SUSTAINABLE BUILDING DESIGN AND REFURBISHMENT IN SCOTLAND

SCOTTISH SUPERHOME RETROFIT IN HAWICK
TWO PROJECTS FROM SCOTLAND’S HOUSING EXPO 2010
LEARNING FROM GRAZ
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FUNDING AVAILABLE THROUGH CIC START ONLINE FOR:

  • 35 FEASIBILITY STUDIES – up to £5,000 each
  • 10 ACADEMIC CONSULTANCIES – up to £3,000 each

More on page 6

SuperHome retrofit in Hawick
More on pages 15-19
studioKAP architects at Scotland’s Housing Expo 2010 by Chris Platt

More on pages 20-29

Bracewell Stirling Consulting at Scotland’s Housing Expo 2010 by David Keith

More on pages 30-41

Graz Insights - Environmental Siedlungs By Prof. Colin Porteous

More on pages 42-55
What is CIC Start Online?

- A three-year project of seven Scottish universities funded by European Regional Development Fund and Scottish Government’s SEEKIT programme

- **AIM**: To embed sustainable building design and refurbishment into practice

- **OBJECTIVE**: To support academic/industry collaboration in developing and testing innovations, and to disseminate the outcomes in order to facilitate the application of innovations in practice

- **WHY?**
  - To reduce CO₂ emissions and other negative environmental impacts from buildings
  - To reduce fuel poverty and improve indoor climate
  - To create jobs and support competitiveness of Scottish construction industry through innovation
  - To remove the barriers to the application of innovation in practice

- **HOW?**
  - Through competitions for academic/industry feasibility studies and for 10-days free academic consultancy on sustainable building design and refurbishment
  - By testing innovations at the testing facilities of the project partners’ institutions
  - By publishing guidelines for the application of innovations in practice
  - By developing and publishing database of design solutions for sustainable refurbishment
  - By providing assistance and advice on sustainable building design and refurbishment to Scottish small to medium sized enterprises
  - By disseminating the project outcomes through the project website, seminars, interactive webinars, webcasts and three whole-day online events that will include an exhibition, a conference and networking facilities
  - By publishing information on products and services for sustainable building design and refurbishment offered by Scottish small to medium sized businesses registered with CIC Start Online.

**BENEFITS OF FREE MEMBERSHIP**

- Publish information on your company’s products or services for sustainable building design and refurbishment
- Receive a set of headphones with a microphone, monthly E-News and quarterly Innovation Review
- Ask for advice/assistance

Please click [here](http://www.cicstart.org) to access the registration page at the project website

**PROJECT PARTNERS**

- Glasgow Caledonian University
- Edinburgh Napier University
- Mackintosh School of Architecture, The Glasgow School of Art
- Heriot-Watt University
- Robert Gordon University
- University of Strathclyde

**FUNDED BY**

- The Scottish Government
- European Regional Development Fund
Welcome to the sixth issue of Innovation Review!

We are happy to announce that CIC Start Online now has over 600 members.

We would like to invite the members from Scottish small to medium size enterprises to apply for the remaining 35 awards for feasibility studies (up to £5,000 each) and 10 academic consultancies (up to £3,000 each) to test or improve products or services for sustainable building design and refurbishment. Please see the call for applications on page 6.

The CIC Start Online members can now access three new video recordings of our seminars (see page 8) and two forthcoming seminars and interactive webinars (see page 9). Sponsorship of seminars, webinars and our forthcoming online conference are welcome – please contact Craig.Bishop@gcu.ac.uk, 0141 273 1401, for more information on sponsorship opportunities.

As we are currently filming videos for our online conference Resilience of Buildings, Neighbourhoods and Cities, its programme is published in this issue to alert you that the conference will take place from 14-17 June 2011. Following each video, an interactive 45-minute session will enable online viewers to ask questions and receive replies from the videos’ authors.

We have established a link with Sustainable Energy Academy who are inviting owners of houses whose carbon emissions have been reduced by 60% to contact them and promote their success in the list of SuperHomes (see pages 13-14).

The first SuperHomes example of house refurbishment in Scotland that has achieved more than 60% reduction of carbon emissions is in Hawick. Andy Maybury, the owner, explains how this has been achieved by investing less than £10,000 into the improvements (see pages 15-19.)

We continue with an in-depth presentation of demonstration homes built for Scotland’s Housing Expo 2010. In this issue, Chris Platt writes about the studioKAP architects’ design of a house whose forms were inspired by Scottish vernacular architecture (on pages 20-29), while David Keith of Bracewell Stirling Consulting writes about their modular timber frame design (on pages 30-41).

Prof. Colin Porteous of Mackintosh School of Architecture, The Glasgow School of Art, shares his insights in the recent sustainable building design and refurbishment in Graz, Austria (pages 42-55).

We welcome the members’ in-depth articles on sustainable building design or refurbishment projects, or the products manufactured or services offered to achieve more sustainable built environment.

The articles for the next issue should be submitted by 15th May 2011. If you would like to discuss the contents of your article, please contact me at Branka@ cicstart.org, 0141 273 1408. I look forward to receiving your articles for the future issues of Innovation Review.

Kind regards,

Branka
CALL FOR APPLICATIONS FOR FEASIBILITY STUDIES AND ACADEMIC CONSULTANCIES

Submission deadline: 13 May 2011

- 35 awards for feasibility studies (up to £5,000 each)
- 10 awards for academic consultancy (up to £3,000 each)

Please see information on how to apply and download the application forms at our website in the sections Feasibility Studies and Academic Consultancies.

If you do not know what university could assist you or have any questions regarding the application, please send an email to branka@bicstart.org.

We look forward to receiving your applications!
SUCCESSFUL APPLICATIONS TO DATE

FEASIBILITY STUDIES

1. “Development of Post Occupancy Evaluation for evaluation of innovative low carbon social housing projects” by Mackintosh School of Architecture at the Glasgow School of Art and John Gilbert Architects
2. “Novel Solar Thermal Collector Design” by Heriot Watt University and AES Ltd
3. “Assessment and Application of Zero Carbon Building in Scotland” by Heriot Watt University and Integrated Environmental Solutions Ltd
4. “A Hybrid Solar Thermal Mass System Development for the Application to Tenants First Housing Co-operative’s Zero-carbon Affordable Homes” by Glasgow School of Art, Edinburgh Napier University and Tenants First Housing Co-operative
5. “Embedding simplified post occupancy evaluation within the design process” by Page&Park Architects and the University of Strathclyde Glasgow.
6. “Tenement Flat Carbon Reduction Shopping List” by Holmes Partnership and University of Strathclyde Glasgow
7. “Upgrade Strategy Development for Garrioch Residents Association” by Collective Architecture and University of Strathclyde Glasgow
8. “Tarryholme Sustainable Housing Project, Irvine” by University of Strathclyde Glasgow and Assist Design
9. “Solar-Wall systems for domestic heating: an affordable solution for fuel poverty” by Heriot Watt University and Changeworks
10. “An Investigation of the Adoption of Low-Carbon Technologies by Scottish Housing Associations” by Robert Gordon University and Anderson Bell and Christie
11. “Assessing the energy impact of different strategies of integrating PV/Thermal Heat Recovery systems in Scottish homes” by the Glasgow School of Art and Robert Ryan Homes
12. “Application of a low cost wireless sensor network” by Glasgow Caledonian University and AppleGreen Homes
13. “Assessing the environment and energy impact of occupant behaviour” by Glasgow School of Art, Robert Gordon University and Fyne Initiatives
14. “Testing of Natural Composite Material based on Earth, Wool and Alginate” by University of Strathclyde Glasgow, Glasgow Caledonian University and ARC Architects

ACADEMIC CONSULTANCY

2. “Independent verification of a climate based worldwide building energy index” by Glasgow Caledonian University and IES Ltd
3. “Enkilt Simple Living” by Ballyconnelly Construction Ltd and Mackintosh School of Architecture, The Glasgow School of Art
4. “In-service testing of a prototype dwellings in relation to passive versus active ventilation strategies” by University of Strathclyde Glasgow and Assist Design.
5. “9-11 Gilmour’s close - comparing theoretical performance against their actual performance” by the Glasgow School of Art and Assist Architects.
6. “Post Occupancy Evaluation of Municipal Terrace in Dumfries” by the Glasgow School of Art and Dumfries & Galloway Housing Partnership
7. “Synergy of Fabric and Energy conservation in older historic properties” by Edinburgh Napier University and the Morrison Partnership
8. “New wood pellet storage facility for biomass heating systems” by Edinburgh Napier University and Glendevon Energy

The outcomes of the completed feasibility studies and academic consultancy are presented at our seminars and interactive webinars.

The recordings of these events and related Power Point slides are published on our website in the section Webcasts.
VIDEO RECORDINGS OF SEMINARS

Since the December issue of Innovation Review three new video recordings of seminars and interactive webinars have been published on our website. To access them, please register as a member of CIC Start Online. Registration is free.

**Webinar 1**

25th January 2011
Embedding Simplified Post Occupancy Evaluation within the Design Process

Prof Joe Clarke, Department of Mechanical Engineering, University of Strathclyde Glasgow

Fiona Bradley, Department of Architecture, University of Strathclyde Glasgow

Karen Nugent, Page and Park

**Webinar 2**

8th February 2011
Tenement Flat Carbon Reduction Shopping List

Dr Jeremy Cockroft and Dr Jon Hand, Department of Mechanical Engineering, University of Strathclyde Glasgow

Douglas Jack, Holmes Partnership

**Webinar 3**

15th February 2011
Novel Solar Thermal Collector Design

Prof Sue Roaf, School of the Built Environment, Heriot-Watt University

Campbell McLennan, AES Ltd
An Investigation of the Adoption of Low-Carbon Technologies by Scottish Housing Associations

15 March 2011, 12:30-14:00

Dr David R Moore, Robert Gordon University
Dr Seonaidh McDonald, Robert Gordon University
Johnathan McQuillan, Anderson Bell + Christie Architects

The starting point for the study was a consideration of what impact incentivisation schemes (in this case particularly feed-in tariffs) had on the adoption of low carbon technologies.

The study developed further, in that it added an objective to assess the feasibility of producing a unified business process (UBP) focused on aiding individual HAs when deciding which low carbon technologies (LCTs) are appropriate to them.

The study involved two housing associations that had both considered the adoption of innovative sustainability technologies, but ultimately made different investment (in the form of purchasing sustainable technologies) decisions.

Development of post occupancy evaluation

14 April 2011, 12:30-14:00

Dr Tim Sharpe, MEARU, Mackintosh School of Architecture, The Glasgow School of Art
Matt Bridgestock, MEARU, Mackintosh School of Architecture, The Glasgow School of Art
John Gilbert, John Gilbert Architects

This project was undertaken by the Mackintosh Environmental Architecture Research Unit (MEARU) in collaboration with the partner SME John Gilbert Architects Ltd (JGA).

The aim of the feasibility study was to explore the potential for the development of a cost effective Post Occupancy Evaluation (POE) methodology (with a particular sustainability focus) that can be used to gather both quantitative and qualitative information regarding energy and environmental performance of housing. This would provide useful data for the designers, clients and users, leading to improved performance of the existing houses and future designs.

JGA assisted in the selection of sample house types from 4 Housing Associations and liaised with participating housing providers. MEARU undertook data acquisition via resident survey questionnaires and durational monitoring of 8 selected housetypes. JGA and MEARU have reviewed the process to identify key areas for inclusion and most cost effective outcomes for a POE methodology which could be widely used. MEARU has also developed a sample on-line POE tool and template documentation which could be applied to future POE exercises carried out by using Associations on their new build housing stock.
Resilience of Buildings, Neighbourhoods and Cities

Online conference, 14-17 June 2011

**Tuesday, 14 June**

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<th>Time</th>
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<tr>
<td>10.55</td>
<td><strong>Welcome</strong> - John Sheridan, Chair of Planet Group, Scottish Construction Forum</td>
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<tr>
<td>11.00</td>
<td><em>Principles and Processes Related to Sustainable Building Design</em>, Dr David Grierson and Carolyn Moultrie, University of Strathclyde Glasgow</td>
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<td>11.50</td>
<td>Q &amp; A – online interactive session with the speakers</td>
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<td>Break</td>
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<td>14.00</td>
<td><em>Learning from Scotland’s Housing Expo: Making resilient buildings and neighbourhoods</em>, John Brennan, University of Edinburgh</td>
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<td>Q &amp; A – online interactive session with the speaker</td>
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**Wednesday, 15 June**

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<tr>
<td>10.59</td>
<td><strong>Welcome</strong> - John Sheridan, Chair of Planet Group, Scottish Construction Forum</td>
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<td>11.00</td>
<td><em>Energy co-operatives as a means of achieving sustainability within the housing sector</em>, Prof. Tariq Muneer and Sarah Borthwick, Edinburgh Napier University</td>
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<td><em>Resilience to Occupancy: Findings from recent Post Occupancy Evaluation projects</em>, Dr Tim Sharpe, Glasgow School of Art</td>
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**Thursday, 16 June**

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<td><em>Flooding resilience: avoidance, resistance and recovery</em>, Prof. Sue Roaf, Heriot Watt University</td>
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<td>14.00</td>
<td><em>Improving energy efficiency of traditional housing = improving occupant health &amp; social cohesion</em>, Dr Paul Baker, Glasgow Caledonian University</td>
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<td>11.00</td>
<td><em>Towards a Visible City for Visually Impaired Users</em>, Dr Mike Grant and Dr Robert White, University of Strathclyde Glasgow</td>
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<td>14.00</td>
<td><em>The theory of self-organising built environments as a response to carbon levels</em>, Dr David Moore, Robert Gordon University</td>
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THE ONLINE CONFERENCE
SPONSORSHIP OPPORTUNITIES

If your company would like to promote its sustainable products and services for the design and refurbishment of the built environment on the conference videos which will be available for viewing not only during the conference but also on demand at our website, please see the sponsorship package details below.

Your marketing messages will reach over 600 members of CIC Start Online, all of them professionals who might become your clients, and other viewers who will access the videos in the future. As the conference will take place online, it can be viewed worldwide.

**Exclusive Seminar Sponsorship - £199**

- Company logo & URL displayed along with mention at beginning and end of seminar
- Company logo & URL displayed on screen throughout presentation
- Company logo & URL shown on promotional materials
- Company logo & URL displayed on conference webpage (containing all recorded webcasts) until August 2012

**Conference Sponsorship (Max 4 Sponsors) - £349**

- Mention in welcoming speech for each day of conference
- Company logo & URL displayed on screen throughout 4 day conference
- Company logo & URL shown on promotional materials
- Company logo & URL displayed on conference webpage (containing all recorded webcasts) until August 2012

Other bespoke packages can also be arranged.

To discuss the sponsorship options, please contact Craig Bishop at Craig@ cicstart.org or on + 44 (0)141 273 1408.
Business Mentoring

YOU CAN!

...think about it
...talk about it
...and even dream about it

If you actually want to grow you business
It can help to have a little extra know-how and expertise at your disposal.

We want you to succeed. How? By giving leaders in growing businesses access to a mentor. We have attracted a group of individuals with extensive expertise and knowledge to help business like yours. Sometimes a small comment, insight or observation from “outside the box” can bring big rewards in helping to take your business to the next level. Opportunities exist – the choice is which to pursue. Your future will be limited only by your imagination.

Our mentors have outstanding competences in an array of business sectors and they help to give businesses the thinking time to consider and reflect on key issues before taking decisions. The mentors are motivated to give something back to other business people.

The programme has been expanded to give flexibility and options to businesses with little time, but aspirations to grow.

The service is free, easy to access and only a phone call away. If you want to grow your business and access a valuable mentor give us a call today on

Call us on 0845 609 6622 and ask about Business mentoring
Or e-mail: admin@businessmentoringscotland.org
Also visit our website www.businessmentoringscotland.co.uk
Hi, we need your help. We are looking for exemplar retrofit dwellings that have saved at least 60% of their carbon emissions, and where owners or residents are happy to open their houses on Open Days. We have 84 houses in the SuperHome Alliance of exemplar houses, but only one so far in Scotland. Can you help with contact details of possible houses that you know of, or email us if you live in an exemplar house and would like to join us? Our web site is www.superhomes.org.uk and please email camille.ruddle@nef.org.uk

The Government has set a target of 80% reduction in CO2 emissions, through all energy sectors, by 2050. This is indeed a challenging target. 27% of our Carbon Emissions come from our existing housing, and a carbon reduction of 80% will save 22% of the UK emissions. In comparison, a carbon neutral policy for new housing will by 2050 reduce emissions by just 1%, around 20 times less saving than tackling the existing housing. So to make significant improvements and have a chance of meeting our 80% targets, we cannot rely on new build housing. We have to reduce carbon emissions from our existing stock.

To achieve an 80% reduction will truly be a challenge. It means that we will on average need to retrofit 500,000 dwellings a year, every year, for the next 40 years. This will require huge increases in funding, skills and knowledge. On funding alone, we will need to spend around £10-15 billion a year, comparable to the historic spend per year on all new build housing.

Who will take action? In the UK as a whole, 70% of the housing stock is owner occupied, and a further 10% is private rented. So 80% of the problem is owned by the private sector. If we are to tackle the problem we need to engage with these private owners.

We need these homeowners to undertake considerable expenditure, often in excess of £30,000, and to accept considerable hassle and disruption. If they are to do this, they need to be convinced that the upheaval is worth it, and to aspire to the end result. Like any other product, potential retrofitters need to see actual examples before they undertake such a major effort. Up to recently there has been practically nowhere that people could go and see exemplar houses, and get a touch-and-feel experience of what these houses are like in practice. Without this, it is very unlikely that homeowners will take action.
The SuperHome Alliance

Old Home SuperHome was set up to meet this need for exemplar housing. A SuperHome is a dwelling that has typically been retrofitted to save at least 60% of its carbon emissions. SuperHomes are also open to the public during Open Days or weekdays. Visiting a SuperHome allows visitors to see for themselves that these houses not only save 60% of their carbon emissions, but also save fuel bills, are more comfortable, and in the longer term have a higher sale value too.

Homes can either be owned by the individual Homeowner, or by local authorities, or Housing Associations. There are currently 84 houses in the Alliance; the majority are owned by individual homeowners who open 2-3 times a year. There are 5 EcoHouses owned by Local Authorities or Housing Associations open during the week, and there are about 10 RSL houses.

Homeowners open their houses for free, although the charity can make a small donation as a disruption allowance for an opening.

Visitor numbers have grown 30% each year, and we are on course to have over 16,000 visitors this year. Superhomes have doubled in just one year, from 40 to over 80. And in a survey, 27% of visitors say that they went on to spend over £5,000 on energy retrofits.

We have built up significant links with affinity groups. We are linked to the web sites of WWF, Friends of the Earth, the Great British Refurb and over 4,500 other organizations. We are continually looking for other ways to involve Homeowners and Housing Associations, for example we will shortly be on the web site of the Women’s Institute and we are working with the Technology Strategy Board to increase visibility of the Retrofit for the Future houses.

If you know of any houses that have been heavily retrofitted and are likely to have saved at least 60% of their carbon emissions, please let us know. john.doggart@s-ea.org.uk
FIRST SCOTTISH SuperHome

By

Andy Maybury

Over the last four years we have done various work on our house that has resulted in a reduction of 71% in carbon emissions. It is now registered as a SuperHome by the Sustainable Energy Academy.

What it took

Much of the work was done in the first 15 months although one important item was only completed recently and we have plans for more enhancements that will further reduce the energy footprint of the building. The main contributory work has been:

- installing a heat recovery ventilation unit
- sealing of floor and other draughts
- underfloor insulation
- cavity wall insulation
- condensing boiler
- solar water heater
- log-burning stove

Heat Recovery Ventilation Unit

One of the first improvements that we fitted was a whole-house mechanical ventilation system with heat recovery. This has proved to be an invaluable component of the energy-saving measures that we have installed. It takes warm, stale air from the upstairs bedrooms and bathrooms and supplies fresh air to the ground floor living room.

Siting

Rather than placing the heat exchanger in the loft, as is common, we opted to site it in the void beneath the ground floor. This was so that we could fit a ground pipe on the inlet side. This would be a relatively large (200 mm φ, 10 m long) pipe buried in the garden to preheat (or cool) the ambient air to around 10°C before it arrived at the heat exchanger. This would reduce the heating load in winter and prevent overheating in summer. We have yet to fit this pipe due to the disruption that cutting a metre-deep trench around the garden would cause.

Condensation

The first obvious difference that the HRVU made was to reduce the amount of condensation on the inside of the windows, particularly upstairs. Even in the depth of winter my neighbours open their bedroom windows in the morning to air the rooms sufficiently to dry off the water on the panes. The condensation trap of the unit produced significant amounts of water for the first few months while the fabric of the building dried out but now emits very little.
Sealing
By ensuring that there is adequate ventilation throughout the house, we could proceed to seal off all gaps and draughts without worrying that we were degrading the quality of the air in the house. (See next section.) This is perhaps one of the greatest knock-on benefits of a HRVU.

Ducting & acoustic
Initially we used flexible ducting for the majority of connections, largely because the unit was initially sited in a temporary location until later work enabled us to fit the current rigid ducts within stud walls and under floors.

Only recently did we discover that sound-absorbing ducting is available. This attenuates both the mechanical noise of the fans and the turbulent sound of the air. Unfortunately, due to space constraints, we have not been able to fit as long lengths as we would have liked but on one main run we have two metres of acoustic, which has reduced the noise by six or seven decibels. If we were to fit a HRVU again, we would fit at least a metre of acoustic ducting close to the heat exchanger unit on the arms that connect to the house.

Heating
Although the unit was very good at recovering much of the heat from the outgoing air, it produced incoming air, blowing across our ankles, that was sometimes cooler than we wanted. When it was freezing outside, the incoming air was about 15°C. We already had a radiator system in the house and so we constructed a small duct radiator from a car heating matrix to heat the air further. This is controlled by a standard TRV in a standard electrical box in the wall (with an automatic bleed valve).

When we installed the log burner (see below) with its air ducts, we decided to tie the incoming air duct into one of the connections on the stove. This is very effective in bringing heat from the fire into the room. We also installed a change-over valve that can divert the air either through the duct radiator or past the fire.

Draught Exclusion
One of the first problems that we became aware of, when we moved into the house, was draughts. Even sitting in front of the gas fire left one’s feet cold. We have a suspended wooden floor with a well-ventilated solum space. Electricians and plumbers have installed various pipes and cables over the years and the floorboards bore the scars. We replaced a number of boards that were badly damaged and attacked every trickle of air with a caulk gun, particularly around the edge of the floor, beneath the skirting board.

A metal-framed patio door was so draughty and cold that one winter we lived with insulating tape along most of the joins and an off-cut of plasterboard wedged in the bottom half of the door frame. We eventually replaced the door with a uPVC unit that performs very much better.

Old double-glazed windows
The house had been double-glazed throughout by a previous owner but some of the frames do not fit perfectly and some of the rubber seals were dislodged or insufficiently flexible to seal the gap. Having clipped the rubber inserts back in, we smeared petroleum jelly on the seals to keep them flexible and bridge small gaps (and even fairly big ones of a few millimetres).

Underfloor Insulation
As well as the draughts, we were conscious that we were only a carpet and a floorboard away from near-outside temperatures an inch or so beneath our feet. Having calculated that we would need at least 70 mm of polyurethane foam to bring us up to modern building standards, we found some 120 mm sheets going for a good price and purchased enough of these to cover the ground floor. By accessing the crawl space below the floor, we were able to measure each gap between joists, cut the insulation with a long knife and wedge the piece into position. This was a very messy and hard job but less intrusive than lifting the floor to install from above and more effective (and probably easier) than using mineral wool supported on a mesh. Cutting about 5 mm undersize usually allowed the piece to be fitted easily without it falling out but we stapled plastic binding tape across the joists to prevent the pieces falling out. Some larger gaps have since been filled with foam from an aerosol. This was a very messy and hard job but less intrusive than lifting the floor to install from above and more effective (and probably easier) than using mineral wool supported on a mesh.
**Cavity Insulation**

Perhaps the most obvious measure was to fill the wall cavities with insulation. This was completed by a commercial installer through a scheme promoted by our energy supplier. The benefit of the insulation was very clear although thermal images show that there are some bridges around an old lintol of a bricked-up external door.

**Condensing Boiler**

Another obvious measure was the replacement of the old gas boiler with a modern, condensing unit.

**Combi or system?**

One of the first questions to answer was whether to go for a combi boiler or not. At the stage that we designed the system, we knew that we wanted to fit a solar water heater to the system. Discussion with the plumber soon showed that although it might be possible to have a solar pre-heated combi system, it was far more straightforward to fit a hot water cylinder and run a system boiler.

**Under pressure**

We wanted to have an unvented hot water system so that water pressure was not a problem, even when we use small-bore pipes. It would also mean that balancing the shower would not be an issue and we could get rid of the cold water header tank in the attic. The pressure regulating valve that came with the boiler is fitted immediately after the main stopcock and controls the pressure of all of the water in the house. We needed to buy a new hot water cylinder that was suitable for the pressure and had two heat exchanger coils.

**50 metres of pipe**

For historic reasons, the old hot water cylinder and the cold header tank were situated at the opposite end of the house from the boiler and all of the taps. By fitting the new cylinder in the same airing cupboard as the boiler, we not only gained useful space where the old cylinder was but also ended up with fifty metres of copper pipes that were surplus to requirement. That weighed in at 50 kg at the scrap merchant!

**External temperature sensor**

While flicking through the installation manual for the boiler, I saw reference to an optional external temperature sensor. The installer had not fitted one before and did not know how much they cost. I bought one off the Internet for £17 and wired it in to the appropriate contacts on the control board. This small box that attaches to the outside of the building increases the flow temperature of the boiler as the outside temperature falls. This means that the boiler runs as cool as possible but as hot as necessary to provide sufficient heating for the house. It took some experimentation to set the parameters correctly for our situation but the benefits are evident and the boiler runs as efficiently as possible for the weather that day. If a cold snap comes unexpectedly, we are not caught out.
Solar Water Heater

We had already seen a Solartwin system in operation and were impressed by its simplicity and elegance. We bought the DIY kit and fitted it to the roof, plumbing it in by the shortest route to the new hot water cylinder. The kit contains almost everything and the only extra items that we needed were some short pieces of lead flashing and a small header tank (recovered from the old, vented radiator system). The wiring and plumbing are very straightforward and the silicone pipe makes the work very easy. The control panel allows us to keep an eye on the temperature at the collector and both upper and lower halves of the cylinder.

Overcast

The unit performs very well and provides all of the hot water that we need during the summer. Over winter, it will heat the lower half of the tank to about 15°C or so, depending on quite how much sunshine we get. We did discover that there were certain conditions where the collector had heated up to a good temperature but that the small PV panel was not producing enough to run the pump. When the pump stalled due to insufficient voltage from the PV panel, it simply dissipated the power generated without doing anything useful.

I contemplated building a charge accumulator whereby the pump is disconnected when the voltage falls below a certain threshold and the output from the PV accumulated in a large capacitor or rechargeable battery. When the charge is sufficient to run the pump for a minute or two, the pump is reconnected until the energy store depletes. I discussed this with the manufacturers, asking for the various data necessary and they suggested adding a second PV panel in parallel to increase the current available. This is what we did as it was easier to implement. The pump now chugs away on overcast days, bringing the warmed water down to the tank where it preheats the hot water, saving on gas even when the boiler does need to fire up.

Log-burning Stove

When we thought about how to heat the house in a more resilient way, it was obvious that, living in the Borders, surrounded by some of the largest forests in the country, we should look to wood fuel as our main heat source. Andy already had experience from 25 years previous of a large wood-chip boiler that heated a ten-bedroomed guest house. Very effective and, in that case, making use of mainly scrap material from the local saw mill.

The house had originally been built with a coal fire with back boiler in the living room. The chimney was still intact and there had been a gas fire using the flue when we bought the place. A modern, efficient, log-burning stove would be ideal in that location.

Change of plans

We would have liked to tie in a back-boiler so that we could heat the water and supply the radiators in the other rooms but it quickly became apparent that although it was possible, this was too complicated and disruptive to consider. We did, however, stumble across stoves with hot air ducts and decided that this would be an easier mechanism to distribute some heat to other rooms. We therefore sought out a unit that came with hot air ducts.

Having ordered up the Nestor Martin IT13 insert stove, we realised that as we used the stove more and the central heating less, the incoming fresh air from the HRVU would not be heated as the boiler was not running. We should heat the incoming air with the stove! More ducting was duly ordered up so that we could connect one of the stove ducts to the HRVU. The second duct takes air upstairs where it splits between the bedrooms and is controlled by “hit-miss” grilles. This is all very effective and the bedroom grilles only get opened briefly in the evenings if necessary. The air coming past the stove brings the heat into the room very effectively while keeping the surrounding chimney breast cooler.
Other Stuff

Water saving
We have also fitted minibore pipes for the hot water feeds to the various taps. This significantly reduces the amount of water that needs to be run off before the hot water arrives, saving both water and heat. The shower has a flow limiter. The new WC in the en-suite is dual-flush and we fitted the cistern of the original WC with a ‘flapper’ type of vario-flush. We have fitted small water spouts with press valves to provide cold water easily were needed; one in the en-suite for tooth-brushing and one beside the kettle to fill that easily and accurately.

Charging bar
To reduce the possibility of leaving chargers on for too long, we set up a charging bar in the cupboard. A six-way mains outlet with individual switches is attached to the wall with a small shelf below. The various chargers remain plugged in and there are boxes for recharged batteries and depleted ones as well as a battery tester to hand. Mobile phones, PDAs, and other equipment can sit on the shelf while being charged and the plugs clip to their associated chargers with “hook and loop” fasteners when not in use.

Lowered ceiling
The space above the stairs went all the way to the top floor ceiling and warm air from the living room would move across the hall ceiling and then rise straight up to the upper ceiling. We added a sloping ceiling above the stairs to guide this hot air up to the top floor corridor. The slope is well insulated.

Why?
What is our motivation in all this? Why spend a year and £15 000 revamping our house? We have worked much of our lives in Africa and are well aware of the inequities in the world and very conscious of the wastage here in the West. “Living simply that others may simply live” is an adage from many years ago but one that holds a pertinent truth. As Christians, we are aware that we have been given responsibility for God’s creation and need to use the resources that he has given us in responsible ways. We therefore aim to use no more than we need and waste as little as possible. By carrying out this work, we have halved the amount of gas that we used and look to halve it again. By using less, more is available for others … including the generations that follow.

SuperHome
We were approached by the Sustainable Energy Academy (SEA), who were looking for eco-retrofits that had saved at least 60% carbon. They sent us a spreadsheet to record the various improvements that we have made. Once the log-burning stove was installed, I completed a SAP worksheet for how the building is now and another one recording how the building was in 2007, before we started work on it. On the basis of these data, the SEA calculated a 71% carbon saving for our house and invited us to join their SuperHome scheme. We will have two open days this spring; the evening of Monday, 28 March and all day Saturday, 2 April 2011. We hope that the work we have done will inspire others to cut their emissions too. You can book places for the open days online at www.superhomes.org.uk

Future Plans
What other things can we do to further improve the efficiency of our house? The next thing that we’re looking at is installing a solar PV system, which should produce about the same amount of electricity as we consume over the year. We would love to fit a porch outside the front door but as this requires planning permission it will have to wait until we have time to complete the formalities. A two-storey conservatory on the south wall would be wonderful but is a major work and will not happen quickly. Insulating the roof slopes in the loft is probably a priority and will happen once the other work on the roof is finished.

Andy Maybury can be contacted at andyinhawick@mac.com and his blog about the work on the house is at 55howdenbank.notlong.com

Gas consumption from November 2007 until February 2011
The Hardcore Softhouse: Scotland’s Housing Expo, Plot 26

by

Christopher Platt

CArch. Dip Arch (Mackintosh) RIBA FRIAS FHEA
studioKAP architects

Christopher Platt studied at the Mackintosh School of Architecture, Glasgow and has held senior positions in architectural practices in Scotland, England, Germany and Ethiopia. He is the founding partner with Roderick Kemsley of the award-winning practice studio KAP architects and senior lecturer and Graduations Studies Director at the Department of architecture, Strathclyde University, Glasgow.

Background to Scotland’s Housing Expo

The Highland Housing Fair (later renamed ‘Scotland’s Housing Expo) was conceived as, “The construction of high quality housing to be designed according to recognised principles of sustainable design for the community at Balvonie, Milton of Leys.” Inspired by a Finnish expo precedent, it was an ambitious initiative aimed at raising the quality of speculative housing standards in the future. The well-considered and attractively designed briefing document by Caddell was explicit in highlighting the fact that issues of design, environmental and technological innovation among others were to be expected in this housing project. Despite having some of its key objectives referenced to such themes as lifestyle quality, social and community significance, public imagination and creativity, one statement has been associated with this development more than most and that is, a desire to, “promote a distinctive local vernacular”. The word vernacular is used very loosely within architectural and social contexts today and is perhaps worth taking time to unpack.

The Gathering Place

“Vernacular Architecture is specifically an image of the world, which makes present the environment in which life takes place, not in an abstract manner, but with a concrete poetic figuration...” The buildings and structures which make up much of our traditional rural landscape such as farm houses, barns and byres, piers and agricultural sheds- ‘unselfconscious buildings’ you could call them, move us in simple yet profound ways. They possess a timeless, sculptural quality in the countryside and a direct and uncomplicated attitude to construction, materials and detail. They also exude a special quality as symbols of humanity at a very simple level, i.e. they communicate something about the lives of those who were responsible for them through the medium of the physical stuff that they are made from. In other words, they have the imprint of human beings on them. From nomadic tribal tented villages to ramshackle squatter settlements; from remote hill settlements to the huddle of stone dwellings on windswept islands, these structures powerfully communicate ideas about the fundamental nature of human dwelling.

The vernacular architecture of any country has an unselfconscious architectural quality which contrasts dramatically with much of what we understand in the contemporary world. This is not to demean the qualities of contemporary design and architecture (sophistication, use of new materials, high environmental standards, artistic or spatial virtuosity, social inclusion to name but a few), but only to distinguish the particular contrasting characteristics which each display. The unselfconscious character of the vernacular in contrast, is a result of both a close relationship between the makers and the users of those buildings and a very direct way of using locally-available materials and technology. As Isi Metzstein has pointed out, the ‘gathering place’ of a vernacular building’s raw materials (both in terms of its physical components and its intellectual and cultural reservoir) is geographically very small. Technical expertise, developed through trial and error and experience is passed down through the generations by local tradition rather than through wider study and theoretical posturing. The final form of the buildings is a very relaxed consequence of the materials and technology using, “the greatest possible stability with the least expenditure of materials and energy.” These buildings tell a number of stories about their original purpose, how they came about and the immediate world around them. For Renzo Piano however, despite their lack of sophistication, they nevertheless communicate much more than a story about the technology they have used or the activities they have supported, “Even when architecture was basically just creating shelter, it was already rich in symbolism. Architecture has always been an activity of expression, and this makes the adventure even more adventurous...” The vernacular illustrates a lively and fruitful series of detailed adjustments to broad, tried and tested building traditions showing how adaptable those traditions can be to changing geographic and climatic circumstances. It displays invention within certain defined parameters. These humble buildings have an ability to communicate to us ideas about climate, technology, the fundamental act of shelter and the lives of those they were built for.
Architecture of the 19\textsuperscript{th} and 20\textsuperscript{th} century was characterised by an ever-increasing ‘gathering place’ of ideas and technological means. International cultural and artistic movements, industrial revolutions, the introduction of railway transport, the post war transformation of the building industries, the socially-inclusive and international development of education and trade and the rise of the Far Eastern and Asian markets have all in different ways transformed the ‘gathering space’ of the contemporary building project to include all corners of the globe and all societies and cultures.

Currently in the 21\textsuperscript{st} century, electrical power coming out of a socket relies on Middle Eastern fossil fuels, materials and components are regularly imported from all over the world and the world of ideas has exploded through the ability of affordable international travel, digital communication and the rise and influence of the media. Against this vortex of influences and choices, there is the growing realisation that for practical as well as ethical reasons, there is an urgent need for responsible husbandry of the planet’s dwindling resources before there are none to go around. Against this background, the original Highland Housing Fair brief was both timely and in parts inspirational.

Concept

Four themed zones were established in the HHF masterplan; namely:

South Zone: Wood-fuel and Micro-renewables.
West Zone: Solar Design.
North Zone: Carbon-neutrality.
East Zone: Adaptability and Re-cycling.

All proposals were allocated to one of these zones and architects were invited to inform their design with an interpretation of a zone’s dedicated theme. Our own plot 26 was located in the East Zone. Our original concept was for a cluster of semi-detached and detached units which together with landscaping elements and external timber screens (a projection of the wall cladding) served to form a sense of containment and place in the communal courtyard Fig. 1. Inspired by the Paul Klee painting, RedGreen and Violet-Yellow-Rhythms (1920 The Metropolitan Museum of Art, The Berggruen Klee Collection), this concept sought to address the often-ignored problem of contemporary houses seeming isolated and un-integrated to their site and wider physical context.
In this case, the physical context had barely been established and to all intents and purposes existed only on paper, in the masterplan. Perhaps anticipating the inevitable round of cost savings later in the design process, we consciously set out to design the simplest of buildings, investing design innovation on spatial and social issues, rather than on extraneous architectural elements, complicated detailing or technological environmental features which might break down or need maintenance in the future (all of which would be the first casualties in any ‘value-engineering’ exercise) Fig. 2. The resulting design produced a language of simple pitched roofs over rectangular footprints without any projecting bays or eaves. Our concept for the landscaping and external spaces focussed strongly on the idea of a repetitive but responsive building block which was capable of creating a sense of place and neighbourhood. Fig. 3.

Key Design Features

The key generic component of each dwelling, which determined both its solar orientation and its social relationship to the site and context as a whole, was a generous double height wintergarten and circulation space. This is the primary point where the sun’s light and energy enter the building. It is also the point where the public and private realms meet and to an extent overlap. Collectively it is the disposition of these elements that most influences the character of external space Fig. 4. Individually it is this element which most influences the spatial relationships, activities and “delight” within each house.
Fig. 3 Simple pitched roof forms spatially inventive

Fig. 4 Key architectural and environmental concept
While in technical terms playing the important moderating role on the internal environment, this is primarily seen as the psychological hearth and “firmness” of the home. Surrounding the core area is a breathable envelope of relatively lightweight construction, that serves to accommodate the more open plan and adaptable/extendable areas – the “commodity” of the dwelling which offers the requisite loose-fit for future patterns of use Fig. 6. In reality, due to economic reasons, only two of the four houses were built which compromised the intended sense of place externally which our original competition design had proposed. A change in the original developer and more stringent financial constraints also meant that the external screens and landscaping were significantly reduced resulting in a diminished sense of external containment and sense of settlement Fig. 7 & 8.
Fig. 7 & 8 Ground and first floor plans
Construction

The Hardcore Softhouse could be described as a contemporary dwelling that carefully considers the appropriate use of construction materials within a solar orientated design. Engineered to a BREEAM excellent rating in collaboration with the Buro Happold Sustainable and Alternative Technologies team, the houses endeavour to remain simple, intuitive and elegant pieces of rural architecture. Whilst it is understandable (and indeed common) within the building industry to use appropriateness and quality as key criteria when specifying products or materials, regardless of where in the world they come from, the ethos of this development was to attempt to deliver the very best quality from a much smaller, local geographic ‘gathering place.

The entire production of construction materials and products and the labour required to assemble and maintain the dwellings was therefore designed to draw on local Highland and other Scottish sources. We decided early on in the competition phase to explore the use of timber frame technology both for economic as well as for environmental performance reasons Fig. 9.
The external breathable timber frame envelope was manufactured nearby in Elgin using locally sourced and recycled materials where possible. This consisted of a deep, highly-insulated cassette system. Durable, affordable and also locally available, Scottish larch was chosen as the cladding finish, enhanced with a light stain to prolong its lifespan and avoid that unfortunate ‘garden shed’ look that untreated timber houses often display while their authors nervously wait for that long-expected silvery-grey weathering to take root. The roof was clad in galvanised corrugated steel sheeting - now almost a vernacular element in the Scottish landscape and in itself recyclable. Space heating and primary domestic hot water generation was provided by means of an externally sited air source heat pump system, connected to an indoor control station.

There were a number of key components to the term ‘sustainability’ which we considered crucial in this project namely:

- Architectural and social longevity
- Environmental performance and quality
- Embodied energy
- Passive design
- Low carbon design
Our practice ethos generally is to focus primarily on producing buildings of inherent quality in terms of the space and sense of place it delivers for its users Fig. 10. A building which will be valued and will therefore endure – the first architectural step towards sustainability.

Conclusions

Was the development successful in meeting all its original aims? It is difficult to say as yet. There is a more in-depth paper to be written still by someone about why the original Fair was halted and whether its successor (Scotland’s Housing Expo) followed through faithfully with those original inspirational aims. Developers didn’t seem to realise that to break the default way of delivering volume housing and building more innovatively will (certainly initially) require a higher level of financial investment. It will be some time before people’s own experiences of living here give indications of what has worked and what hasn’t from a community and lifestyle perspective. Even at this stage, we as authors of two houses are asking ourselves these questions. Certainly some important component parts of our own design were removed in the changeover from our original developer to the contractor which eventually built the buildings. The outbuildings and connecting walls as well as the full extent of the external timber screens which were all important elements in creating a proper external place, integrating the buildings with the wider landscape, were omitted. We as architects feel that loss keenly. Our original proposals for using recycled concrete internally and unfired clay bricks for the core all of which would have established a richer tectonic character are also losses, as is the omission of certain details in the contractor’s rush to complete the buildings for the official opening (which wasn’t fully achieved in any case).

The character of Scottish rural architecture is traditionally characterised by a robust simplicity of form and a very direct attitude to materials and detail Fig. 11, 12. On reflection, despite the dilution of some of our initial ideas and elements, we see similar characteristics displayed in the Hardcore Softhouse. We see this as an important progression as the growing emphasis on sustainability reinforces a need to return to more location-specific building (effectively a contemporary vernacular) in terms of siting, grouping, selection and source of materials and energy. At the same time, we firmly believe that the careful placing of a fine piece of architecture – one which offers a firmness, commodity and delight to its inhabitants and passers-by – is the single most important step one can take towards sustainable development.

**Fig. 11 Character from construction**

<table>
<thead>
<tr>
<th>General Information</th>
<th>The Hardcore Softhouse</th>
</tr>
</thead>
<tbody>
<tr>
<td>House Name</td>
<td>studioKAP Architects</td>
</tr>
<tr>
<td>Architect</td>
<td>O'Brien Homes</td>
</tr>
<tr>
<td>Contractor</td>
<td>Highland Housing Alliance</td>
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<td>Owner/ Developer</td>
<td>2 semi-detached houses</td>
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<td>Number of Public Rooms</td>
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<tr>
<td>Predicted annual energy performance/running cost (from SAP rating)</td>
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<td>SAP Rating</td>
<td>B 83</td>
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<tr>
<td>Energy usage (heating only) in KWH/m²</td>
<td>106kWh/m²</td>
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Acknowledgements

I would like to acknowledge the contributions of my fellow-directors of studioKAP, Roderick Kemsley and Helen Campbell in the writing of this paper.

The following people worked on the design and delivery of this project: Helen Campbell, Roderick Kemsley, Christopher Platt, Kathy Li, Rupert Daly.

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THE MODULAR HOUSE - PLOT 15 - SCOTLAND’S HOUSING EXPO

by

David Keith
Bracewell Stirling Consulting

“A state-of-the-art, carbon neutral living space as natural as the environment, which considers carbon reduction from every angle.

High thermal performance air tight external structure with complementary heating/ventilation system. Factory assembled long panel construction, high quality finish, quick on site assembly, minimised waste during construction.”

This is the tag line that accompanied the house designed by Architects Bracewell Stirling Consulting at Plot 15 of the Scottish Housing Expo in 2010 - the house known as The Modular House.

With a predicted annual running cost for the space heating of less than £400, the technology in the construction of the house has certainly been selected with low running costs and reduced carbon generation in mind.

The house boasts under floor heating, increased thermal insulation levels and an innovative ventilation system which is centred on a Swedish NIBE heat pump, around which the house is quite literally built. The system recycles heat from kitchen and bathroom extract air and redistributes it around the remainder of the property, so bringing energy bills down and at the same time reducing CO₂ emissions.

The technology and systems adopted in the house were all selected on the basis that they were viable solutions that could be rolled out on larger commercial housing developments.

The Modular House was described as “a cutting edge exploration in air-tight prefabricated design” by Building Design magazine whose critic positively spoke about its contribution to the “cause of progressive residential architecture”.

The Practice

Bracewell Stirling is a long established Scottish based architectural practice with a strong background in designing energy efficient solutions for both mainstream and affordable housing.

The practice strives to push the boundaries of new and existing building materials and technologies using them in new ways to provide efficient and comfortable homes that are within the reach of everyone.

The Practice’s Expo house was an opportunity to design a bespoke house with features that were transferable to mainstream housing, embracing the philosophy of off-site manufacturing and stepping toward ‘zero carbon’ building.
History

The Scottish Housing Expo was held in August 2010 on an elevated site to the South of Inverness, attracting significant numbers of visitors during the month that its doors were open to the public.

Bracewell Stirling was awarded Plot 15 to develop in May 2007 following the submission of a successful competition design entry, made in conjunction with Inverness based Developer/Contractor Tulloch Homes Express.

The Design Competition for the Expo dictated that various zones within the overall 52 house development followed specific design codes. Plot 15 was located on North Street in the ‘North Zone’, an awkward corner site where the building form was obligated to follow the street frontage. The Energy Efficiency theme of the North Zone was Carbon Neutrality, targeting zero CO₂ emissions in use.
Carbon Neutrality

The Practice’s design targeted the Expo’s Carbon Neutrality aspiration by adopting a ‘fabric first’ approach, following the basic principle of minimising heat loss through the building envelope. This concept was achieved in practice by:

- Maximising off-site manufacture to improve thermal performance and air tightness;
- Adopting highly insulated wall, floor and roof constructions; and
- Specifying components such, as windows and doors, with high thermal performance.
The above concepts are all passive solutions and were fundamental to the effectiveness of the solution at Plot 15 - a principle based on getting the building fabric right first before considering heating, ventilation and any on-site energy generation that might be adopted to offset energy use.
At the early design development stages, the plan had been to connect the house into the Expo site’s proposed district communal heating plant. The establishment of the communal system was however abandoned by the Expo organisers and resultantly the house at Plot 15 was required to ‘stand alone’. The target of Carbon Neutrality suddenly became much more difficult to achieve, requiring energy generation within the plot. However, due to both budget and practical constraints, the planned adoption of on-site generation was abandoned and the focus moved towards reducing CO\textsubscript{2} emissions as opposed to achieving a target of zero emissions. While budget had been a leading factor in the decision to drop on-site energy generation, the decision was also influenced by the fact that the ridge line of the house ran north to south, due to plot location, meaning that opportunities to adopt roof mounted solutions such as solar or photovoltaic panels were limited.

Once the decision was made to adopt the ‘fabric first’ approach the next stage was to balance this with a suitably efficient and cost effective solution for the heating and ventilation, a system that would continue the principle of reducing heat loss, while minimising running costs and at the same time minimising the property's long term reliance on finite fossil fuels.

With this target in mind a NIBE recycled air source heat pump was selected, a system which not only delivers the heating and ventilation to the property, but also provides efficient heat recovery - and a system which has been used successfully across the Continent for many years.
Building Performance Facts and Figures

The Building Regulations demand that a new house achieves a CO₂ emission rate no worse than that of a theoretical house of the same type and construction. The Modular House not only met this target but almost halved it, with emissions expected to be around 55% of the legislative standard. Therefore, the house, while it easily met the regulations in force at the time, would also have met the more stringent regulations that came into force in late 2010, with the potential of also meeting the further enhanced standards that are expected to be released in both 2013 and 2016, as the Scottish Government strives to achieve its ambitious environmental targets.

The fabric of the building also significantly exceeds that required by the Building Regulations. With U-values, the mark of the thermal performance of a specific building element, reading as follows for the walls, maximum allowed 0.25 w/m²K, actual 0.11 w/m²K and for the roof, maximum allowed 0.16 w/m²K, actual 0.12 w/m²K.

The house was also designed to the highest Ecohomes rating of ‘Excellent’.

Off-Site Manufacture

The Modular House was constructed using a Closed Panel timber frame system, a system that Bracewell Stirling developed with manufacturer Scotframe Timber Engineering Ltd, initially as part of a roll out of affordable homes across the north of Scotland for the Highland Housing Alliance. The system utilizes a ‘Supawall’ injected polyurethane foam timber frame panel at its core and is delivered to site complete with external finishings, doors, windows and internal service zone.

Bracewell Stirling’s involvement in the development of the design of the system, including the design of the panel build-up and junctions, as well as the practicalities of transportation and erection, have gone a long way towards delivering what is a highly insulated and extremely air tight and therefore draught free house.
The construction system has the advantages of minimising on site construction periods (Plot 15 was the first house completed at the Expo); improving construction quality through factory control of panel assembly; less wastage and reduced transportation; and, reduced defects through improved quality and reduced exposure to the elements during construction.

Bracewell Stirling is proud to have been instrumental in the successful development of this product, which is now being rolled out on many development sites across the country, a product which embraces the principles of Modern Methods of Construction where the target is to provide better quality products in less time.
Plot Design Constraints and Features

The Expo brief dictated that the house on Plot 15 should follow the street frontage of North Street. This design constraint came with its own challenges as the street frontage at this plot turns slightly right halfway along the plot frontage, resulting in a ‘kinked’ front elevation to the house.

The brief also dictated that there could be no main windows on the ground floor storey on the street frontage.
The solution adopted for The Modular House was to build the house out of two 2-storey blocks, with the south-most block stepped back from the street frontage to allow south facing windows to be located on the other block, serving both the lounge and the kitchen, but sited so that they would not overlook the neighbouring property to the south. To maintain the ‘kinked’ street frontage a single storey office space was provided at ground level to the front of the south-most 2-storey block, the roof of which doubled as a south facing deck area.
Internally natural light and space are important elements of this house with a double height volume over the ground floor kitchen, providing linkage with the first floor lounge. Windows, where allowed by the brief, are sized to provide a successful balance of natural light without compromising the internal comfort of the house through excessive solar gain or glare.
The house is one of the largest units at the Expo, comprising of 3 public rooms, 4 bedrooms and an integrated office space, all within a 169m² floor area.

The house is clad in a combination of locally sourced hard wearing timber linings and white and grey render panels that are finished with a high performance thin coat render system. The external aesthetic of the building is bold and contemporary while at the same time being sympathetic to its Highland setting.
Summary

The Modular House at Plot 15 of the Scottish Housing Expo is considered to be a successful exercise in the use of an off-site manufactured construction system, delivering reduced building heat losses, reduced CO₂ emissions and reduced running costs for the occupant.

Bracewell Stirling Consulting have set a high benchmark for low energy housing at this plot, but it is a benchmark that can and should be achieved in the mainstream housing market and for that reason the house has achieved its goal.
Graz Insights - Environmental Siedlungs
Lessons from site visits prior to Eurosun 2010, 29th September to 1st October

by

Prof. Colin Porteous,
Mackintosh Environmental Architecture Research Unit, The Glasgow School of Art

Siedlungs as Demonstration Projects

A ‘siedlung’ is a settlement, or one might say a neighbourhood. At any rate it implies community and cohesion. Also, according to the monograph on the work of Manfred Kovatsch, the lead architect for one of the projects discussed below, the siedlung has again come into focus as “a demonstration project and a fragment of utopia”\(^1\). It is therefore of interest to examine a number of discrete siedlungs completed over the last three decades in Graz, especially since each, apart perhaps from the first dating from the early 1980s, has a very explicit agenda directed at energy efficiency and environmental sustainability. The last project is a retrofit of housing blocks to 21st C Passivhaus standard, forming one coherent settlement, but built over the three preceding decades. This in turn raises the question as to how easy it would be to upgrade the examples from the 1980s, 1990s and 21st C ‘noughties’ to current expectations and beyond. Finally it is of interest to compare these examples with those from Zurich and Freiburg published in the March 2010 issue of Innovation Review. In particular, although the railway journey through Austria to Graz seemed to be lined with solar photovoltaic roofs, passive and active solar thermal applications are in evidence in the examples below, but not PV.

Alte Poststrasse by Michael Szyszkowitz and Karla Kowalski, 1982-84

This project is included partly because it evokes a strong sense of low-rise urban and social place in a relatively featureless context, and partly because it offers potential for active solar collection in addition to the present passive solar gain. It lies close to the edge of a mixed residential area (flats and houses) to the west of the main station in an area that was heavily bombed during WW2, and now has industrial buildings to south and east, and a large hospital to the west. It is a rectilinear corner site with a short side facing west on to quite a busy road, and a long side facing south on to a relatively quiet street, with both these public faces set comfortably back from traffic and enjoying both private and communal landscaped spaces. The plan form is that of a letter ‘C’, but with the top straightened and extended eastwards and separated from the northern boundary by a narrow service lane.

Fig. 1 Entrance to Szyszkowitz Kowalski’s housing at Alte Poststrasse

The complex thus encloses a substantial court, which extends eastwards towards the adjacent site. Although the court is entered by what we would call a ‘pend’ or ‘close’ in Scotland (Fig 1), it constitutes a salubrious entrance threshold in the continental European manner, not a utilitarian ‘back court’ of the Scottish kind. Moreover, the service lane to the north provides ramped access to car parking below the court.
What we can say now, approaching three decades after this project was built, is that the 4-floor, courtyard typology is socially sustainable (Fig 2). One may reasonably assume that it is also economically sustainable since it formally defers to historical precedents and has been repeated in essence many times since. What is perhaps more contentious is whether it could be rendered environmentally sustainable according to current forecasts or expectations of future standards and best practice. Reasonable passive solar design was there from the start, complete with external shading. There are also tempting opportunities for active solar collection, implied by glass canopies, and no doubt heating and ventilation systems may be fairly readily upgraded to a more energy-efficient and renewable status. Glazing replacement might have to wait some years before being considered economically viable, but it is also an easy option when that time comes. And, having done all that, the walls and roofs might be left at least until their outer ‘skins’ start to wear out; while the ground floor might have to be left in its existing condition, which in any case probably includes a reasonable layer of insulation.

To get down to net annual zero carbon, or net annual zero energy, for all thermal loads (space heating and hot water) would be challenging. To achieve this for all power loads as well would be harder still. A small-scale biomass, combined heat and power (CHP) system is possibly the best option, depending on what larger scale district systems are available. In reality, grid electricity for Graz may come from hydro-power or biomass, so that on-site renewable power is not such an issue as in the UK – see concluding comments; but the situation in Graz may not conform closely to the national picture.

Passive Solar Housing at Rettenbacherstrasse by Bernhard Hafner, 1985-1991

This is a project, the design of which coincides with the building of Scotland’s first passive solar housing project in Stornoway², and the building of which roughly matches Scotland’s first major passive solar retrofit in Glasgow – the latter also a CEC-funded demonstration project⁴. The architect, Bernhard Hafner, also happens to have an indirect connection to Graz in that he was a colleague and friend of John Voelcker while both were teaching at UCLA in Los Angeles, and before the latter became Head of the Mackintosh School of Architecture in the early 1970s. As a matter of record, Bernhard also edited a 1969 special addition of the Austrian periodical Bau, which described the work of the ‘Studio Revolution’ of Graz at that time. As a member of the first generation of what is now labelled New Graz architects, he was at the centre of this radical movement for change. More on his background is described in a book by Peter Blundell Jones⁵, including his interest in the spacing of buildings and solar access.
The context here is a small river valley in the northeast of Graz, up and down which snakes a tram. Thus it is quite different from that of the Alte Poststrasse siedlung. At this point, the tramway is running only slightly north of due east and Bernhard has placed two blocks parallel to this and just east of the residential access road, Rettenbacherstrasse, which crosses the tramline at a stop. There is a relatively small hard area with parking immediately next to the tramline, while the northern, and shorter, block is closely hemmed in and separated from the watercourse (burn or brook) by quite mature trees (Fig. 3).

Both blocks are designed to receive passive solar gain, but the southern block has ‘veranda-type’ or ‘wintergarden-type’ solar buffer spaces (Fig 4). Due to cost constraints and regulatory compliance, these were double-glazed on the outer surface, but single-glazed at the interface with heated rooms. This was the strategy adopted for the same reasons at Stornoway; while, a few years later, both inner and outer skins in the Glasgow project were double-glazed. At Rettenbacher, high and low level opening windows on the outer glazing, together with opening windows above doors in the inner glazing, provide adequate summer cooling in tandem with fabric blinds in the sunspaces and thermal mass. In the last regard, ceilings have an exposed ribbed concrete construction, which increases the surface area relevant for thermal response – i.e. admittance or Y-factor.

Floors are finished in ceramic tiles and walls are exposed aerated or autoclaved concrete blocks 250 mm thick and insulated with 60 mm rock-wool. Assuming the block has a resistivity of 6.25 mK/W (similar to Siporex), the U-value for a typical wall is 0.27 W/m²K.

Anecdotally, the operation of windows and blinds proved effective in summer, while in winter “little additional heating is needed”. Moreover, a study of inhabitants’ satisfaction with architect-designed public housing conducted by a team of sociologists indicated the highest possible ranking for this project. One might envisage further improving thermal performance by replacement of the inner windows in the first instance. It is also possible that winter ventilation could be improved by exploiting both sunspaces and mechanical heat recovery. Active solar thermal arrays could also be added without undue difficulty. However, as with Alte Poststrasse, to go further is more difficult, but may be addressed through local circumstances such as availability of renewable power and district heating.

Manfred Kovatsch was another member of what may be regarded as the first generation of New Graz architects, studying alongside Bernhard Hafner, leaving Graz on graduation, working for a time in USA, and with his practice thereafter based in Munich. The monograph of his work cited above also makes the following comment under the heading The Role of the Siedlung: “Like a miniature city each project attempts to recuperate the street and thus community as well as making individual units that respond to the cultural and natural environment.” This particular project brings one street under cover. This is a glazed arcade aligned on a north-south axis, a ‘transitional space’ that mediates between indoor and outdoor activity, with all entrances to dwellings from the east and west sides of the street. This idea has many precedents – not only other modern housing applications of the technique in Denmark and Sweden for example, but also an unrealised 19th C scheme by Alexander ‘Greek’ Thomson to replace slum housing in Glasgow’s East End.

The context is suburban, some two kilometres south and somewhat further west than the Alte Postrasse site. The three-storey section adopted, which sits on top of a basement car park, promotes a more urban scale, without compromising the quite verdant character of the wider neighbourhood.

Heights of main rooms inside are also relatively generous, with flats located over maisonettes - see cross-section Fig. 5. Ceiling heights at ground level are 3.0 m, and 2.7 m at first floor level in maisonettes, while ceiling heights vary up to 3.6 m in the living rooms in the 2nd floor flats, with a mean of 2.75 m. The dwelling depth is a relatively shallow 6.5 m, with living rooms taking up this entire dimension, so that either single-sided or cross-ventilation is feasible depending on circumstances. In winter, for example, adequate ventilation of the main living space can come from the glazed arcade, which has 10 cm permanent ventilation slots on each side.

The generosity of ceiling heights not only enhances natural lighting of the rooms, but also makes them more robust in terms of ventilation stress in the absence of mechanical control. In dwellings with low ceiling heights and tight floor areas – e.g. Scottish two-bedroom flats for up to four persons with areas less than 70 m² and ceiling at 2.3 m – there is a great temptation to throw open windows while heating is on at a high setting in order to adjust stuffiness. At Tyroltgasse, which is a social housing project, a typical two-bedroom flat is approximately 87 m² and a three-bedroom flat 108 m², with a three-bedroom maisonette slightly more including its porch. Coupled with the significantly higher ceilings, the stuffiness issue for typical family occupancy will be less pressing, and the ability to introduce fresh air from the arcade, normally no lower than 8°C even in very cold winter weather, is an added bonus. On hot summer days, the ability to cross-ventilate, with exhaust from the arcade supplemented by opening lights at the apex, is again advantageous.
According to Manfred Kovatsch, the temperature at the top of the arcade is never more than 2-3 K above ambient in summer – e.g. circa 35-36°C. There are also external shading devices of various kinds on the east and west facades (Fig. 6).

The dimensions of the arcade itself are of interest – approximately 7.7 m wide by 11.0 m high at the apex. Peter Blundell Jones tells us that a “threatened requirement for compartmentalisation” to meet fire regulations was overcome by “patient discussions”. In terms of realisation, the length of some 110 m is perhaps more contentious (Fig. 7). With a central bridge and links at each end enabling cross-over from respective east-west access decks serving 2nd floor flats, inevitably some may draw analogies – for example prisons. But prisons operate on removal of freedom, whereas opportunities for both privacy and neighbourly interaction are the issues here, as well as for personalising individual thresholds. In the last regard, the presence of projecting porches is key, as are the recessed thresholds at 2nd floor gallery level.

Fig. 6 Detail of east faced at Tyroltgasse, noting various shading devices

Fig. 7 - Inside the arcade at Tyroltgasse looking south from 2nd floor bridge

Overall, as a model, the lightness and brightness of the arcade is in stark contrast to the 2.3 m high, 2.9 m wide, 126 m long artificially lit internal corridor in Le Corbusier’s famous Unité d’Habitation at Marseilles.

Finally, the provision of private gardens for maisonettes, with patios of some 27 m², and balconies for flats of roughly 3.3 m wide by 1.8 m deep, adds value amid the salubrious communal landscaping, which evokes pride of place as well as biodiversity. At any rate, it is a far cry from that associated with the majority of social housing in cities like Glasgow. In urban Scotland private outdoor space is in short supply, balconies for flats are now a rarity, and communal spaces tend towards a hard dreariness, a prime concern often the avoidance of cover for nefarious activities rather than issues of quality and sustainability.

Although the design of this project is contemporaneous with the building of the previous two, its realisation takes us to the last year of the 20th C. Winning the Grand Austrian Housing Award 1991, building did not commence until September 1997, with completion by March 1999. Although this is again a suburban context, this time at the western fringe of Graz, the topography could not be more different than that of Tyroltgasse – a steep south-easterly slope, with a commanding view towards the city centre.

The architect, Dr Adil Lari, has taken advantage of this with two floors of single-aspect, passive solar flats, completely embedded in the slope, and topped by dual aspect flats. There are forty-two dwellings in all, seven accessed off each of six stairwells in the usual way for tenements. Each set of seven has four different apartment types. The net area is approximately 3,500 m$^2$, indicating an average area per dwelling of 83 m$^2$. This is again a social housing project, where the client and developer is a housing association.

Thus although there is commonality with Tyroltgasse in terms of floor height and varying numbers of rooms, the housing form on this site is quite different, including orientation. Here there is a single, gently convex curve facing some 30 degrees east of due south. The fenestration forms 100% of this façade on all three floors, with full-width balconies across each bay at each floor level, which are just deep enough to accommodate a deckchair sideways. The roof projects the same distance as the balconies and hence there is a degree of fixed summer shading.

However, the main shading device is an electronically controlled and programmable blind, normally in four widths per structural bay, with individual adjustment capability evidenced in Figs. 8 and 9, with only the top floors visible.

Allowing for framing, the net glass area is of the order of 85% of the façade, and has a mean U-value of 1.1 W/m$^2K$.

As there is no “controlled ventilation scheme”, by which it is assumed no mechanical heat recovery and delivery of fresh air, the operation of windows by occupants in winter will be critical for thermal performance, with extract from ‘wet’ areas towards the north of the single-aspect flats probably contributing to a degree of cross-ventilation in those two floors. Indeed monitoring apparently showed that user behaviour could increase energy demand by up to 70%. However, since the predicted heating demand was 32.2 kWh/m$^2$ and the mean monitored consumption was 40.3 kWh/m$^2$, a 25% increase, it must be assumed that many residents achieved consumption reasonably close to the predicted value. It is also of interest to note the relationship between prediction and consumption in this case, with a relatively relaxed ventilation approach, mainly reliant on window opening by occupants, and the benchmark value of 15 kWh/m$^2$ for Passivhaus.

Undoubtedly a large part of the creditable thermal performance for this project, given the lack of mechanically controlled ventilation with heat recovery, is due to the combination of earth sheltering – the roof is also earth covered with a U-value of 0.17 W/m$^2K$ – and passive solar gain. It is estimated that about two-thirds of thermal energy lost through transmission is balanced by solar energy. In addition there is an active solar thermal array on the roof to offset demand for domestic hot water, the balance heated by condensing gas boilers, which also provide the energy for space heating.
WIST Students’ Residence by Alfred Bramberger, 1994-1997

Peter Blundell Jones acknowledges Albert Bramberger as one of the third generation of New Graz architects (14 years younger than Berhard Hafner and Manfred Kovatsch), having initially worked in the office of Volker Gienke who was second generation8. Indeed Bramberger lives in a Gienke housing project nearby the WIST Students’ Residence in Graz-St. Peter for which he was project architect. It is interesting that the monograph for the WIST project cites Aldo van Eyck in terms of his idea of city and house aired at CIAM IX, in Aix-en-Provence in 19539 (a concept shared with John Voelcker, Bernhard Hafner’s friend), and subsequently published in the 1962 Architect’s Year book in an article about his famous Amsterdam orphanage (1955-60): “As for this home for children, the idea was to persuade it to become both ‘house’ and ‘city’: a city-like house and a house-like city.”10 Clearly Kovatsch has this idea in mind for his WIST students, the founding aim of WIST was to provide low cost board and lodging in order to stimulate the opportunity for those from socially and economically disadvantaged backgrounds to take up university studies. Noting also that Aldo van Eyck’s humanist view of architecture was underpinned by a passion for poetry and fine art, and that he viewed the precedent of both classical and indigenous vernacular architecture as equally valid as the 1920s De Stijil of Theo van Doesburg and Gerrit Rietveld, it is gratifying to find Hannes Meyer also cited in the Bramberger monograph. Meyer was Director of the Bauhaus from 1928-30 and known for his “advocacy of architecture as pure social science and sheer function”11.

Even though ‘sheer function’ is an anathema to many, part of Meyer’s quote in the WIST monograph is worth repeating in this article with the focus on environmental siedlungs: “We will analyse the relationships of the house and its inhabitants with what is unknown..., we will analyse the relationship between human and animal and the garden..., we will find out differences in the ground temperature throughout the year ... according to this we will calculate the shadow movement of the house in the garden and the way sunlight falls in through the bedroom window...”12. Here we have rational functionalism based on humanism, which does not challenge Van Eyck’s or Voelcker’s theories, and seems perfectly in step with appropriate environmental architecture today.

The site context here might be regarded as relatively constrained, having a narrow frontage of about 37.5 m on to an east-west street that links two main arteries to the city centre and lying to the north of one of the outlying Technical University campus in Graz-St. Peter. On the other hand the depth or length of the site is considerable - just over 130 m (to give 4,888 m²), with the axis skewed some 13 degrees anti-clockwise from due north-south. On to this Alfred Bramberger has neatly fitted two buildings (Figs. 10 & 11).

![Fig. 10 Plan of WIST blocks (source: Alfred Bramberger, HDA Baudokumentationen 12)](image)

One is an inverted 4-storey L-shape, again skewed from the site axis to provide roughly triangular open ground on three sides; while the other is a relatively short east-west block of accommodation at first floor level, which sits astride a semi-public realm accessed from the street and accommodating a cafeteria, events hall and administration.
Other communal accommodation occurs in the main block. For example, there is a central common room at ground level, complemented by a roof garden at 3rd floor level, which is terminated by a lecture room at right angles to the main spine at its south end. The last ‘penthouse’ feature projects to the west with a dramatic propped cantilever (Fig. 12), and its roof is geometrically enlivened in a visual compliment by two solar thermal arrays and equally by a dramatic external, but glazed, cascade staircase on the east side. This ability to aesthetically harmonise structure, access and active solar collection should not be underestimated. Each element strengthens the other, a relatively rare occurrence when it comes to solar technology and architecture. Moreover, the relatively slender depth of the main accommodation spine, circa 11.4 m internally, not only permits a reasonable amount of open ground on each side, but also allows for cross ventilation and still leaves space for servant plumbing cores with served rooms on each side. The planning key to this arrangement is to access all apartments directly from the outside at ground level and from decks along the east and south facades above this.

The net result of this is maximum useful internal space, with reasonably generous areas per bed-space. For example, a single room is about 12 m$^2$, and a double room 22m$^2$, both figures well above the former minimum Scottish Space Standards prior to their abandonment in the mid-1980s. On the other hand, hygiene facilities are compact and shared. The variety of flats and maisonettes is also intended to provide flexibility relative to different student demography, as well as the vacation rental market (without resorting to *ensuite* toilet and shower for each bedroom).

For example, a maisonette with three single and one twin bedroom is 121 m$^2$, a flat with one single and one twin bedroom is 70 m$^2$, and a flat with two single bedrooms is 60 m$^2$. If we were to assume the same number of each of these three types, the area per bed-space would be approximately 25 m$^2$.  

Fig. 12 Solar collectors on cantilevered WIST lecture room
In terms of energy efficiency, consultants from the Institute of Heat Technology at Graz TU were commissioned by Graz Stadtwerke AG "to establish a cluster of measures for additional energy saving". Their analysis showed that an additional investment of 2% in building cost could yield approximately 32% energy savings. This included insulating above regulation standard, and the 100 m² solar array with 5 m³ thermal store is predicted to save 52 MWh annually (520 kWh/m²) from the energy purchased from Graz Stadtwerke AG for district heating (space heating and domestic hot water). In addition, the plan form allows for a reasonable passive solar contribution from east south and west.

Concrete cross-walls and floors also assist the thermal storage of passive gain and help to damp down any excessive swings in internal temperature. Solar gain is also controlled with external venetian blinds — especially important for the westerly façade. There is an additional passive gain feature for the five units above the communal accommodation. The access deck here is glazed to the sky, as well as offering a view down into the events room (Fig. 13). Although open at either end solar radiation through the roof glazing, absorbed and re-emitted from absorbing wall and floor, should significantly enhance the microclimate of this transition space — i.e. similar to the Tyroltgasse project.

Fig. 13 Glazed 1st floor arcade to WIST southern block
The founder of this practice, Josef Hohensinn, was born in upper Austria and went to Linz Technical College before studying structural engineering at Graz TU. By generation, he belongs in the third group emerging from Graz with Alfred Bramberger and others, including Hubert Riess, with whom he had a partnership from 1996-97. In turn, Riess had worked for Ralph Erskine in Sweden for a period after 1980 before returning to Styria as job architect for a Graz housing project by Erskine won by competition.

Ries’s housing estate, I and II Tanhofgrunde, is located not far upstream and ‘up-tram’ from Bernhard’s solar project, and has no specific solar energy features; but it is strong on place (Fig. 14) just as the Alte Poststrasse housing by Michael Szyszkwitz and Karla Kowalski, while differing in terms of its adherence to the pragmatic humanistic rationality of Erskine.

At Dieselweg, Hohensinn’s team have had to work with a given place – one long mirror-L-shaped block from 1952, two shorter rectangular blocks at right angles to this to the northeast from 1959, and three more of the same form to the southeast from 1970 (Fig. 15). All comprised four floors over a basement, and all used tenement stair or ‘close’ access to sets of four single-aspect flats per floor. The respective orientations for the leg of the mirror-L were thus southeast and northwest; while its base and all the shorter blocks faced principally southwest and northeast. The site is flat, some 2.7 km south of the WIST student residence, more generous in area with some mature trees, but still constrained by the infrastructure of railway and roads. In urban terms, the long 1952 block bisects the site as a wall to a truncated triangle of communal green area between it and the northwest boundary; while the newer five blocks are parallel but staggered object buildings in the remaining open part of the site.

The philosophy of the practice on its website mentions “caution in the use of found objects and respect for the needs of users” and uses the analogy of meeting needs “like a tailored suit”. This seems particularly apposite for the Dieselweg retrofit, where space-heating reductions of over 90% form the core of task, with all work carried out with a minimum of disturbance to the residents. The retrofit also included the provision of lifts, with stair access only in the ‘found object’.

The housing association and developer is GIWOG. The specialist for the energy concept is ESA (Energy Systems Aschauer) while the reporting consultant is AEE Institute for Sustainable Technologies, Gleisdorf. AEE’s main personnel on this project are Armin Knotzer, key guide during the Eurosun 2010 Technical Tour on 28/09/10, and Sonja Geier, who gave an oral presentation on the project at the conference itself on 30/09/10.

A largely prefabricated cladding system, which incorporates heating and mechanical heat recovery ventilation (MHRV), as well as insulation, solar-thermal cladding and high-performance windows, was critical to addressing the energy challenge. Coupled to this was the ‘found object’ of homogeneous solid walls, with the potential to act as large thermal storage flywheels once warmed. In order to deliver the required amount of heat for this and hot water, two sources were used – the sun and the earth. The roofs of the 1959 and 1970 blocks, a carport and the façade of the long 1952 block, provided an average of 3 m² flat-plate collectors per flat, which numbered 212 after retrofit – i.e. approximately 636 m² of thermal array in total.
Groundwater heat pumps provide the balance of heat required, these and the solar arrays supplying hot water storage of 5 m$^3$ in each of the smaller blocks and three of 5 m$^3$ in the long block – overall 40 m$^3$, or just under 0.2 m$^3$ per flat centrally, also serving hot water tanks in each dwelling. This solution again recognizes the ‘found object’ in that there was no district heating supply to Dieselweg, only individual heating appliances.

The solar-thermal cladding requires further explanation. As indicated above part of the façade of the long 1952 block comprises integrated flat-plate collectors (Fig. 16).

The remainder of the façade on this block is also clad in glass, as are the other five shorter blocks. Most of this is based on a ‘solar comb’ principle, first introduced by another Austrian architect, Walter Unterrainer in the early part of the 21st C at a house in Bregenz. The essence of the technique is a layer of stacked corrugated cardboard (the ‘solar comb’) forming a honeycomb structure at right angles to the glass and separated by a slim ventilated air gap. The ‘comb’ acts as a lightweight solar absorber, with roughly the first 12 mm of its depth rapidly gaining heat as well as the air in the gap at times of high solar irradiation. Hence the effective U-value will vary below the ‘cold’ (night or negligible radiation) value during the daylight period. Unterrainer estimates that if the cold U-value is 0.2 W/m$^2$K, the mean effective value will be 0.13 W/m$^2$K, but that at times the value will be negative, thus constituting a situation of net heat gain. Overall, this is a 35% saving due to the dynamic enhancement; and at Dieselweg, Sonja Geier of AEE claims that “even in winter days with low solar radiation, the ‘effective’ U-value shows an improvement of approximately 21% ...” The cardboard layer here is 30 mm (Unterrainer’s Bregenz prototype used 160 mm), behind which is an insulated, timber-framed panel encased in MDF and OSB (medium density fibreboard and oriented strand board) – see Fig. 17.
Another element of solar-thermal cladding for the five short blocks is the extension of area and glazing in of original projecting open balconies to form fairly substantial winter gardens as buffer spaces (Fig 18). While it was the prefabricated modules with the ‘solar comb’ that received greatest emphasis at Eurosun 2010\textsuperscript{16}, Sonja Geier had earlier explained at one of the WP7 Treco-SQUARE Workshops that another fundamental aim was to achieve window U-values <0.85 W/m\textdegree{}K – overall to retrofit to better then Passivhaus standard\textsuperscript{17}.

Fig. 18 - 1970 Dieselweg block from south, noting projecting winter gardens

Fig. 19 Detail of 1970 block from south with flat-plate solar arrays visible on roof
Uniform use of such a high standard of glazing not only addresses less favourable orientations for roughly half of the flats, that is northeast and northwest, but also tackles the issue of the winter gardens being used as part of the main heated volume – in other words, indirectly heated by leaving the intervening doors open, since it is not directly connected to the wall-integrated heating.

In any event it will be interesting to compare monitored performance with prediction in this regard.

The final element of solar cladding is the integration of individual room MHRV units behind small glazed panels located adjacent to windows, as in Fig 19, which also shows rooftop solar arrays. Air is drawn in to the supply duct through a slot at the bottom of this panel and similarly exhausted through a slot at the top of the panel. Although the laboratory efficiency at 73% is much lower than that of normal Passivhaus whole-house MHRV systems, it solves the problem of not interrupting the residents. The supply and extract holes through the wall are not completed until the new cladding is in place; and, once complete, filters are accessible internally. Similarly, existing windows are removed from the inside at the end of the contract, and represent the only seriously disruptive part of the entire operation, but not one that leaves the flat exposed to the elements at any time.

Despite the relatively poor performance of the individual MHRV units, the predicted reductions in space heating loads for the three ages of housing are impressive, even allowing for the fact that additional area for add-on winter gardens and lifts favours the first two phases in particular (sets of three and two short blocks) – see Table 1.

### Table 1 Building data before and after retrofit
(Source: gap-solution, GIWOG)\(^{16}\)

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<tr>
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<th>Before retrofit</th>
<th>After retrofit</th>
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<td>Net floor area, stage 1 (1970)</td>
<td>3,720 m(^2)</td>
<td>4,767 m(^2)</td>
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<td>Net floor area, stage 3 (1952)</td>
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*calculated using PHPP 2004

### Concluding Comments

Retrofits along the lines of that executed at Dieselweg undoubtedly represent both a great challenge and opportunity to mitigating carbon emissions from housing - circa 27% of the UK’s total. Part of this challenge and opportunity is purely technical, but partly both also relate to quality assurance procedures. The authors of Dieselweg accept that many problems of both types had to be overcome, and dissemination alongside similar European projects at events such as the WP7 Treco-SQUARE Workshops\(^{17}\) constitutes an important part of the learning curve. The key issue overall was working around the existing envelope with minimal disturbance to the occupants. This involved transportation of large new envelope components, and their erection on site together with smaller servicing ones, and having to achieve airtightness tested following ISO 9072 – a sequence more demanding than new-build due to the intrinsic nature of the ‘found object’.

Although Dieselweg represents a potentially replicable paradigm, it does not achieve net annual zero-carbon for thermal demand on site. Nevertheless, that needed to power the heat pumps and solar thermal pumps is not too numerically daunting, and one might assume that a significant proportion of grid electricity in Graz is renewably generated.

Therefore, to approach net annual zero carbon for all energy needs might be attainable for such a project in future; that is if one accepts that a proportion is supplied renewably from the grid, and that only the balance requires to be met on site. One may note in this regard that in 2005 hydro-power accounted for 54.6% of Austria’s gross electricity generation, biomass 3.1% and wind 2%\(^{18}\), with all renewable energy (RE) accounting for 62.89% and most of the balance from gas and oil\(^{20}\). Of course such figures may not represent the true picture for renewable grid electricity supply to Graz, but it does show that the context is very different from that in the UK, and even in Scotland today with its historic legacy of hydro-electricity schemes now supplemented with gathering momentum for wind.

Nonetheless, despite the numerous PV installations that one may see from a train travelling to Graz, the absence of such applications for much of its urban housing seems somewhat paradoxical. PV was a fairly consistent feature in the article describing various projects in and around Zurich and Freiburg published in Innovation Review last year\(^{21}\); sometimes meeting all power needs on site and sometimes meeting particular needs such as the net annual power to run a heat pump. It may well be that the feed in tariff (FIT) will provide future scope for PV in at least some of these case studies, in such a way that it does not compromise existing architectural strengths. For example, Alfred Bramberger’s WIST students’ residence might benefit from a canopy of PV over its roof garden.
The other point to come out of this brief study of a number of 'environmental siedlungs’ built over the last three decades, excluding the last case study at Dieselweg, is that the argument for upgrading will be harder in terms of cost-benefit.

Not only is the starting position one of affordable comfort, but also the possible upgrades such as window or plant replacement will be relatively expensive. In this regard, the costs for Dieselweg are illuminating. For example the average renovation costs for all phases was €816 Euros/m² (net floor area after retrofit) or €862 Euros/m² (net floor area before retrofit). This makes a reasonably strong case for retrofit rather than demolition and rebuild, and there are clearly social benefits from maintaining the status quo of location, while greatly improving comfort and lowering running costs. On the other hand, there are aspects of the layout in some of the houses that remain far from ideal post-retrofit. For example, a kitchen in the oldest 1952 block are rather small in terms of accommodating modern needs, even for one-bedroom flat; and cross-circulation through one room, assumed to be a bedroom to reach another bedroom in the case of two of the flats per floor in Phase 1 is hardly convenient.

Overall each of the six case studies discussed above has a distinct approach, even though there are certain missions in common. The most important of the latter is a high ‘quality of life’ for affordable housing. It is also evident that all six projects tick the social, environmental and economic (or people, place and prosperity) boxes of sustainability. It is only the proportional effort given to each aspect that varies in terms of architectural and engineering design and financial investment. For example, the social dimension in Szyszkwowitz Kowalski’s first housing project is particularly high, whilst energy efficiency is the prime criterion at Dieselweg, going well beyond that demanded by regulations, while very much in step with current European trends for Passivhaus standards and beyond.

References

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