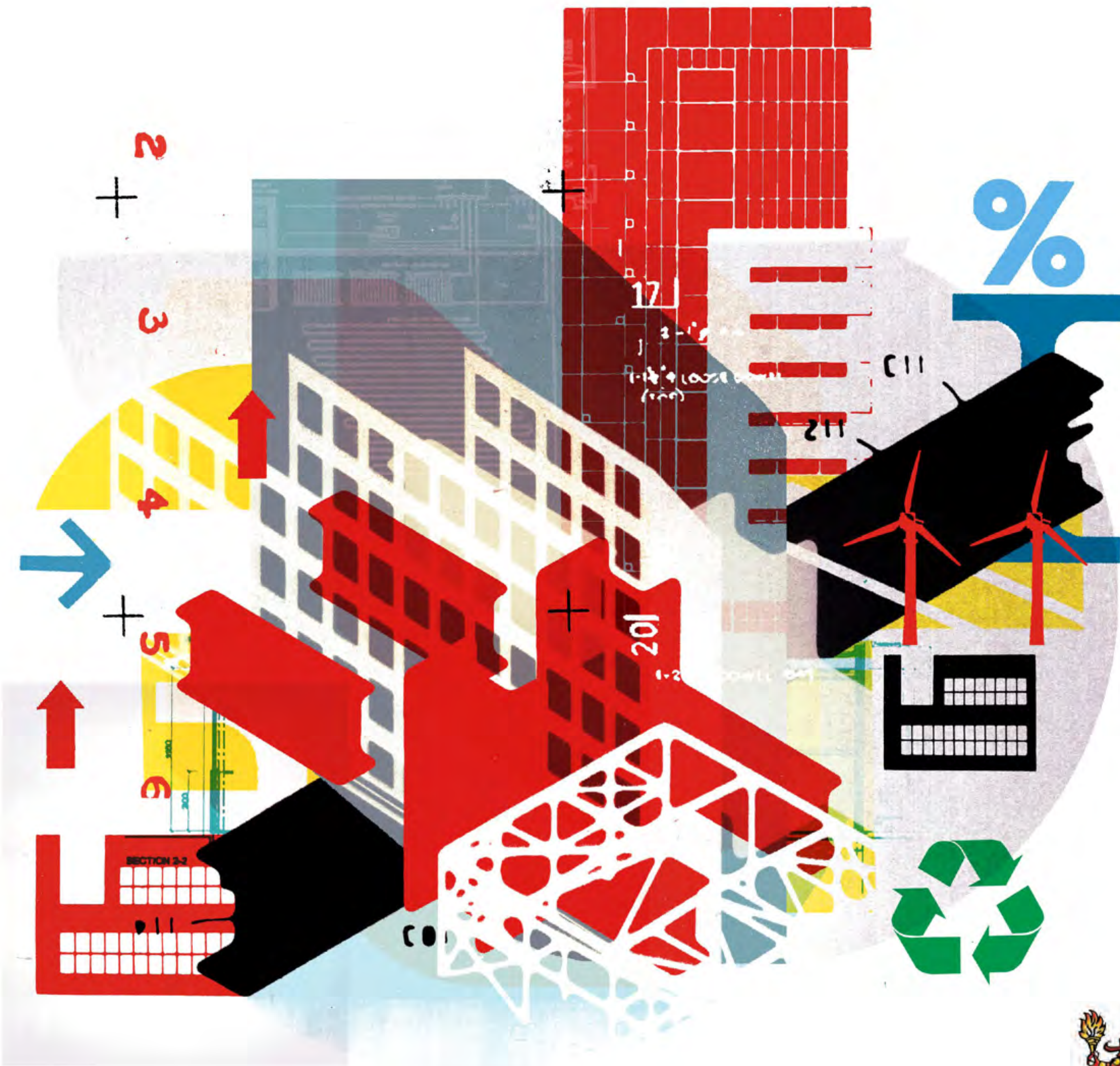
TARGET ZERO®

COST EFFECTIVE ROUTES TO CARBON REDUCTION



IN ASSOCIATION WITH TATA STEEL BCSA

Target Zero was made possible by the kind co-operation of these organisations

TARGET ZERO

How do we design zero carbon, steel-framed buildings? That was the question we wanted to answer in 2008 when we commissioned Aecom and Cyril Sweett to carry out this study into the routes to low and zero carbon.

The findings aren't just limited to the steel frame. And as you will see if you read on, the choice of structural material actually has little or no impact on a building's operational energy use and carbon emissions.

We think that you will find some of the answers surprising. We hope that you will find them useful.

Our intention is that clients and designers will use the results of this study at the feasibility stage of a project to help guide their decision-making and budget-setting in relation to energy efficiency and renewable energy targets for their buildings.

This foreword wouldn't be complete without a gentle plug for steel: a material that is naturally recycled and re-used continuously, we believe that when whole-life impacts are fully considered, steel is the ultimate sustainable material.

Derek Tordoff
director general, BCSA

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Editor Kristina Smith
Sub-editors Chloe McCulloch, Deborah Duke
Art director Nick Watts
Cover/main illustrations Alex Williamson
Diagram illustration Infomen

Project manager Francois Morrow
Business development manager
Daniel Woods: daniel.woods@ubm.com

BCSA/Target Zero
Roger Steeper: 020 7747 8135
www.targetzero.info

Produced by:

+44 (0) 20 7560 4291 | www.bdclientsolutions.com

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STARTING FROM ZERO

We know government has set tough deadlines for achieving zero carbon buildings, but there's little guidance about how to actually make it happen. Now BCSA and Tata Steel's Target Zero study should address that

The British Constructional Steelwork Association (BCSA) and Tata Steel have just spent two-and-a-half years and £1m on a study which wasn't primarily intended to compare steel favourably against concrete. Can that really be true?

It can and it is. The study in question is called Target Zero. Its purpose is to determine the most cost-effective combinations of materials and technologies needed to make low and zero carbon buildings a reality. Its results give clients and designers a clear steer on early decisions for the five different building types studied: schools, warehouses, supermarkets, offices and mixed-use.

"The research was about understanding the government strategy to achieve zero carbon for buildings," says Alan Todd, Tata Steel's general manager. "Targets were being set, but there was very little guidance available to inform people about what was needed to achieve them. Without good guidance people have to make their own assumptions. In order to make correct decisions people need good information on key factors like energy and cost."

There are major cost implications. But they don't impact in the choice of structural frame. The work by consultants Aecom and Cyril Sweett, showed a building's structure has almost no impact on its regulated carbon emissions. In fact it's more important to make the right choice of lighting strategy.

"When it comes to choosing the structural material, it's the normal decisions you should be taking: what is the best material for what you want the building to do? The same still applies to low or zero carbon buildings," says David Moore, BCSA's director of engineering. "I don't think that was clear two or three years ago."

> The work shows a building's structure has almost no impact on its regulated carbon emissions

For most buildings, the capital cost of reaching the next level of energy efficiency required in the proposed 2013 revisions to the Building Regulations is not unreasonable. But the costings in this research demonstrate that it will get painful if the government decides on a definition of zero carbon that calls for a higher proportion of on-site low and zero carbon (LZC) technologies.

Decisions taken early on impact hugely on the possible routes to zero carbon, and on the costs, both capital and lifetime. "There are various ways of getting there, some of them cheaper than others," says Ant Wilson, Aecom's head of sustainability.

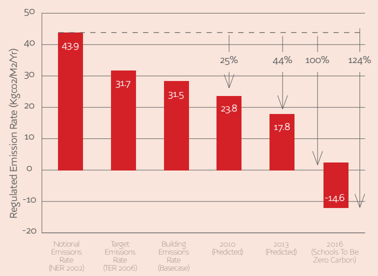
One striking finding across all the building types is the huge impact of lighting on a building's carbon emissions. While many new buildings will already have high efficiency lamps and luminaires, Aecom says that further carbon savings can be identified by using thermal dynamic modelling at the very early stages of design.

Some may be surprised to read that wind turbines are a cost-effective solution for many of the building types, albeit with caveats relating to site and planning hurdles. "Wind is good in the right location," says David Cheshire, Aecom's project manager for Target Zero. "We are really influenced by fashion in this industry. Everyone started out saying micro wind is great. Then they decided that none of it works. We should be taking a more scientific view and look at the size of the turbine and its location."

Most building types struggle to get anywhere close to zero carbon without →

WHAT IS ZERO CARBON?

As the government's chief construction adviser Paul Morrell once said: "If they talk about zero carbon, they don't mean zero and they don't mean carbon." Our quest towards "zero carbon" means we are trying to produce buildings that generate the little energy they require, using low and zero carbon (LZC) technologies like PV or heat pumps. However, this isn't viable at the moment, so zero carbon has to take in other possibilities too.



How changes to Part L will take us to zero carbon

Government is likely to set some minimum requirements for reducing carbon emissions: a proportion from energy efficiency measures, some from LZCs and the remainder from "allowable solutions". We don't know what these are yet, but they could include exporting renewable heat to neighbouring schemes or investing in LZC community heating.

The government is steering buildings towards zero carbon via Part L of the Building Regulations which deals with the conservation of fuel and power (see diagram). The 2006 revisions saw a 23.5% saving compared to the 2002 standards for naturally ventilated spaces, 28% for mechanically ventilated and air conditioned. The 2010 revisions saw a further 25% reduction in average carbon emissions from buildings. In 2013, another 25% saving will be called for, equivalent to 44% compared to 2006.

After that, we're not sure. If the government decides on its "offsite rich" scenario outlined in its policy consultation document, only 44% improvement on 2006 will be called for using energy efficiency and on-site LZCs. If they go for the challenging "on-site rich", that figure rises to 63%. And the costings in Target Zero demonstrate how expensive every percentage rise is once you get beyond the 40% mark, although that varies between building types.

looking for solutions off site. There is one exception: warehouses can get there with energy efficiency measures and PV alone.

When BCSA and Tata Steel commissioned this research the government had yet to decide on a definition for zero carbon. In fact, despite the consultation on zero carbon non-domestic buildings ending in February

At the moment embodied carbon seems like an issue for the future

2010 we are still waiting. The government has set the date for when new non-domestic buildings must be zero carbon: 2019. Public buildings and schools must get there earlier: 2018 and 2016 respectively. There is a route plan of sorts to get there: Part L of the Building Regulations was stepped up in 2010 to give, on average, 25% less carbon emissions than the 2006 version; Part L 2013 will do the same. And then there's a mighty leap to reach a definition of zero carbon, which is likely to include emissions from the building and also from the equipment inside it (see "What is zero carbon?", left).

Aecom and Cyril Sweett also worked out the costs of achieving BREEAM ratings of "very good" "excellent" and for the first time "outstanding", which was introduced in the 2008 revision BREEAM that rates buildings against sustainability measures. This work also highlighted the most cost-effective credits to go after in order to achieve the various ratings, which varied markedly depending on the site of the building.

The third leg of the research looked at embodied carbon, comparing the whole life impacts of materials and in particular comparing steel with concrete and timber. At the moment embodied carbon seems like an issue for the future; small compared with a building's emissions during operation. However, its importance will increase as operational carbon emissions decrease.

This is a contentious issue. Should embodied carbon assessments be limited to the energy expended to get a material or element into a building, so called "cradle-to-gate" calculations? Or should they encompass the energy spent in demolishing and recycling or disposal, known as "cradle-to-grave"? Steel is very much in the latter camp. Other materials with less impeccable recycling histories may differ.

Target Zero has answered some questions. And although no one claims the study provides absolute answers, it does inform developers and designers at the feasibility stage. The research also provides some robust methodologies for taking commercially based decisions. ■

Below: New schools must be zero carbon by 2016, see page 18

Above: The mixed-use study was based on part of the BBC's Salford Quays development

Q: In the mixed-use study, which energy efficiency measure proved the most cost-effective?

A: Reducing the height of the windows in the hotel

TARGET ZERO: HOW DID THEY DO IT?

The first challenge for consultant Aecom in carrying out the Target Zero research into the most cost-effective routes to low and zero carbon buildings was finding the buildings. Unusually Tata Steel and BCSA wanted to base the research on real buildings, rather than model ones because they wanted to provide properly costed out answers for present-day developments.

Adjustments had to be made to the five "typical" schemes – schools, warehouses, supermarkets, offices and mixed-use – to make some of the buildings "more typical".

The next big hurdle was deciding on the scope of the research. "Coming up with boundaries and sensible scenarios was challenging," says Aecom's head of sustainability Ant Wilson.

The research has involved modelling and scenario-testing for Aecom and number crunching from Cyril Sweett, which also worked on the study. For each building type the researchers produced a report considering operational carbon, BREEAM and embodied carbon. Three of the guides are available on the Target Zero website, with the final two due soon.

All the buildings were built – and the study began – before the latest change in the Building Regs Part L. So the comparative costs of energy efficiency measures and LZC technologies were taken from a 2006 Part L compliant level, as does the government's 2009 consultation paper on zero carbon non-domestic buildings.

Because the study looked at the design of buildings to comply with the increasing requirements of the Building Regs, it used dynamic thermal modelling software based on the National Calculation Method (NCM) to compare scenarios. The researchers did note the NCM does not tell us how buildings will perform in operation: "Building models are perfect at the early stages for optimising building design," says David Cheshire, Aecom's Target Zero project manager. "But in absolute terms, they are not great. Mainly because buildings are so complicated and you can't predict what will happen once you get people inside them."

Left: One Kingdom Street was used as a case study for different ways of achieving zero carbon

THE A B C OF OFFICE DESIGN

How do you work out what green measures really cut carbon – and which just aren't worth the cash? Aecom and Cyril Sweett took an existing office building and remodelled it to find out

What does a low carbon office look like? Perhaps not too different from this one. This is One Kingdom Street, in London's Paddington basin, designed by Sheppard Robson for Development Securities and completed in 2008. Aecom selected it as the building on which they would base their research into the most cost-effective routes to zero carbon for city centre offices.

One Kingdom Street contained some sound energy efficiency measures: higher levels of insulation than required by the Building Regulations at the time, a ground source heat pump to provide heating and cooling, solar panels on the roof for hot water, solar shading and solar control glass and good levels of airtightness. However, for the Target Zero study, all this good stuff had to be stripped out to create a base case building that just complied with the 2006 version of Part L of the Building Regulations.

Aecom, working with Cyril Sweett, then set about selecting the most cost-effective combinations of energy efficiency measures, on-site and offsite low and zero carbon (LZC) technologies to get the base case building and its unregulated carbon emissions from sources like office equipment to zero carbon.

The results, says David Cheshire, Aecom's project manager for Target Zero, provide guidance for clients and designers at the very early stages of design: "This research starts to show what some rules of thumb might be about what you gain by optimising elements and how far you go in terms of cost," he says.

So what did the study find? To get the most for your money, any client looking to develop low-carbon buildings must set targets for carbon reduction early on. And – critically – they must communicate the target to the whole design team. "The target must be set in stone," says Cheshire. "If there is something written down that says 'this is the target', then the QS and all the other parties will work towards it."

Hand-in-hand with target-setting comes budget-setting. "There is no point in having unreasonable expectations," says Cheshire. "Clients can't always have the highest standard of comfort with high energy reduction targets, at no extra cost."

But Target Zero can help by providing some ballpark figures from which to start. And the good news from this research is that you can get a good reduction in your building's carbon emissions - and save money over the building's life - for very little capital cost.

"For a relatively small outlay, really just a bit more care in the design and construction, you can get an enormous improvement in energy efficiency," says John Dowling, sustainability manager at the British Constructional Steelwork Association (BCSA) who co-sponsored the research with Tata Steel.

It may be no surprise that the lighting strategy is vital to reducing energy consumption. In the base case office, it accounted for 27% of regulated emissions. To reduce emissions, the building's orientation should be modelled much earlier than usual, according to Ewan Jones, Aecom's low carbon specialist. This will give pointers to the architect about the best balance between daylight and heating. "If you can optimise the model early on, you can give proper advice to architects about the orientation and window size," says Jones. "Designers don't do it enough." Even on a city centre site, where the orientation is likely to be fixed, thermal simulation modelling can improve early decisions.

At this point, the designer should give the electrical engineer a call. This role is often left out in the cold at the early stages of a building's design, while the mechanical specialists put their heads together. "We need to tap into the electrical engineers' knowledge about efficient lighting systems," suggests Jones.

It's then a case of balancing the budget: should it go on more insulation, more efficient services, glazing or would it be better →

FAST FINDINGS

Here are the main findings from the Target Zero study into city centre offices. They apply to the base case building, which is a modified version of the actual building:

1 The increase in capital cost of designing a city centre office that conforms to last year's changes to Part L of the Building Regulations was 0.27% compared to a building that just satisfied 2006 Part L. However, these measures would lead to a 25-year net present value saving of £1.85m.

2 Lighting accounted for 27% of the building's carbon emissions in operation (including non-regulated emissions). Dynamic thermal modelling was used to work out the best combination of energy-efficient lighting, glazing and solar shading.

3 Heating and cooling accounted for similar amounts of energy and therefore carbon emissions, so optimising them is a balancing act.

4 Achieving reductions in regulated carbon emissions significantly above 44% is technically challenging for this type of building. The options for on-site renewables are limited. So a greater reliance on offsite LZC solutions would be needed to approach true zero carbon.

5 The estimated capital cost uplift of the base case office building to achieve BREEAM ratings is:

- 0.2% for "very good"
- 0.7% for "excellent"
- 9.5% for "outstanding".

6 The impact of the structure on the operational carbon emissions was found to be small. The building emissions rate (BER) varied by just 0.05% between a steel-frame composite and a post-tensioned concrete structure.

Q: How much of the Target Zero office's carbon emissions are down to small power loads, such as computers, photocopiers and kettles?
A: 32%

→ spent on photovoltaics or combined heat and power (CHP), for example? Energy efficiency measures which impact on the heating or cooling are difficult to optimise, since the energy used to both heat and cool an office may be similar. So, for example, adding more thermal insulation reduces your heating bill but can add to the cost of cooling.

The Target Zero research provides some clear guidance, by ranking energy efficiency measures by cost-effectiveness: 25-year net present value (NPV) per kg of CO_2 saved.

A fairly modest energy efficiency package which includes elements such as improving the efficiency of mechanical kit and lighting, optimising the glazing and adding active chilled beams, costs just £172,400 or 0.27% of the building's capital cost, while reducing the building's emissions by 42%. And over 25 years, these measures lead to a saving of £1.85m

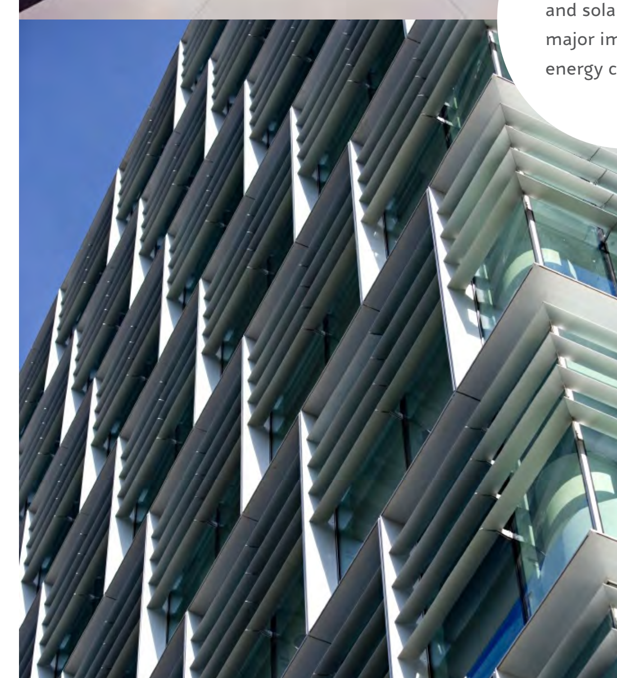
Keep beefing the energy efficiency measures up, however, and carbon saving becomes expensive. A more advanced energy efficiency package saves 52% of carbon emissions but attracts a capital cost increase of 2.79%. And a yet more advanced set of measures saves just 3% more carbon but brings the capital uplift to 3.41%.

But if you do want to go further than the 42% achieved with modest energy efficiency improvements, Cyril Sweett's costings show that the best way to reduce carbon is to start looking at on-site and offsite LZC technologies.

Ranked in terms of cost-effectiveness, the case study directs you to consider refrigeration heat recovery first, followed by PV and then wind turbines (though both may be subject to site constraints) and finally biogas combined cooling heat and power (CCHP) or air-source heat pumps.

Offsite LZC technologies have lower capital costs, because someone else is paying for the equipment, but it is not clear yet what the government will allow as part of a zero carbon solution. "The other problem with offsite LZC solutions," says Jones, "is that clients often don't always want to connect to them, due to the perceived extra level of risk they introduce." ■

> This research starts to show rules of thumb about what you gain by optimising elements



Left: Orientation, glazing and solar controls have a major impact on an office's energy consumption

THERMAL MASS

Thermal mass or fabric energy storage, is the ability of a material to absorb energy. In order to make use of it in modern buildings, the soffits of ceilings must be exposed so that the material can soak up excess heat. Then, at night, the building must somehow be ventilated so that cool air flows across the soffits, taking the heat back out of the building (see diagrams below).

One of the first buildings to use thermal mass in place of air conditioning was an office built by BRE on its Garston site in 1997. Since then, others have been built, several of them steel-framed buildings with a standard composite steel/concrete floor. Since heat storage only takes place in the first 75 to 100mm of the concrete, thicker floors offer no benefit in this respect.

However, thermal mass is not suitable in every case. City centre office blocks with deep floor plates, air pollution and security issues will seldom be naturally ventilated. However, arguments about thermal mass still come into play when considering structural frames. "There is an assumption that thermal mass helps. Full stop," says David Cheshire, Aecom's project manager for Target Zero.

The Target Zero study disproved this. Researchers looked at two types of structural frame: steel frame with lightweight concrete slab on steel profile decking, which is One Kingdom Street's actual construction; and a concrete frame with a 350mm post-tensioned concrete flat slab. The researchers took away the false ceilings to expose the thermal mass of both floor constructions and modelled what would happen to energy use. They found the energy saved by reducing the cooling energy was replaced by the increased heating energy required, so the carbon emissions rate between the two structural forms varied by less than 1%.

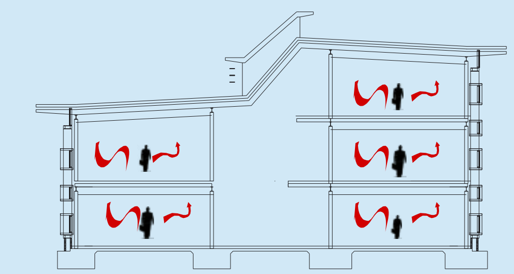


Fig 1: Heat from people and equipment is absorbed into the exposed soffits, reduing the air and radiant surface temperatures

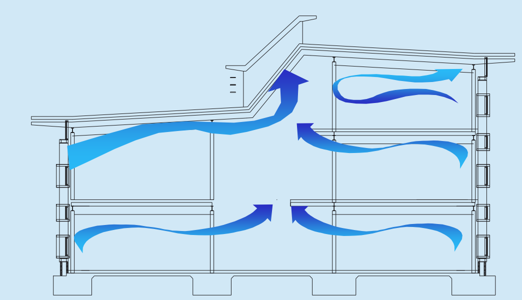


Fig 2: The flow of cool air across the soffit at night expels the heat stored in the structure

BREEAM TIPS

BREEAM tips: Seven things you need to know

By David Cheshire, Target Zero project manager, Aecom

What does it cost to get a BREEAM "very good" rating? Or "excellent"? Or "outstanding"? The answer of course depends on the location of your new building, but also on the route the design team takes in deciding what credits to pursue.

Considering each of the five building types in the Target Zero study, we took all the available BREEAM credits, and costed all those that went over and above standard practice. We then divided the capital cost of the credit by its weighting, as assigned by BREEAM, to produce a weighted value for that credit.

This gave us a ranking of credits which we used to define the most cost-effective route for a range of scenarios, using the base case building. We think these rankings will help with the really early stage decisions, before you even know what the building looks like. It could help to inform the design of your building and its position on the site, if you require a high BREEAM rating.

The rankings are all available in the building study reports which can be downloaded from the Target Zero website www.targetzero.info.

These are some of the messages which emerged from our findings across the five building types:

1 Carbon reduction costs

The latest version of BREEAM, launched in 2008, introduced the concept of minimum standards in some categories. Before then, all credits were tradable, which meant you could theoretically end up with a building that had a high BREEAM rating but was not that energy efficient.

Most of the mandatory credits are simple and cost-effective to achieve. But the credit relating to CO_2 reduction, Ene1, isn't. For the base case office building used in the study, achieving the mandatory Ene1 credit for "excellent" cost £172,400 and for "outstanding" £1.5m.

2 Ecology ain't cheap

Adding a pond or a wildflower meadow is sometimes seen as a cost-efficient way of enhancing your score, but our research showed that often this is not the case. For example, in the schools study we found to get all three credits under the LE5 "Enhancing site ecology" category would cost £82,500.

Additionally, if your building is on a rural site rather than a city centre one, it will cost you more to get the full credits relating to "Mitigating ecological impact", LE5. That is because you have to go quite a long way to mitigate the impact of the new building, before you start gaining.

3 Not all costs are BREEAM costs

When calculating the capital cost of achieving BREEAM ratings, it is tempting to look at every credit and allocate the cost of that item or element to BREEAM, making it appear costly to obtain high ratings. However, in our calculations we did not attribute costs to

BREEAM if something was likely to be part of standard practice anyway. For example, the average score across all sites under the Considerate Constructors Scheme is 32/40 which achieves two credits; since this is standard practice, we didn't attach a cost to it.

4 Urban beats greenfield

If your building is on a greenfield site, it's going to cost you more to get to the higher BREEAM ratings. Urban sites tend to score more credits in the Transport (Tra) and, Land Use and Ecology (LE) sections. Conversely, if you are on a greenfield site, you often cannot get those credits, so you have to go after others. In the school building for example, the researchers showed that the most cost-effective credits to go after for a greenfield site were in the Water (Wat), Materials (Mat) and Health and Well-being (Hea) sections.

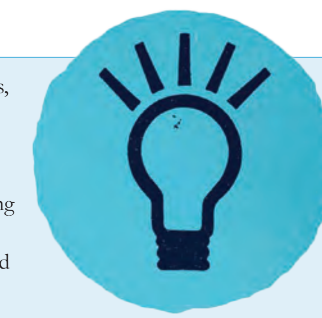
Target Zero worked out the difference in cost for achieving "very good", "excellent" and "outstanding" ratings for greenfield and urban scenarios.

For the supermarket case study the difference is at its most extreme: the study showed that achieving "outstanding" on an urban site would cost an extra 9%, whereas for a greenfield site it was 20.6%. For schools the capital uplift required for "outstanding" was 6.6% for urban compared to 7.5% for greenfield.

5 Innovation is cheap

The 2008 version of BREEAM introduced innovation credits, with any building being allowed to score up to 10. There are three ways of getting them: by meeting "exemplary performance criteria" for an existing BREEAM issue such as increasing daylight factors from 2% to 3%; by the client setting a specific BREEAM performance target and appointing a BREEAM accredited professional throughout the project; and by using something new and different.

In order to have the new feature, system or process



accredited, you must apply to BRE Global, which can decide that your idea is "innovative" and award you the points. Recent examples include an energy dashboard in reception to give building users feedback on how much energy they are using and easy-clean floor surfaces to cut down on the use of environmentally harmful cleaning products.

Going after a "true innovation credit" can sometimes be a cost-effective way of helping to secure those last few points to push you into the next rating band.

6 BREEAM experience counts

If a client wants to achieve a certain BREEAM rating for their new building, that requirement should be part of the earliest briefs. And they will save themselves money by employing consultants and a contractor who are well-versed in BREEAM.

Designers with BREEAM experience are more likely to have specifications that match the credit requirements, template reports for the additional studies required and experience of using specialists such as ecologists.

A cost consultant with a track record in BREEAM projects will have costings from similar projects to refer back to, which can help with early budget decisions.

Contractors can provide a building with 10 BREEAM credits at a reasonably small cost if they have systems in place. They need to monitor energy, waste and water and understand how the sourcing credits relate to procurement of materials. BREEAM 2008 also requires post-construction reviews.

7 Early decisions save cash

If you've got an experienced team of designers on board they will be well aware of the credits which are directly affected by decisions about the form and fabric of the building. For example, on the office building we identified the following credits which should be incorporated into the design as early as possible in order to get the best results in terms of cost: daylighting (Hea1), view out (Hea2), potential for natural ventilation (Hea7) and reduction of CO_2 emissions (Ene1).

If the design is advanced before you start thinking about these strategic issues, you can often still achieve a good rating but it will cost you more.

And what it really costs ...

The Target Zero study modelled a number of different routes that designers could take in order to obtain "very good", "excellent" and "outstanding" BREEAM ratings. The research reports contain details of the variations in cost between the different scenarios.

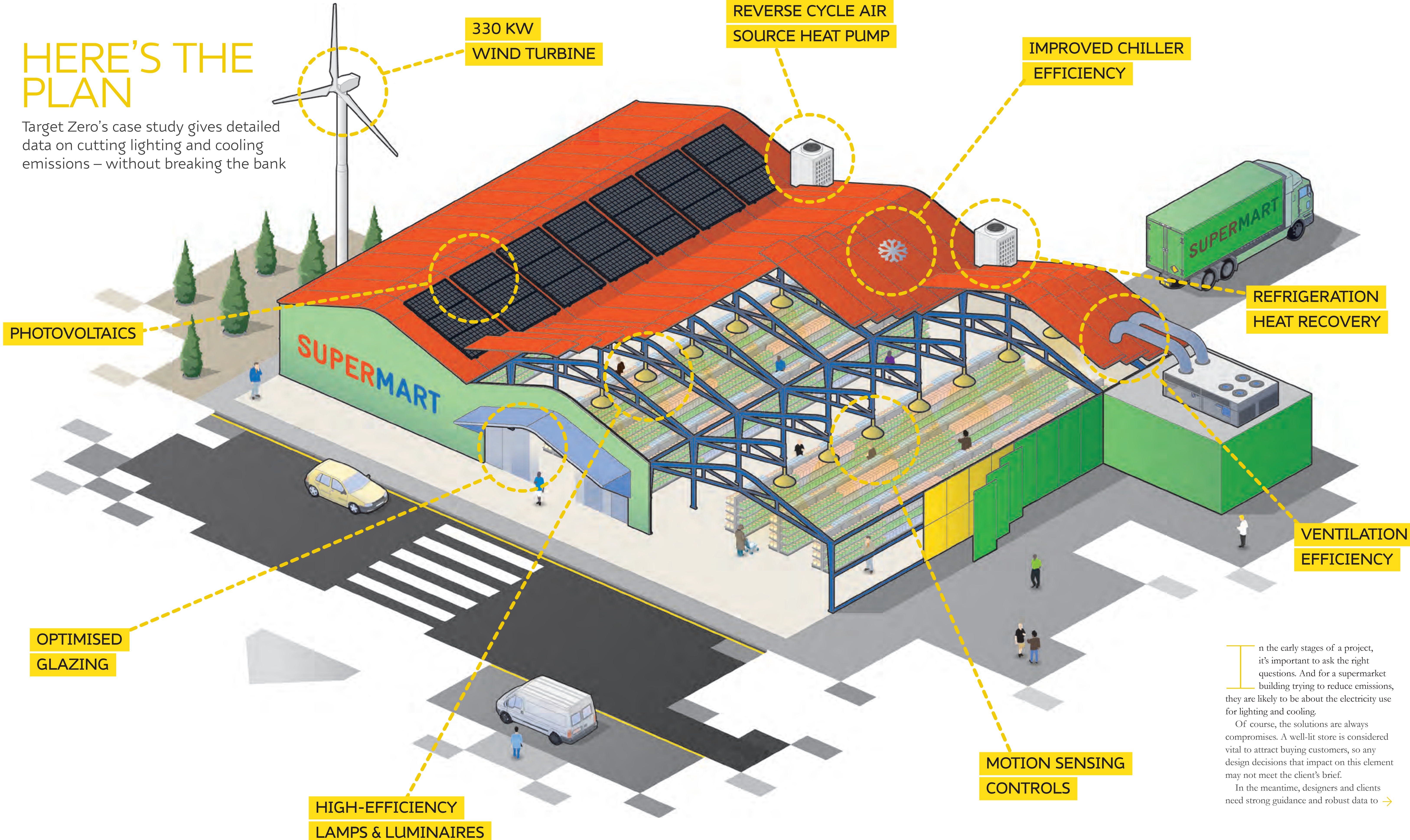
The table, below, shows the uplift costs calculated to achieve the top three BREEAM ratings for the actual case study buildings.

RATING	SCHOOL	INDUSTRIAL	RETAIL	OFFICE	MIXED USE
Very good	0.2%	0.1%	0.2%	0.2%	0.1%
Excellent	0.7%	0.4%	1.8%	0.8%	1.5%
Outstanding	5.8%	4.8%	10.1%	9.8%	4.8%

ENERGY EFFICIENCY

HERE'S THE PLAN

Target Zero's case study gives detailed data on cutting lighting and cooling emissions – without breaking the bank



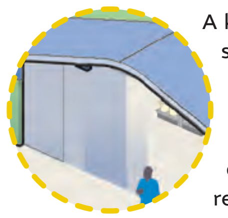
In the early stages of a project, it's important to ask the right questions. And for a supermarket building trying to reduce emissions, they are likely to be about the electricity use for lighting and cooling.

Of course, the solutions are always compromises. A well-lit store is considered vital to attract buying customers, so any design decisions that impact on this element may not meet the client's brief.

In the meantime, designers and clients need strong guidance and robust data to →

help them make well-informed decisions about where to concentrate effort and money. Which is what Target Zero aims to do. The information below is a very simplified version of the guidance available in the Target Zero reports. In addition to supermarkets, the reports cover schools, offices, warehouses and a building of mixed use.

OPTIMISED GLAZING



A key issue for a supermarket building is the positioning of the glazing. This has an impact on the risk of overheating, the requirement for artificial lighting and energy for space heating.

The optimum arrangement is to minimise east and west facing glazing as it is harder to control sunlight and heat through windows at this orientation. Toilets and storage are ideal for these rooms.

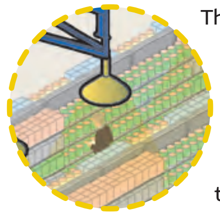
North facing rooms have low solar heat gain and could work well for server rooms, which will require less cooling, or offices. South facing rooms have high useful winter solar heat gain and, when shaded, low solar heat gain in summer.

For the retailer, the positioning of the building will also be governed by access, consumer patterns and the placing of the car parking. There will have to be a compromise between the best glazing strategy in relation to solar gain and the best strategy for attracting customers.

Optimising the glazing can often reduce the cost, but if additional solar shading were required, that would add to the cost.

COST	£0
COST/M²	£0
% OVERALL COST	0
CO_2 SAVED (% BASE EMISSIONS)	0.06
WHOLE LIFE COST (NPV OVER 25 YEARS)	-£99

MOTION SENSING CONTROLS



This technology is routinely employed in modern supermarket buildings out of hours or in the areas not frequented by customers. However, the Target Zero study did consider the energy savings that could be gained from using it in the store itself during opening hours.

Given the significance of lighting in the energy use of a typical store, this measure would contribute significantly to reducing carbon emissions and could be implemented cost effectively. However, for retailers, bright lighting is critical in attracting customers to stores. To accept motion sensing controls would require a fundamental change of ethos and approach on their part.

The study assumed the building already included passive infrared (PIR) sensors in non-retail areas, and added two PIR sensors per aisle and one at each checkout. Together with some in the cafe and other areas, this gave 120 sensors, or about one per 47m².

COST	£12,000
COST/M²	£1.28
% OVERALL COST	0.08
CO_2 SAVED (% BASE EMISSIONS)	4.0
WHOLE LIFE COST (NPV OVER 25 YEARS)	-£106,105

HIGH-EFFICIENCY LAMPS AND LUMINAIRES

This measure would effectively achieve a 25% carbon reduction on its own. While most retailers are aware how important lighting is and use high-efficiency lighting, they may not realise how much of the electricity bill goes on lights, unless stores have intelligent metering.

In the base case building, over 810 lights were up-rated, approximately one per 10m². We upgraded the mix of modular recessed luminaires and halide highbay luminaires and added high efficacy reflectors. Some fitting specifications were also improved.

When designing lighting, it is important to consider the store layout and position of the shelves. Designers should also be aware that the Building Regulations calculation method assumes one big open space, rather than one divided by high racks as in warehousing areas.

COST	£42,900
COST/M²	£4.57
% OVERALL COST	0.27
CO_2 SAVED (% BASE EMISSIONS)	22
WHOLE LIFE COST (NPV OVER 25 YEARS)	-£758,082

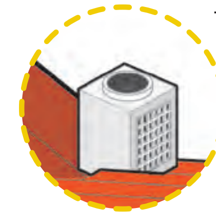
VENTILATION EFFICIENCY

This means improving the efficiency with which air is moved around to provide ventilation and cooling. In this case, we found 20% reduction of power for 11 supply and extract fans and four air handling units was quite achievable.

Often a specification from the last similar store is used. But this exercise shows that it pays to fine-tune M&E systems. Retailers may look into this in more detail as pressures such as the Carbon Reduction Commitment come to bear.

COST	£8,900
COST/M²	£0.95
% OVERALL COST	0.06
CO_2 SAVED (% BASE EMISSIONS)	2.37
WHOLE LIFE COST (NPV OVER 25 YEARS)	-£68,695

REVERSE CYCLE AIR SOURCE HEAT PUMP

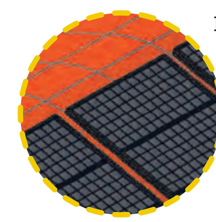


The gas-fired boiler and chiller plant specified in the base case building were replaced with two-way heat pump units, configured to provide 590kW heating output and 530kW cooling. The cost takes into account additional pipework and power supplies.

Although this technology helps push the building towards low carbon emissions, its impact is limited due to the relatively low proportion of a supermarket's energy that is spent on heating and cooling.

COST	£39,000
COST/M²	£4.15
% OVERALL COST	0.25
CO_2 SAVED (% BASE EMISSIONS)	5
WHOLE LIFE COST (NPV OVER 25 YEARS)	-£82,312

PHOTOVOLTAICS



In a building with a huge roof where lighting and chillers dominate, electricity-generating PV panels make sense. With the added benefit of feed-in tariffs, where owners are paid for the electricity they generate, this is now a financially attractive way of reducing carbon emissions for a supermarket with a medium-term interest in the site.

The cost includes 4,000m² of amorphous type PVs integrated into the standing seam roof, with a rate of £450/m² used for the PV when the effect of offsetting the cost of standard roof panels is taken into account.

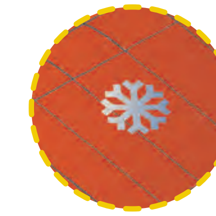
COST	£1.649M
COST/M²	£175.56
% OVERALL COST	10.44
CO_2 SAVED (% BASE EMISSIONS)	14.41
WHOLE LIFE COST (NPV OVER 25 YEARS)	£170,513

330KW WIND TURBINE

This was the largest wind turbine that we felt could be modelled on site. Obviously, the viability of a wind turbine is very site-dependant. Wind turbines should not be positioned within "topple distance" of any occupied buildings or where they will have significant impact on residential buildings.

COST	£670,000
COST/M²	£71.33
% OVERALL COST	4.24
CO_2 SAVED (% BASE EMISSIONS)	27.16
WHOLE LIFE COST (NPV OVER 25 YEARS)	-£1,440,606

IMPROVED CHILLER EFFICIENCY



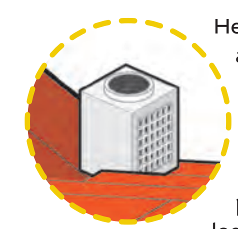
The big supermarket chains would be carrying out this sort of analysis for themselves and upgrading chillers, because of their impact on energy bills. The performance of chillers improves on almost a monthly basis and new products are constantly coming onto the market. Designers should make sure they have the very latest details from manufacturers.

In the study building, the efficiency of the chiller was increased to a SEER (Seasonal Energy Efficiency Rating) of 6.00 by introducing air cooled chillers in lieu of direct expansion cooling to the air handling units.

COST	£47,600
COST/M²	£5.07
% OVERALL COST	0.30
CO_2 SAVED (% BASE EMISSIONS)	4.56
WHOLE LIFE COST (NPV OVER 25 YEARS)	£79,998

Refrigeration heat recovery is a cost-effective way to provide hot water

REFRIGERATION HEAT RECOVERY



Heat exchangers were added to the fridge and freezer chiller units to generate domestic hot water. The cost includes for additional pipework and increased local hot water storage to 4,000 litres.

Like the air source heat pump, this technology does not have a huge impact on carbon emissions, but is doing its bit as part of a package of low and zero-carbon technologies. This long-established technology is more cost effective than most of the renewables considered and could be applied to many building types.

COST	£26,780
COST/M²	£2.85
% OVERALL COST	0.17
CO_2 SAVED (% BASE EMISSIONS)	1.83
WHOLE LIFE COST (NPV OVER 25 YEARS)	-£6,003

LESSONS WE HAVE LEARNED

All new schools are meant to be zero carbon by 2016, so Aecom and Cyril Sweett carried out research to find some cost-effective solutions

Above: The Target Zero study building was based on the Christ the King Centre for Learning, Knowsley, Merseyside

A lot can happen in two-and-a-half years. When the Target Zero study into the most cost-effective routes to zero carbon buildings began, no one quite knew what zero carbon would mean.

Today, plans for the UK's first zero carbon school are well advanced. Willmott Dixon is to build a zero carbon primary school and nursery as part of the £13m Crouch Hill Community Park in Islington, London.

Crouch Hill will reach its zero carbon target with energy efficiency measures and an energy centre, combining a biomass boiler and gas combined heat and power (CHP), which will share its heat with a neighbouring housing development.

For schools not in such dense urban areas, however, community CHP schemes become less viable. According to the Department for Energy and Climate Change the potential for community heating nationally, could be as high as 20% of heat demand, but that figure is likely to be lower for schools as they are generally in suburban areas.

The Target Zero study helps us understand where the most cost-effective cut-off points are. By combining energy efficiency measures and low and zero carbon (LZC) technologies, 44% savings in carbon compared with 2006 can be achieved for just 0.26% increase in capital cost. Beyond that, saving carbon really starts to eat into a school's building budget (see diagram, p20).

"The work that came out of the schools study began to inform us it would be far too expensive to use only local measures in the school to achieve zero carbon," says David Moore, director of engineering at the British Constructional Steelwork Association (BSCA), which funded the research with Tata Steel. "It becomes prohibitively expensive even to achieve zero carbon in terms of regulated energy emissions. Zero carbon in terms of true zero is even more difficult to achieve." →

Q: What is the most cost-effective option? Ultra insulation or a 50kW wind turbine?

A: The wind turbine

Above: Balfour Beatty built the Christ the King Centre for Learning under the Building Schools for the Future programme

School designers have got a tougher challenge on than the rest, since the government has set the target of all new schools being zero carbon from 2016, compared with 2018 for all public buildings and 2019 for all non-domestic buildings. And zero carbon means cancelling out emissions from the building (known as "regulated" emissions) and those from the equipment inside it ("unregulated"), which account for about 20% of a school's total carbon emissions.

The Building Schools for the Future (BSF) programme, which aimed to rebuild or refurbish every secondary school in the country until it fell victim to the coalition government's spending cuts, had already been steering new schools towards lower carbon emissions. So the school which consultants Aecom selected for the study, the Christ the King Centre for Learning in Knowsley, Merseyside, built as part of BSF, included energy efficiency measures and LZC technologies beyond those required by the Building Regulations at the time. Balfour Beatty installed a ground source heat pump and heat recovery technology in the school, which opened its doors to 900 pupils and 50 staff in January 2009.

For the purposes of the study, the building was modelled so that it was just compliant with the 2006 Building Regulations. The changes included swapping the ground source heat pump for a conventional boiler, lessening insulation levels and lowering the efficiency of M&E systems and removing the ETFE roof from a winter garden.

In order to work out what the most cost-effective measures for a school would be, researchers from Aecom and Cyril Sweett ranked energy efficiency measures and on-site and offsite LZCs in terms of 25 year net present value (NPV) per kg of CO_2 saved. This allowed them to create three "packages" of energy efficiency measures ordered in terms of increasing capital cost.

Package A (see diagram below), which cut regulated carbon emissions by 26%, included the following energy efficiency measures, listed in order of cost-effectiveness: passive chilled beams, ideal orientation with shading and strategic resizing of windows, 95% efficiency boiler, very high-efficiency lamps and luminaires, daylight dimming controls throughout and advanced air tightness. This package added only 0.14% to the capital cost and saved £580,950 over 25 years.

> Even schools that use CHPs, PV or wind turbines will not reach true zero carbon

Adding more energy efficiency measures saves more CO_2: 41% for a 1.44% increase in capital cost; 49% for an uplift in capital of 6.57%. Both scenarios save money over 25 years. However, the researchers discovered more cost-effective routes by combining different energy efficiency packages with various LZC technologies (see diagram, below).

The diagram shows the most cost-effective combination to achieve a 44% reduction in regulated carbon compared with 2006, which is the probable level which the 2013 revisions to Building Regulations Part L will require. To get to 70% with on-site measures, which was the target set for zero carbon housing, would add 5% onto capital costs.

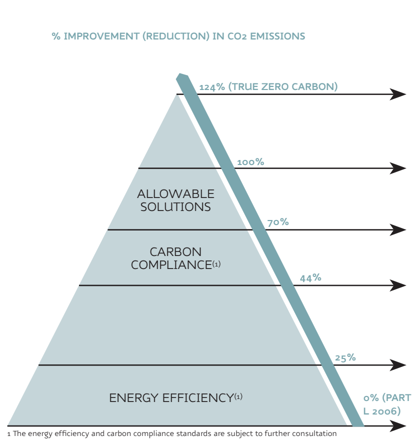
Air source heat pumps, a 50kW wind turbine, a 20kW wind turbine, large photovoltaics and biomass came out as the most cost-effective on-site LZCs. Off-site district heat solutions, whether CHP or energy from waste, were more cost-effective than any of the on-site technologies.

However, all the on-site LZCs added significantly to the budget. And quite aside from the extra capital cost, many school sites would not be suited to some or all of them. Wind turbines, for example, cannot be within topple distance of other buildings or near housing; school roofs do not have big enough areas to do enough with PV.

Even schools which could use district CHPs, PV or wind turbines, will not be able to reach true zero carbon. So what the government calls "allowable solutions" would be required. These might include exporting renewable heat or cooling, as in the case of Crouch Hill, or physical connections to offsite renewable electricity.

What the Target Zero work demonstrates is that targets must be flexible to accommodate the range of school locations. It does not seem to make sense to divert significant amounts of a school's building budget away from creating a learning environment towards LZC installations. ■

Carbon reduction: What's the best mix?



1 The energy efficiency and carbon compliance standards are subject to further consultation

ENERGY-EFFICIENCY MEASURES	LZC TECHNOLOGIES	ADDITIONAL CAPITAL COSTS (£)	25 YEAR NET PRESENT VALUE (£)
CANNOT BE ACHIEVED BY ON SITE LZC TECHNOLOGIES ALONE			
PACKAGE A plus: Occupancy sensing lighting controls throughout; Ultra low fan power 1.5W/l.s; Improved roof insulation 0.2W/m2K; Very high chiller effi ciency SEER = 700; Advanced thermal bridging; Improved wall insulation 0.25W/m2K	Biomass boiler 50kW wind turbine 216m2 of solar thermal panels 1,300m2 array of photovoltaics	2,591,400 [12%]	1,525,921
PACKAGE A	Air source heat pump 1,300m2 array of photovoltaics	1,144,900 [5%]	140,692
PACKAGE A	Air source heat pump	57,750 [0.26%]	-433,864
PACKAGE A: Radiant ceiling; Ideal orientation; Window size optimisation; 95% effi cient boiler; Efficient lighting 1.75W/m2 per 100lux; Daylight dimming; Advanced air tightness 3m3/hr per m2 @50Pa		31,900 [0.14%]	-580,950
BASE CASE BUILDING			

FAST FINDINGS

Here are the main findings from the Target Zero study into schools. They apply to the base case building, which was a modified version of the actual building.

1. It only cost 0.14% of capital cost to get from a building just compliant with the 2006 Building Regs to one that meets the 2010 changes to Part L. And the measures saved money over 25 years.

2. True zero carbon – cancelling out emissions from the building and the equipment in it – was not achievable using only energy efficiency and on-site low and zero carbon (LZC) technologies.

3. To cancel out the building's regulated carbon emissions would increase capital cost by 12%. The most cost-effective combination was energy efficiency measures, 50kW wind turbine, photovoltaics, a biomass boiler and solar thermal panels.

4. The most cost-effective offsite solution would be to purchase a share in a wind farm. If the government decides this is not allowed, district CHP is next best.

5. The estimated capital cost uplift of the base case school building to achieve BREEAM ratings is:
   - 0.2% for Very Good
   - 0.7% for Excellent
   - 5.8% for Outstanding.

6. There was virtually no impact on the operational carbon emissions of the school from the structure of the building. The building emissions rate (kg of CO_2 emitted per m² of building per year) varied by less than 1% between steel and concrete.

IS TIMBER ALWAYS MORE SUSTAINABLE?

Trees absorb carbon dioxide when they grow, they can be replaced by new trees once cut down, and at the end of timber's life it can be burnt to generate energy, putting the carbon dioxide back into the atmosphere. Timber must be the most sustainable building material ever, right?

Well, not necessarily. Imagine instead that trees are not replanted and the timber is not re-used or incinerated but instead is sent to landfill. Suddenly, it's a very different story.

Welcome to the world of life cycle assessment (LCA). "Life cycle assessment is based on a lot of assumptions," says Alex Hardwick, LCA researcher, "you need to make sure the assumptions are robust and consider realistic scenarios rather than best case."

This, of course, means that there is no definitive answer to any one question. And sometimes, a fact that we have always assumed to be true is turned on its head.

Biodiesel is a case in point, and also the story that whetted Hardwick's interest in LCA. As a student, he landed himself a work placement as a process chemist with a Brazilian biodiesel firm. "When I got the job, biodiesel was the saviour of the planet," remembers Hardwick who now works for Tata Steel RD&T. "By the time I was on the plane flying over there, many regarded it as the worst industry in the world." The reality lies somewhere in between and the answer is the whole life cycle. Hardwick says: "Biodiesal from waste is generally a good, sustainable source of fuel. The case is less favourable if biodiesal has replaced crops."

The Target Zero study involved researchers, including Hardwick, comparing the embodied carbon emissions of different materials. While people won't be shocked to learn that steel has less embodied carbon than reinforced concrete in comparable structural situations, they might be surprised to hear that the steel frame in the retail building study had less embodied carbon than the timber alternative.

The result may seem counter-intuitive, but it was reached by considering current practice: the amount of steel recycled now compared with how much timber is currently recycled, incinerated and sent to landfill. "Timber in landfill produces methane, much of which escapes to the atmosphere," says Hardwick, "and methane is a greenhouse gas 25 times more damaging than carbon dioxide. If we had assumed a best case scenario for the amount of timber that was incinerated to generate energy in the future, the result may have been different."

Some would argue that it's unfair to assume current practice for the end of life treatment of timber: we may get better at reusing timber, and incinerators may be able to cope better with treated timber in the future. The counter-argument for steel would be that new ultra low-energy technologies for making steel are already in an advanced stage of development and there is likely to be even higher levels of steel recycling and re-use.

It is clear that one of the most important aspects of proper life cycle assessment, particularly when comparisons are being made, is to ensure that apples are compared with apples. ■

WHEN IS A SHED NOT A SHED?

When it's a power station. Slash your energy consumption with efficient lighting, says Target Zero, and the government's feed-in tariff can turn your warehouse roof into a source of income

Photovoltaics and warehouses were made for each other. And the introduction of the feed-in tariff in April 2010 has made the combination of PV and shed even better.

Decisions about where to allocate budget when selecting energy efficiency improvements and low and zero carbon (LZC) technologies should always be guided by what the building's dominant energy loads are. For warehouses, it's lighting.

The Target Zero study showed that for a warehouse designed to the 2006 Building Regulations, 73% of its energy was expended on lighting. For a 2010 Regs-compliant shed, that falls to 42%, still a sizeable proportion.

So a LZC technology which produces electricity is ideal. And now the feed-in tariff (FIT), which applies to new anaerobic digestion, hydro and wind installations up to 5MW as well as PV, means that the building owner will be paid a generation tariff for every kilowatt hour of electricity generated and an export tariff for electricity that is exported to the grid.

With energy-efficient lighting cutting electrical demand and a roof full of PV panels, warehouses can now provide a double income for their owners. "Leases will change to allow developers to have separate business models for the space within the shed and its roof," says BCSA consultant Roger Pope. A whole new industry offering sale-and-leaseback type deals on PV installations is already emerging.

Target Zero also demonstrates that warehouse developers can make serious inroads into carbon emissions with energy efficiency measures alone. The building on which the study is founded, the DC3 distribution warehouse on ProLogis Park, Stoke-on-Trent, is a good example.

ProLogis' building, which was completed in December 2007 and is leased by a large UK retailer, has an A-rated Energy Performance Certificate, achieved a building emissions rate 55% lower than required by the 2006 Building Regulations and a BREEAM "excellent" rating (the highest available at that time). To create a base case building for the Target Zero calculations, the building was re-modelled, taking away energy efficiency measures, to make it just compliant with Part L of the Building Regulations 2006.

The researchers found that by adding a package of energy efficiency measures to the base case, including more efficient lighting, improved rooflights, 10% of rooflights with daylight dimming, improved airtightness and advanced thermal bridging, CO_2 emissions fell by 54%. And the uplift in capital cost was just 0.98%.

If developers are really serious about slashing their carbon emissions, warehouses are one of the few building types which can get there without having to resort to offsite technologies. The research showed that a combination of energy efficiency and 17,200m² of PV panels covering about half the roof area could produce a true zero carbon building. The capital uplift would be 37.3%, but there would be NPV savings of £3.6m over 25 years.

For this particular site a more cost-effective option proved to be a smaller PV array with a 330kW wind turbine. A larger turbine shared with other buildings could be better, although not feasible on all sites. ■

FAST FINDINGS

Here are the main findings from the Target Zero study into warehouses. They apply to the base case building, which was a modified version of the actual building

1. Energy-efficient lighting alone can achieve the carbon reductions required between Part L of the Building Regulations 2006 and 2010, giving a 37% reduction in regulated carbon emissions.

2. Energy efficiency measures alone generated substantial carbon savings: 54% of regulated emissions with a 0.98 % reduced capital cost, up to 81% of regulated emissions for a 3% increased capital cost.

3. Efficient lighting systems combined with optimum rooflight design were key in delivering operational carbon reductions.

4. Low and zero carbon (LZC) technologies providing heat were predicted to increase – not decrease – carbon emissions. This is because the pumps that run the underfloor heating-type systems require more energy than the radiant system assumed in the base case.

5. Combining energy efficiency measures with either a large array of PV panels or a large 2.5MW turbine would result in true zero carbon (including emissions from both the building and its activities). However, this size of wind turbine would not have been suitable for the base case building's site.

6. The estimated capital cost uplift of the base case warehouse building to achieve BREEAM ratings is:
0.04% for "very good"
0.4% for "excellent"
4.8% for "outstanding".

Q: Which heating method was predicted to produce the most CO2? Warm air blowers or a radiant heat system?

A: Warm air blowers, due to the fan power required

Below left: Warehouses could benefit from having photovoltaic panels installed on the roof

TIMBER: IN THE FRAME

Glulam beams are being used to shout the credentials of a new generation of 'eco-stores'. But do the figures add up?

Above: Target Zero showed that steel-framed supermarkets and 'eco-stores' with glulam have very similar embodied energy.

Glulam beams are becoming a prominent feature in some new "eco-stores", with Tesco citing timber's lower embodied carbon as the reason for their inclusion in the "most energy-efficient ever supermarket" which opened in Manchester in 2009.

As part of the Target Zero study, glulam's embodied carbon credentials were tested. Aecom took the study building – Asda's Stockton-on-Tees food store, which opened in May 2008 – and replaced its steel frame with a glulam one, a move which cost consultant Cyril Sweett calculated would add 2.4% onto the capital cost of the building.

Comparing the operational energy of the two versions of the building, there was little in it. The glulam structure produced slightly more carbon, because the height of the building was increased to accommodate the depth of the beams.

What some will find surprising is the embodied carbon result. The glulam frame came in with 16% more embodied carbon than the standard steel frame. The main reason for this poor performance on the part of the glulam was the assumptions made in the life cycle assessment. Glulam is rarely incinerated so it goes to landfill, as does most timber, where it produces methane – a greenhouse gas 25 times more potent than carbon.

It is a closer run thing when the whole building is considered, as much of the embodied carbon of any building is found in the foundations and floor slabs. The total embodied carbon in the glulam building is 2.1% more than the steel framed one.

These findings create a conundrum for supermarkets. The most important thing for a retailer's profitability and financial sustainability is to keep the customers coming. And if shoppers perceive timber as sustainable, that perception has a value.

"If they are looking for a commercial argument for glulam, there may be one," concedes Roger Pope, a consultant with BCSA. "But if they are looking for a technically sound argument about embodied carbon, there isn't one." ■

Left: The base case for the supermarket study was modelled on Asda's food stores in Stockton-on-Tees

FAST FINDINGS

Here are the main findings from the Target Zero study into supermarkets. They apply to the base case building, a modified version of the actual building

1. Adding energy efficiency measures to upgrade a 2006 Part L-compliant supermarket to be 2010 compliant saved 0.36% of the capital cost, 35% of carbon and £973,545 NPV over 25 years.

2. Saving more carbon through beefing up energy efficiency measures further attracted higher capital costs of 0.8% to save 51% carbon, compared with the 2006 base case, and 5.1% to save 58%. Both packages saved money over 25 years, the second one less so.

3. Lighting accounted for about half the building's carbon emissions. Improved efficiency cut emissions by up to 27%, and daylight dimming saved a further 10%.

4. Heating and cooling of a supermarket building take similar amounts of energy. Spending time and money on energy efficiency measures to reduce heating will add to cooling and vice versa.

5. The research showed that it is possible to achieve a zero carbon supermarket by using energy efficiency measures and on-site low and zero carbon (LZC) technologies. However, this would incur a capital uplift of 26.5% and require a 330kW wind turbine and a biogas-fired combined cooling heat and power (CCHP), neither of which will work on most sites.

6. The estimated capital cost uplift of the base case supermarket building to achieve BREEAM ratings is:
0.2% for "very good"
1.8% for "excellent"
10.1% for "outstanding".

THE SECOND AGE OF STEEL

How many designers consider steel bearing piles for a building? Concrete piles – whether cast in-situ or pre-cast – account for the lion's share of the foundation market for reasons that are well rehearsed: they're cheaper, quieter and proven.

But Cyril Sweett's work on Target Zero has shown steel bearing piles can be more cost-effective than concrete. On the schools study, the QSs found that they came in 20% cheaper than the pre-cast concrete piles which had been used. Steel piles also score high on recyclability: when the building is demolished, pull them out of the ground, leaving the land the way you found it.

Steel had a much stronger market position until the seventies and eighties, according to Dave Rowbottom, Tata Steel's construction development manager, when industrial action temporarily restricted the supply of steel and this, combined with improving techniques in concrete piling, changed the balance.

In the Target Zero study, the team did not fall into the trap of replacing concrete piles with steel ones as a one-for-one exercise. The strength of steel meant it was possible to reduce the number of piles under the building significantly. "This advantage is not always recognised by designers," observes Rowbottom. "Steel may appear uncompetitive if they simply compare costs using a one-to-one substitution against a concrete design."

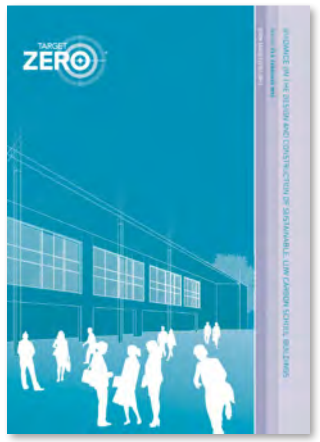
Fewer piles means smaller pile caps, so less excavation and less concrete: all positives in terms of reducing cost. However, smaller pile caps can mean that the floor slab has to be beefed up to span the longer distances. That was the case on the supermarket study, where the cost difference between steel and concrete piles was much closer.

But what about the noise of installation? Technology could be about to wipe out concrete's perceived advantage, and machines now exist that can push a number of sheet piles into the ground using hydraulic rams. And, says Rowbottom, the same technology will soon be used to install groups of H-piles without noise and vibration.

The combination of cost savings, sustainabilty and advancing technology can start to make designers think again about steel bearing piles. ■

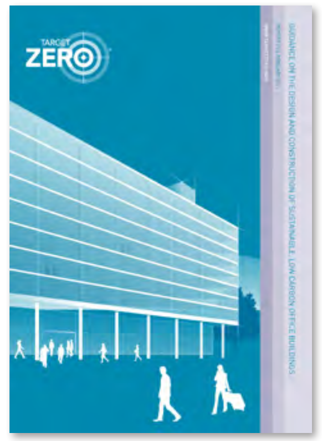
WANT TO KNOW MORE?

The articles in this supplement have only touched on some of the findings from the Target Zero research. The first three guidance reports, below, can be downloaded and read free-of-charge from the Target Zero website, **www.targetzero.info**, now. The two others will be available shortly and you can pre-register to receive them.



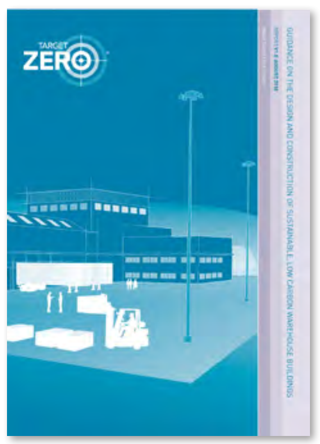
SCHOOLS

The first Target Zero guidance report on a secondary school building was based on Christ the King Centre for Learning in Knowsley, Merseyside, built by Balfour Beatty under the Building Schools for the Future programme and opened in January 2009. Occupied by 900 pupils and 50 staff, the 9,637m² steel framed building is based on a 9m by 9m structural grid. The depth of the classrooms, which was a requirement of the local authority, means that mechanical ventilation is required.



OFFICES

The building on which the office research is based is One Kingdom Street, near Paddington in central London, which Development Securities completed in 2008. Providing 24,490m² of open-plan office space over 10 floors, the building was designed to achieve the maximum floor plate depth in line with British Council of Offices guidance. The building has a steel structure, on a typical 12m x 10.5m grid, comprising fabricated cellular steel beams supporting a lightweight concrete slab on a profiled steel deck.



WAREHOUSES

The warehouse study is based on the 34,000m² DC3 distribution warehouse at ProLogis Park, Stoke, which was completed in December 2007 and is currently leased by a large UK retailer. The four span steel portal frame warehouse is attached to a two-storey office wing, providing 1,400m² of space. This report was written before the government introduced its feed-in tariffs for renewable energy sources in April 2010. A revised report taking the tariff into account will be published on the website shortly.

MIXED-USE

The mixed-use building is based on a tower block on the Salford Quays, part of a much larger scheme which will house the BBC, incorporating three buildings and a new studio complex providing 70,000m² offices, 25,000m² studios, 6,000m² retail and leisure and two residential blocks of apartments. The block used for the study is attached to the main studio building and made up of office space in its lower half and a hotel above.

SUPERMARKETS

The base case building for the supermarket report is based on Asda's food store at Stockton-on-Tees in Cleveland, completed in May 2008. The building has a floor area of 9,393m² over two levels. The retail floor area, including a 1,910m² mezzanine level, is 5,731m². The remaining (back-of-house) accommodation comprises offices, warehousing, cold storage, a bakery and a staff cafeteria.

HELP YOURSELF ...

TALK TO US ...

The experts who worked on the Target Zero guidance reports are available to answer your questions. To benefit from this free service, please contact us on the Target Zero information line. Alternatively, if you have a training requirement or would like to know more about the Target Zero project, our experts are also available to deliver in-house presentations.

Call or email us for further details or advice on the Target Zero project

information line:
01709 825 544
email:
info@targetzero.info

HAVE FUN ...

... why not visit the website anyway? As well as containing the guidance reports, newsletters and information on legislation related to zero carbon, you can play the Target Zero Turbine Challenge. Can you keep the wind at the optimum level to keep your three turbines turning and carbon emissions down?