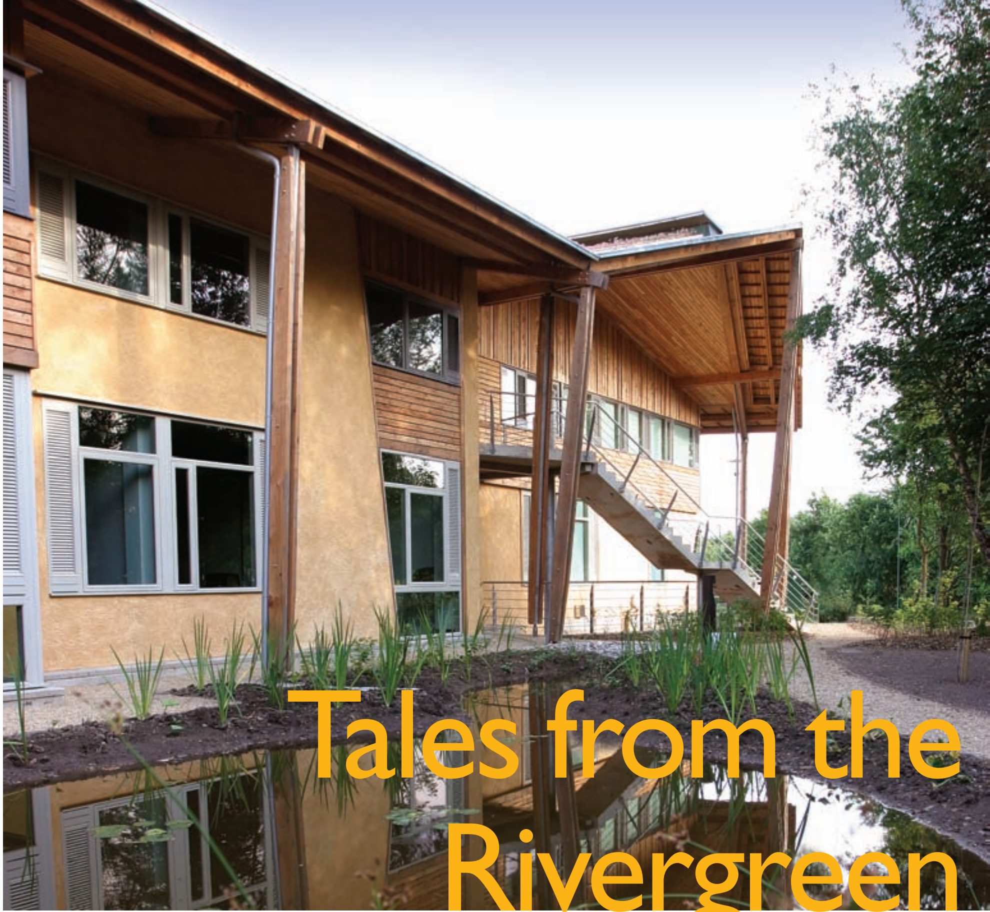

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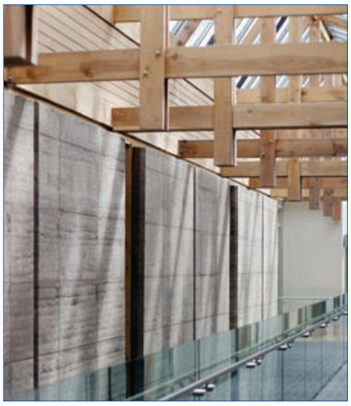
Tales from the Rivergreen

Left: Rivergreen's architecture is not intentionally Scandinavian – despite appearances. "It's just got a lot of wood in it," as developer Peter Candler put it. The walls are finished with a rough-cast lime and horse-hair render, which acts as a breathing membrane.

A naturally ventilated speculative office that beats best practice energy targets and houses happy and productive occupants – surely some mistake ? **Roderic Bunn** heads to Durham to find out more



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The Rivergreen Centre has a 6 m high, 500 mm thick rammed-earth wall inside the atrium. Being south-facing and subject to direct solar gain, the wall absorbs the sun's energy during the day and releases it at night and early morning to pre-heat the adjacent offices prior to occupation.

FACTS AND FIGURES

Rivergreen Centre, Aykley Heads, Durham, DH1 5TS

Client
Rivergreen Developments
Project architect
Jane Darbyshire and David Kendall
Environmental design consultants
Armstrong Rhead Partnership

Start on site: August 2004

Occupation: February-August 2006

Treated floor area 4852 m^2

Occupancy: 300 (500 theoretical max)

Mechanical services: £450 000
Electrical services: £700 000

Advanced naturally-ventilated buildings are often the most difficult to get right. Unlike a mechanically controlled environment, a naturally controlled environment is comparatively more difficult to manage without wasting energy. In a naturally ventilated building where conditions are more likely to float, the control of key elements like windows, blinds and lighting becomes critical to both energy efficiency and occupant satisfaction. Either the occupants can have local control, or systems can be automated and managed by a computer. Either way, there's lots of potential for error.

So to find a naturally ventilated, speculative office building that not only has remarkably good occupant satisfaction scores but also exemplary carbon dioxide emissions is unusual. But the Rivergreen Business Centre at Aykley Heads in Durham seems to have pulled it off.

Named after its owner-occupier Rivergreen Developments, the Centre is located on a leafy business park just outside the City. The 4852 m^2 building was occupied from February 2006. Since September 2006 Arup Research and Development has been carrying out environmental monitoring, while occupant satisfaction has been analysed by Building Use Studies.

Rivergreen Developments had a hands-on role, being the promoter, financier, project manager and design team leader of the Centre. It also built it, and continues to own and maintain it – ideal conditions for a building to be a success.

Although the Centre is Rivergreen's headquarters, it is also home to around 20 tenants, varying in size from one-man-bands to Durham County Council, which occupies half of the building. Total occupancy varies depending on hot-desking arrangements and whether the 200-seat conference centre is in use, but averages around the 300 mark.

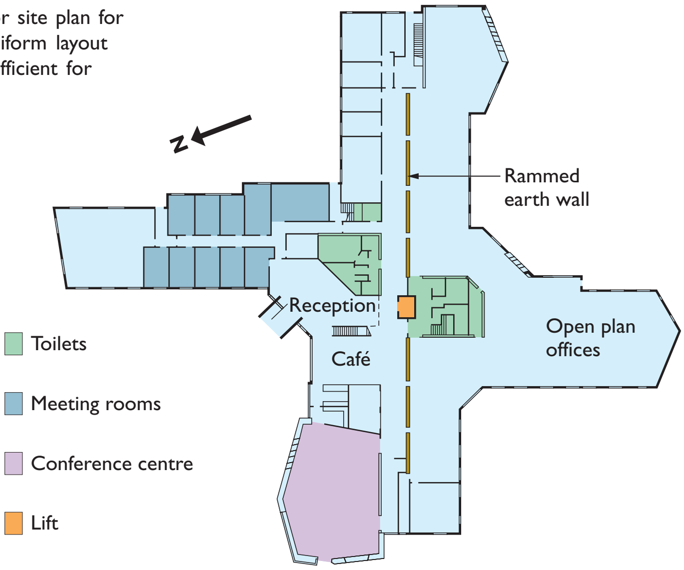
Procurement

Rivergreen's principal Peter Candler believes in developing stable and long-standing relationships with professional designers and builders. Architect JDDK Architects and environmental consulting firm Armstrong Rhead had worked together on many of Rivergreen's projects before. There was no JCT-type contract, no RIBA stages, and no formal design team submissions.

"The big difference with Rivergreen projects is that the client leads the design team – it's not a case of the design team trying to find out what the client wants," said Mike Rhead. "We spend many hours talking about it and discussing options."

These discussions took placed in what Peter Candler of Rivergreen calls a pre-design period. "Before we got into the nitty-gritty of design we stood back for five months to look at examples of best practice and visit the Centre for Alternative Technology to see if there were interesting

Right, Figure 1: The ground-floor site plan for the Rivergreen Centre. The cruciform layout aided daylighting and was very efficient for natural ventilation.



things to learn, like rammed-earth walls and Sedum roofs," said Candler. "I wanted to make a major step-change" he added, "not just make this building five percent better than the buildings we've procured previously. Everyone bought into that."

"I told the architect David Kendal that the architecture was not important," revealed Candler. "Instead, I wanted him to take the environmental challenge – and my commercial requirements – and make a project out of that. For me the important architecture was the spaces and how they are organised, and how they could be made naturally ventilated."

Environmental design

The largely timber-framed building is cruciform in plan, with a double-height glazed central circulation space running east-west. A south-facing rammed-earth wall runs along the length of this space to provide the building with some useful thermal mass. The asymmetric roof is covered in Sedum which attracts insects while reducing rainwater run-off.

The building is wholly naturally ventilated. Cross and stack ventilation to the 13 m-deep offices spaces is aided by motorised clerestory windows that open out to the atrium. The atrium glazing has motorised vents under the control of the bms, along with local thermostat control so that occupants can take control when they wish.

Office ventilation is provided by manually openable windows and vents. The open windows provide rapid ventilation, while the vents to the side allow for background ventilation and night cooling. The high-level windows that open on to the glazed atrium are motorised, with override control switches in gangs by the core areas for the occupants to use.

Unusually, the conference centre is also naturally ventilated – with no comfort cooling. BSRIA carried out computational analysis for Rivergreen to determine whether the double-height space would work without air-conditioning, and concluded that conditions would be uncomfortable in high summer.

Rivergreen's response was to accept a limit of about 80 occupants on hot summer days rather than resort to air-conditioning. The conference suite is therefore ventilated by openable windows and by four roof-mounted Monodraught Windcatchers.

All space heating is provided by two Talbot biomass boilers, with rated outputs of 50 kW and 100 kW. These are used to

BSRIA **MODEL PROJECT**

Model project articles report on the more interesting and influential building projects worked on by BSRIA's Member organisations.

A model project is either a construction project notable for its contribution to design innovation and sustainability, or a process in a company that demonstrated a step-change in delivering improvement through the supply chain.

This report on the Rivergreen Centre uses energy monitoring data provided by Arup R&D, occupant satisfaction data provided by Building Use Studies, and a site visit by the author on 22 August 2007.

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Above: A typical open-plan office. Note the rammed-earth wall to the left, openable windows and T5 dimmable fluorescents (controllable by hand-held controllers). The corridor zone has underfloor heating to accommodate future full-height partitioning.

©Rivergreen Developments

THINGS THAT WORK

Users can open vents beside their windows for draught and insect-free ventilation. The doors seal well, and can be locked in position so they don't blow shut. The window timber is from managed softwoods.

The atrium glazing vents are opened by the bms when a temperature setpoint is reached. User override controls are also provided on the atrium corridors so that occupants are able to deal with any discomfort themselves.

THINGS TO IMPROVE

Locating user controls away from the devices they control – and not providing descriptive labels – invites problems. At Rivergreen this does not seem to be an issue yet as the building is otherwise user-friendly.

Experience at Rivergreen – and elsewhere – has shown that biomass boilers have difficulty operating intermittently as a conventional fossil-fuel boiler. Continuous running tends to be the outcome. The supplier is upgrading the boilers at Rivergreen to improve performance.

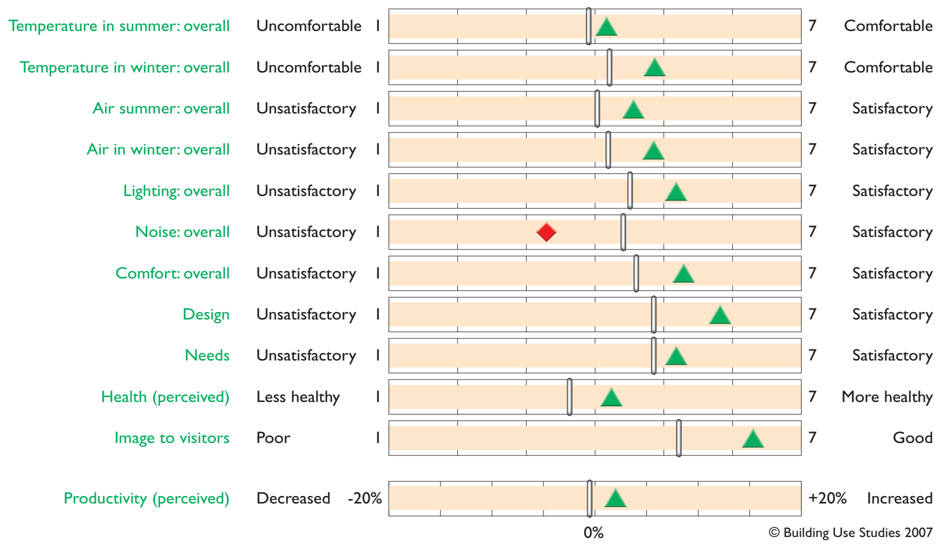

Figure 2: Building Use Studies carried out an occupant satisfaction survey in the Rivergreen Centre in March 2007. Green triangles represent mean values significantly better or higher than both the benchmark and scale midpoint. Amber circles are mean values no different from benchmark. Red diamonds are mean values worse or lower than benchmark and scale midpoint. Be careful to read the directions of the scales and the scale labels. The UK benchmarks are represented by the white line through each variable.

deliver heating to radiators and underfloor heating circuits in four zones that correspond to the building's wings. The boilers heat a 1000 litre buffer vessel which acts as a low-loss header in the system and to allow the boilers to react more quickly to changes in load.

Domestic hot water is heated by six solar panels installed along the atrium roof, and by two biomass boilers when solar heating is not available. An immersion heater provides a back-up.

A 12 000 litre underground rainwater tank supplies water to the toilets and the Sedum roof irrigation system. The building has Airflush waterless urinals, and all WCs are low-flush units.

Lighting is a mix of daylight-linked T5 fluorescents in office areas, and compact fluorescents for feature lighting.

The Rivergreen Centre has a 6 m high, 600 mm thick rammed earth wall, constructed in six separate panels inside the atrium. Being south facing and subject to direct solar gain, the wall absorbs the sun's energy during the day and releases it at night and early morning to pre-heat the adjacent offices prior to occupation.

Approximately 80 percent of the material used in the construction of the wall is fine sand obtained from the basement excavation. The remainder consists of gravels and clay obtained from local quarries.

JDDK Architects commissioned the Department of Architecture and Civil Engineering at Bath University to develop the optimum blend of clay, sand and gravel. Sample panels were built prior to the main construction to test the physical characteristics of the wall and to provide training for the construction workers.

"The main risk is to do with controlling the shrinkage of the wall," says JDDK project architect Ruth Walters. "At Rivergreen we were able to build in a controlled environment – it's much easier to build internally. But we still made the wall in six separate panels, with expansion joints between them."

The building's features enabled it to achieve a BREEAM rating of 'excellent'.

Occupant survey results

An occupant satisfaction survey was carried out in March 2007 by Arup Research & Development using the Building Use Studies (BUS) methodology.

The Rivergreen Centre is in the top 17 percent of the BUS UK dataset. This is a good result, given the size and complexity of the building. Eleven of the main study variables are significantly higher or better than the UK benchmark (Figure 2)

The building is well-liked, and receives good ratings for perceived health, which BUS finds rare in a building like this. However, the building is excessively noisy, with ratings significantly below benchmark

Right: The naturally-ventilated conference theatre. BSRIA undertook computational analysis for Armstrong Rhead to determine how the double-height space would perform without air-conditioning, concluding that conditions would be uncomfortable in high summer. Rivergreen's response was to set a limit on occupant numbers on hot summer days rather than install air-conditioning – a case of managing expectations first before reaching for energy-hungry technology.

©Roderic Bunn/BSRIA

on the five noise variables measured by BUS. This puts the building in the bottom seven percent of the UK dataset for noise.

Some occupants complain about excessive glare from the sun and sky, and give poor ratings for control over the lighting and daylight. Some occupants expressed their dislike about the hot-desking, which some said made them feel uneasy, insecure or nomadic.

Nevertheless, BUS found that the Rivergreen Centre is the best building of its type in the UK – unusual for a building with a relatively large, open-plan floorplate with many green features and credentials. In general, BUS finds that bigger green buildings tend to score lower than smaller ones because it is more difficult to create good thermal comfort and acceptable noise conditions in bigger buildings.

Environmental performance

Rivergreen's starting point for the building was not to use energy if it could avoid it. Surprisingly, this did not manifest itself in detailed energy targets for the building. "We just tried to adopt best practice," said Mike Rhead. "We considered green issues but they weren't the overriding factors. If a green technology didn't suit the building – composting toilets for example – they didn't go in."

Arup Research & Development were commissioned by Rivergreen Developments to conduct an environmental assessment of the Centre. Electricity consumption has been taken from utility bill records and from the extensive sub-metering of end use loads, which have been logged on the bms between October 2006 to August 2007. Figure 3 shows annual electricity consumption by those end-uses.

The figures include some extrapolation for the missing months. As lighting use changes with the seasons the extrapolation may over-estimate the actual annual consumption. The hvac loads have been based on a restricted amount of data due to a fault on a sub-meter.

Analysis of the electrical maximum demand revealed a base load overnight and over weekends of 12-15 kW. This is made up of 6 kW of small power, 5 kW of lighting, and 2 kW from the kitchen.

The monitoring shows that the total annual electricity load is 53·3 kWh/m^2 (or 37 of which lighting contributes 17·8 kWh/m^2, small power 18·1 kWh/m^2, and IT small power 6·5 kWh/m^2. This almost exactly matches the good practice benchmark in *Energy Consumption Guide 19* (*ECON 19*) of 53 kWh/m^2 per annum.

For lighting, the largest single component during the occupied period seems to be from the ground floor common lighting. Lighting demand is modest during peak occupancy at 3·5 W/m^2 in spring and summer, and 6 W/m^2 in winter.

Analysis of the office small-power loads show that the Rivergreen Centre is showing specific demands of around 5 W/m^2. This is considerably lower than other typical offices where small power loads are in the region of 15-18 W/m^2. This figure may be partially due to the effect of low occupant density.

Space heating and hot water is delivered by the two biomass boilers with a combined heat output of 150 kW. The biomass boilers are fuelled by wood pellets produced locally from recycled material

PROJECT WHO'S WHO

Peter Candler "I didn't want the building designed to suit some esoteric architectural principle that forced sophisticated controls upon us It was a case of: orientate the building, then choose systems that enable us to minimise the amount of active control."

Mike Rhead "We designed the conference centre for the average and not for the worst case. If the worst case only exists for a half a dozen days a year, then air conditioning is not an intelligent use of resources."

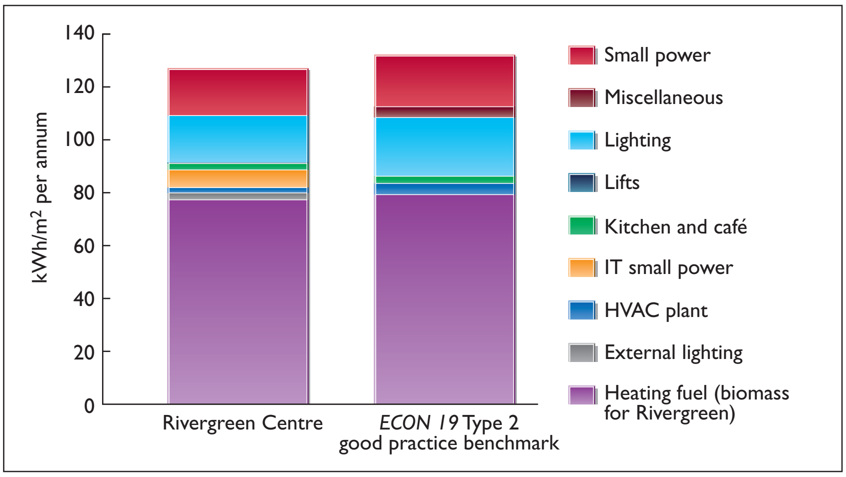

Figure 3: Annual energy consumption (with some data extrapolation) of the Rivergreen Centre compared with the *ECON 19* 'good practice' benchmark for a naturally ventilated office

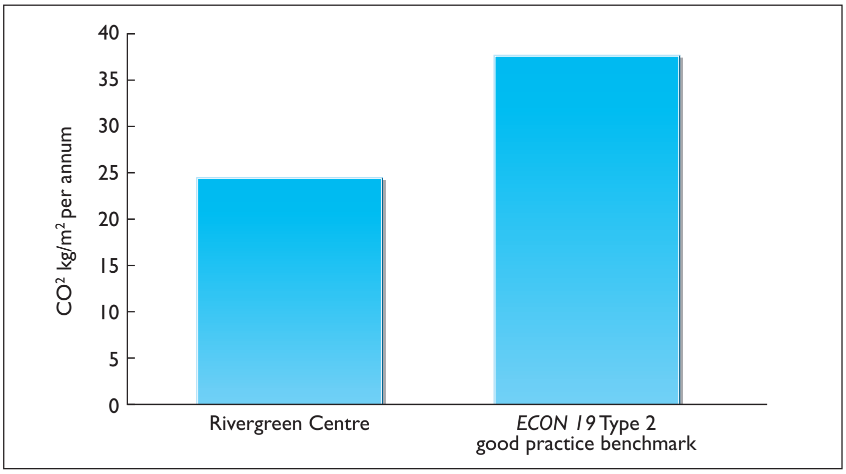

Figure 4: Carbon dioxide emissions from the Rivergreen Centre for the year 2006-2007 compared with the *ECON 19* 'good practice' benchmark for a naturally ventilated office. The carbon dioxide conversion factor was taken as 0·422 for electricity, and 0·0025 for biomass.

such as wooden pallets and packing crates. The pellets have a calorific value of around 17 600 KJ/kg.

The biomass boilers have suffered a number of problems, such as tripping on high water temperature, over-feeding of pellets and difficulty in reacting to rapid changes in loads. To overcome these problems the supplier is in the process of upgrading the boilers.

Arup assessed the efficiency of the boilers based on energy input data from the bulk pellet deliveries, which occurs approximately monthly. The conclusions that can be drawn from this broad analysis are limited, but it appears that boiler efficiency has been around 24 percent.

The total fuel consumption data for the heating season from September 2006 to May 2007 is estimated to be 77 kWh/m^2. In CO_2 terms, this equates to 24·5 kg CO_2/m^2 per annum at a conversion factor of 0·025 kg/kWh of heat (from *Approved Document L2A*)

Overall, Arup's interim results indicate that the Rivergreen Centre emits 24·5 kgCO_2/m^2 compared with the 'best practice' benchmark of 37·7 kg CO_2/m^2 in *Econ 19*.

Overall assessment

On the basis of the building's carbon dioxide and occupant satisfaction score, the Rivergreen Centre is clearly an exemplar of its kind, despite the problems with the biomass heating system. There are one or two other minor bugs, such as a storage vessel for the solar panels located in the basement, which means a 5°C temperature loss between the panels and the tank ("We should have put that on the roof", admits Mike Rhead), and a blinds-down, lights-on problem in some areas. But, overall, Rivergreen is a highly successful example of the genre.

Interestingly the building's good performance is largely down to an enlightened client that, while highly experienced in designing and constructing buildings, was not afraid to take risks in order to achieve a step-change in energy efficiency. Witness the rammed-earth wall – an innovative technology for which there are few equivalent installations in the UK, and none in a speculative office.

That said, Rivergreen knew where to draw the line. "Everything we do has to be responsible," he says. "We do not want to be a guinea pig. People might think that we were being reckless building an earth wall, but that's not the case. We looked at that very carefully and made an informed decision on whether we could do it."

The building's sustainable design extended beyond the building to the landscaping. The planting scheme used a healthy mix of apples trees, alpine strawberry bushes, and herbs like chives and dill. The produce is used in the sandwiches and cakes sold in the staff cafeteria.

So where does Rivergreen go from here? "We are going to build another one like this in Northumberland," says Peter Candler. "So I need to know what worked and what didn't work, and second, what contextual things will be different in Northumberland that will influence changes in design."

True evidenced-based design is what this is: repeating what works and reducing the risk of failure in order to make good performance routine. A worthy ambition.

Further reading

Bunn R, 'Friends of the earth', *Building Design*, 12 May 2006.

BSRIA acknowledges the help of Rivergreen Developments, Armstrong Rhead Partnership, Building Use Studies and Arup Research and Development for the data used in this article.