for how digital fabrication facilities can be introduced into The Works to continue a history of innovative manufacture and knowledge sharing, and to support the economic sustainability of the works.

The report was done in collaboration with the building manager and members of the Portland Works campaign group and was funded by the Architectural Heritage Fund, though a 'Cold Spots' grant. As well as being a snapshot of the Works a number of live documents allow the client group to update and add information to them.

Fig. 1: Photograph of Portland Works entrance

Fig2: Photograph of window prior to renovation

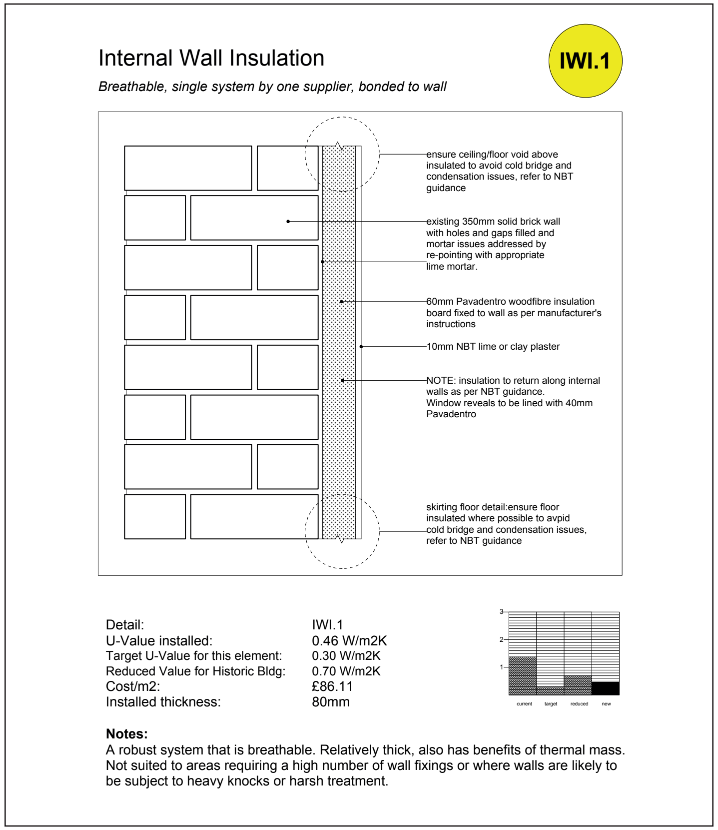


Fig. 3: One of a series of detail drawings showing retrofitted environmental upgrade options for walls, floors and ceilings.

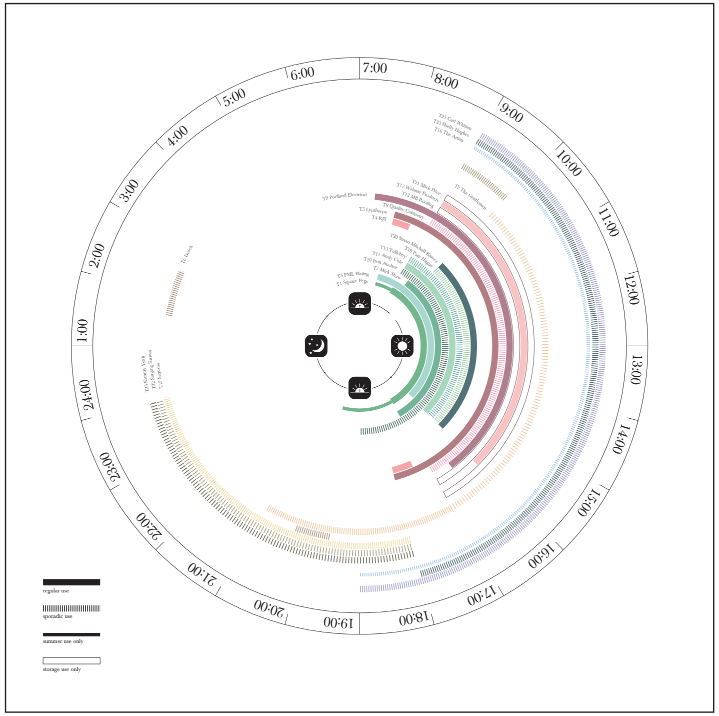


Fig. 4: Graphic mapping the use of Portland Works at different times (weekday version, coloured by tenant type)

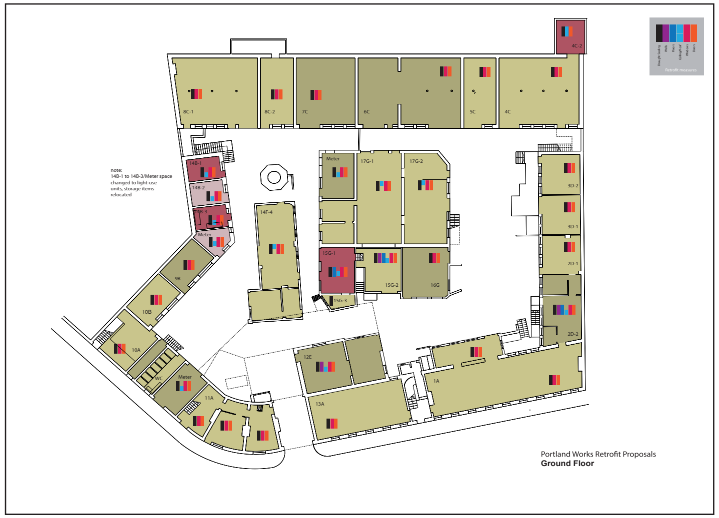


Fig. 5: Ground floor plan showing existing occupation and proposed retrofit measures

Collaborative and Sustainable Decision-Making

Within the Portland Works group a number of areas of interest exist. Motivations for being involved and supporting the project include: a desire to protect a historical building, a belief that the building should continue to support craft, a pragmatic need for cheap studio and rehearsal space, and the ability to collaborate and learn from different craftspeople. In many instances it is a combination of these and other factors which make Portland Works a special place.

The report was therefore designed to allow differing considerations and motivations to be acknowledged, understood and cross-referenced, and therefore facilitate collaborative decision-making. The divergent sections of the report can be used together to make informed decisions about sustainable and environmental reuse at Portland Works, for example through renovations to the building (see *Fig. 6* opposite) or introducing new tenants. Graphic posters can also be used to communicate priorities and strategies for future grand funding and renovation, based on existing cost information.

Success and Impact of the Coldspots Report

Some of the proposals in the Cold Spots Report have already been successfully implemented, including the renovation of one of the blocks at Portland Works by volunteers - which was recently shortlisted for a Historic England 'Heritage Angels' award. The strategies for future renovation and retrofit details included in the report mean that further renovation can continue independently, helping to bring more parts of the building into use and more revenue into the project. Tenants who have moved into new studios include a number of digital fabricators, who are helping to continue a culture of collaboration and innovation on the site and putting into practice some of the reports fab-lab proposals.

Studio Polpo developed a sustainability strategy for Portland Works which maintained and enhanced the existing on-site manufacturing and craft activities. This resulted in the protection of "Makers" being written into the Portland Works business plan. A group of 12 architecture students from The University of Sheffield undertook a 'live project' to extend the report and explore energy use at the Works, leading to the construction of secondary glazing and heating systems, developed with the existing makers and manufacturing processes at Portland Works.

The full report can be read online at:
http://issuu.com/studiopolpo/docs/coldspots_report_final

Contact:
Mark Parsons
Studio Polpo
office@studiopolpo.com
Address: 18-20 Union Street, Sheffield, S12JP
Tel: 07973815874

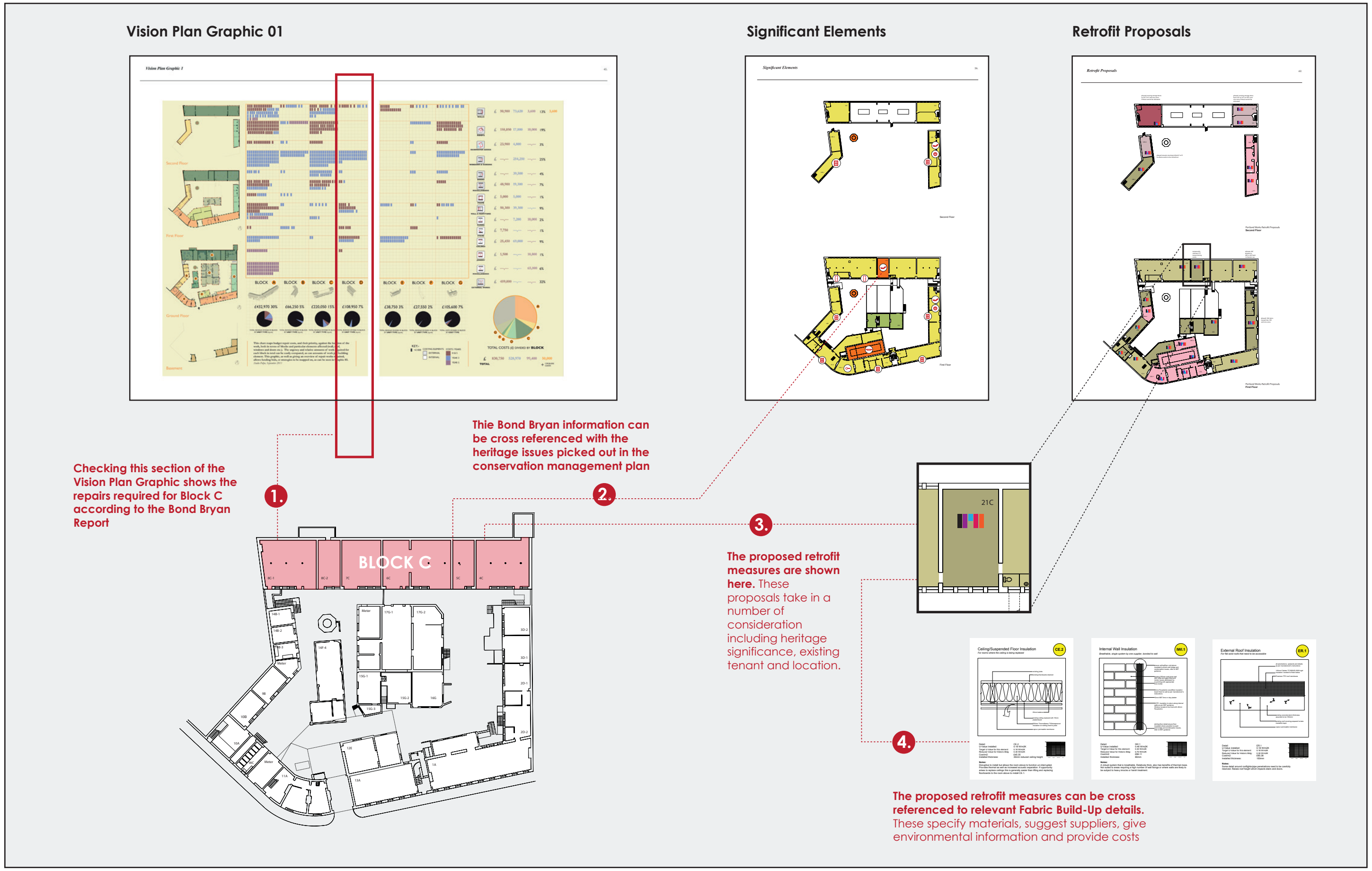


Fig. 6: Diagram, included in the report, showing how drawings, graphics and details can be used together to make decisions about renovating blocks, taking heritage, use, ease and cost into consideration

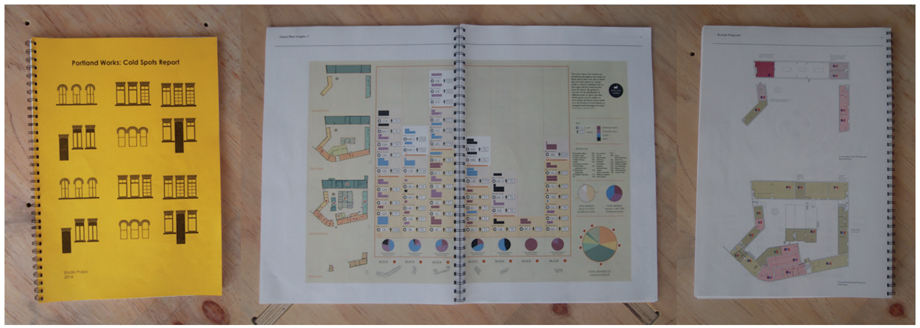


Fig. 7: The Cold Spots Report. (A3, 96 pages, including 35 drawing sheets)

Fig. 8:Final touches to Block A renovation.

RISE Awards 2015

Research | Innovation | Sustainability | Enterprise

Sustainable Developments & Energy

Designing and implementing an efficient Building Performance Evaluation system

WDH (Wakefield and District Housing) is a registered social landlord with charitable objectives. It provides a range of business services including: good quality, well-managed housing for rent, primarily by people who are unable to rent or buy at open market rates; supported housing and care for people who need additional housing related support or additional care; and a repairs and maintenance service for other housing associations.

The business is taking part in an innovative Knowledge Transfer Partnership with Leeds Beckett University to research, develop and execute a building performance evaluation capability in order to enhance the performance of the company's own properties and to generate revenue from the provision of consultancy services.

Aims of the Project include:

- To facilitate the evaluation of post-construction and post-occupation performance. This represents a significant increase in technical capability;
- Development of an internal WDH capability – currently WDH's delivery of zero-carbon homes relies on the use of external consultants to provide advice regarding building performance;
- An embedded capability in building performance evaluation will give WDH more control over its buildings from a performance, quality and cost perspective driving down the cost of new build whilst maintaining performance levels;
- The partnership will address the challenges associated with the introduction of new skills, new tools, new techniques and new methods of working;
- To increase commercial revenue generation through maintenance and consultancy contracts with other housing associations.

The project is being part-funded under a Knowledge Transfer Partnership from Innovate UK and is based at the company's offices in Castleford, West Yorkshire. Led by Agnieszka Knera, the project is receiving academic support and guidance from Dr Jim Parker from the Leeds Sustainability Institute at Leeds Beckett University.

Wakefield & District Housing

Email: sustainabilityteam@wdh.co.uk

Phone: 0345 8 507 507