INNOVATION REVIEW

ISSUE 9, December 2011

SUSTAINABLE BUILDING DESIGN AND REFURBISHMENT IN SCOTLAND

ECO-WAND COMFOMETER
ANDERSON BELL CHRISTIE
KRAFT ARCHITECTURE
KINGDOM HOUSING ASSOCIATION
CONTENTS

ABOUT CIC START ONLINE 4
EDITORIAL 5
COMPETITIONS
  Awards at the 7th round and next submission date 6-7
NEW VIDEOS
  Optimisation of economic, environmental and energy savings in buildings 8
  Synergy of Fabric and Energy Conservation in Older Historic Properties 9
FORTHCOMING EVENTS
  Testing of a method for insulation of masonry and lath walls in Existing Domestic Scottish Construction 10
  Other webinars 11
  Live conferences 12
  Sponsorship and exhibition opportunities 3
SUPPORT
  Talent Bank 14-15
INNOVATIONS
  Eco-wand ComfoMeter 16-20
BEST PRACTICE
  Anderson Bell + Christie 21-27
  Kraft Architecture 28-38
  Kingdom Housing Association 39-45
RESEARCH
  Interactive simulation and visualisation platform 46-48
  Exploring the adoption of low carbon technologies by Scottish housing associations 49
  Architectural Design Principles and Processes for Sustainability 50-58
ENGAGEMENT
  Wishing you a Happy New Year!
CONTENTS

Cross Laminated Timber Construction in Scotland
Anderson Bell Christie Architects
More on pages 21-27

Fife Innovation Terrace
Kraft Architecture
More on pages 28-38

A Scottish innovation of 2011
More on pages 16-20

The Kingdom House
Kingdom Housing Association
More on pages 39-45

Interactive simulation and visualisation platform
University of Abertay
More on pages 46-48
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 to access the registration page at the project website [www.cicstart.org](http://www.cicstart.org)
As the membership of CIC Start Online is continuously growing, we expect to welcome the 1,000th member before the start of 2012. The above figures also show the growing number of viewings of our webinars and videos.

The independent Assessment Panel has approved four applications for feasibility studies and one for academic consultancy submitted in November 2011 (page 6). The next submission deadline is 9th December (page 7). Two more video recordings of webinars have been published on our website (page 8).

Dates of forthcoming webinars have currently been set up until April 2012 (pages 13 and 14). We are also planning seven live conferences whose titles and dates are published on page 12.

An article by Energy and Utility Skills provides information on a new project that aims to support skills development across the United Kingdom (pages 14 and 15).

An innovative device for measuring temperature and humidity by Kyle Electronic Design Ltd, a member of CIC Start Online, has recently been named as the Sustainable Product of the year 2011 by Heating and Ventilation Review (pages 16-20).

The Best Practice section includes projects by Anderson, Bell and Christie Architects (pages 21-27), Kraft Architecture (pages 28-38) and Kingdom Housing Association (pages 40-45).

Information on an interactive simulation and visualisation platform developed at the University of Abertay is provided on pages 46-48 and on the paper on a feasibility study undertaken through CIC Start Online published in International Journal of Low-Carbon Technologies on page 49.

The paper on Architectural Design Principles and Processes for Sustainability (pages 50-58) is related to the video presented at our online conference in June 2011.

We look forward to welcoming you at our forthcoming webinars and live conference and wish you a successful and a more sustainable 2012!

Kind regards,

Branka
APPROVED APPLICATIONS
SUBMITTED BY 15TH DECEMBER 2011

FEASIBILITY STUDIES

1. **Co-heating test for Alternative Refurbishment Strategy on `Hard to treat` House on Uist**, Glasgow Caledonian University and Locate Architects

2. **Achieving Higher Heat Pump COP through the use of roof-top thermal solar collectors**, Edinburgh Napier University and European Energy Centre

3. **Monitoring building fabric and internal environmental behaviour of a recently insulated historic building**, Robert Gordon University and Kishorn Developments Ltd

4. **Examining the performance of a balanced mechanical ventilation with heat recovery system as an extractor of roof-integrated PV heated air applied to Scottish zero-energy affordable housing**, Glasgow School of Art and Sigma EPD Ltd

ACADEMIC CONSULTANCY

1. **Life cycle analysis of PVC windows**, Glasgow Caledonian University and CMS Enviro Systems
CALL FOR APPLICATIONS FOR FEASIBILITY STUDIES AND ACADEMIC CONSULTANCIES

Submission deadline: 9 December 2011

- 14 awards for feasibility studies (up to £5,000 each)
- 2 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 at www.cicstart.org. You can also watch a video on ‘How to Apply?’ at the same pages.

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

branka@cicstart.org.

We look forward to receiving your applications!
Optimisation of economic, environmental and energy savings in buildings

Dr Aymeric Girard (Environmental Consultant) and Douglas Prentice (GeoCapita Ltd)
Synergy of Fabric and Energy Conservation in Older Historic Properties

Dr Julio Bros-Williamson (Edinburgh Napier University), Cameron Purdie (The Morrison Partnership)
Testing of a method for insulation of masonry and lath walls in Existing Domestic Scottish Construction

Seminar and webinar on Friday, 13th January 2012

Summary
The main aim of this research project is to develop and test the feasibility of a method of insulating an existing historic listed building whilst maintaining its original architectural features. The success of the project is conditioned by the avoidance of any damage of the inner lath plaster wall leaf.

The application of the feasibility study involved a trial off site to make sure the process won't bring any harm to the building. Despite these precautions, alterations of the method took place during the trial due to onsite discoveries related to the building's age and condition.

Speakers
Dr Amar Bennadji
Lecturer at Robert Gordon University since 2002. Founding member of IDEAS "Innovation DEsign And Sustainability" Research Institute. Amar's research interests relate to sustainability in general and energy conservation in particular. This project that merges historic and energy values as a result of studies that he undertook. Amar has an MSc in Civilisations and an MSc in Bioclimatic Architecture.

Michael Levie, Craigie Levie
<table>
<thead>
<tr>
<th>Date</th>
<th>Title</th>
<th>Speakers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thu 26th Jan</td>
<td>Benefits and options for the retrofit of an 18th Century traditional Scottish House using the PassivHaus standard</td>
<td>Julio Bros Williamson (Edinburgh Napier University) and John Stephen (SA Estates)</td>
</tr>
<tr>
<td>Thu 9th Feb</td>
<td>Feasibility Study into Energy Efficiency Improvements in Tenements</td>
<td>Julio Bros Williamson (Edinburgh Napier University) and Gavin Young (Lanarkshire Housing Association)</td>
</tr>
<tr>
<td>Thu 16th Feb</td>
<td>Environmental Design Teaching Model</td>
<td>Ola Oduku (University of Edinburgh) and Ruth Kerrigan (IES Ltd)</td>
</tr>
<tr>
<td>Thu 23rd Feb</td>
<td>Implications of installation of Solar Photovoltaic Panels on Properties of Fairfield Housing Co-operative</td>
<td>Anila Ahmed (Fairfield Housing Association), Masa Noguchi (Glasgow School of Art) and Tariq Muneer (Edinburgh Napier University)</td>
</tr>
<tr>
<td>Thu 8th March</td>
<td>Energy efficiency retrofit cost-benefit calculator</td>
<td>David Jenkins (Heriot Watt University) and Stuart Hay (Changeworks)</td>
</tr>
<tr>
<td>Wed 14th Mar</td>
<td>Retrofitting of Solar PV in Housing stock (Malcolm Homes)</td>
<td>Julio Bros-Williamson (Edinburgh Napier University; Michael Hui (Malcolm Homes Ltd)</td>
</tr>
<tr>
<td>Wed 28th Mar</td>
<td>Solar PV Feasibility Project (Easthall Park)</td>
<td>Julio Bros-Williamson (Edinburgh Napier University) and John McMorrow (Easthall Park Housing Co-operative Ltd)</td>
</tr>
<tr>
<td>Thu 29th March</td>
<td>Developing Homegrown Natural Fibre Insulation Products</td>
<td>Paul Baker (Glasgow Caledonian University) and Bruce Newlands (Kraft Architecture)</td>
</tr>
</tbody>
</table>

Online booking at www.cicstart.org
FORTHCOMING LIVE CONFERENCES

CIC Start Online is preparing a series of high profile conferences on various themes of importance to planning and designing of new buildings and refurbishing of the existing building stock. They will be hosted by the universities who are the project partners. Speakers will be international and national experts, academics and practitioners. Conferences planned to date are listed below.

<table>
<thead>
<tr>
<th>Date</th>
<th>Title, hosting institutions and partners</th>
</tr>
</thead>
</table>
| Thu 2nd Feb   | Build Tight, Ventilate Right  
at the Glasgow School of Art                                                     |
| Wed 29th Feb  | The Green Deal and Sustainable Refurbishment of Traditional Buildings  
a joint conference with Historic Scotland at Glasgow Caledonian University    |
| Fri 30th Mar  | Informing Visions of Innovative Regional Sustainable Construction Development  
at the Robert Gordon University                                                 |
| Wed 18th Apr  | Micro-renewables for Buildings and Transport: Deliverables and Barriers  
at Edinburgh Napier University                                                 |
| Wed 9th May   | Beyond Carbon for Sustainable Housing  
at the University of Edinburgh                                                   |

Online booking at www.cicstart.org
EXHIBITING AT OUR CONFERENCES

As part of our series of whole-day conferences, we are offering companies the opportunity to exhibit and promote products and services related to sustainable building design and refurbishment.

When attending the conference, you can bring your company marketing material and exhibition stands – providing an ideal opportunity to meet new clients and build new business relationships with those in the industry.

You can exhibit at our conferences for only £100
The exhibition fee is in addition to the delegate fee, and is priced per conference.

For more information on what we can provide, please contact us. Due to limited space available, please book early to take advantage of this excellent offer.

SPONSORING A CONFERENCE

We are also offering sponsorship opportunities for our whole-day conferences. Your business or organisation will:

- Be included in all marketing, both print and digital;
  - printed conference programme
  - monthly e-newsletter
  - quarterly online magazine Innovation Review
- Have the opportunity to speak for 15 minutes
- Exhibit with their company stand and marketing material

We are offering both partial and exclusive sponsorship options; please contact us.

CONTACT US

Please contact Craig Bishop at cbishop@cicstart.org or on + 44 (0)141 273 1401
Talent Bank – the effective way to recruit and train your future workforce

Andrea Allison
Energy and Utility Skills

Energy & Utility Skills (EU Skills) the Sector Skills Council for the gas, power, waste management and water industries – has worked extensively with employers over the last three years to understand the scale and nature of the skills challenges facing the sector. All evidence points towards a critical skills shortage across engineering and technical skill sets emerging within the next 15 years.

The gas, power, waste management and water industries have an ageing workforce profile whilst at the same time experiencing growth through significant capital expenditure programmes, in particular, new technologies. EU Skills’ Workforce Planning Model and other sector intelligence estimate that there are requirements to recruit and train over 30,000 staff over the next five years. This number could probably be doubled if the supply chain is taken into account.

However - despite the compelling evidence - the sector as a whole is still not investing sufficiently in skills and talent pipe development, with likely outcomes being salary inflation and the need to buy expertise from abroad in order to maintain safe levels of competence within the workforce.

So what is preventing investment?

Employers – particularly smaller organisations within the supply chain – face multiple barriers which make the levels of workforce renewal activity we require increasingly difficult to achieve in the current economic climate. These barriers include:

- **A lack of suitable training provision** – employers often require highly specialised training in low volumes, meaning buying power and choice is severely limited.

- **High risk recruitment** – in industries where short term contracting arrangements are the norm, longer term investment in quality training and apprenticeship programmes is not always viable.

- **Regulation** – employers subject to price control reviews are often unable to carry significant numbers of non-productive staff (i.e. those in training) on their headcount).

- **Cost and bureaucracy** - for smaller organisations in particular the support and pastoral care required by apprentices or graduates, breadth of work placements and additional paperwork incurred are too costly.

**Talent Bank – the solution**

EU Skills has worked closely with employers to understand how these barriers need to be overcome and have arrived at an exciting and ground breaking solution for the sector – Talent Bank.
Utilising the Government’s Growth and Innovation Fund (GIF) to support start-up costs, Talent Bank will be managed and administered by EU Skills and is designed to minimise and spread the risk associated with medium to long-term investment in workforce development, ensure our industries and local communities can capitalise on the rapid growth expected in Renewable Energy and new technologies, and create high quality industry endorsed training programmes giving both learners and employers greater choice whilst driving down costs.

Broadly based upon a Group Training Association (GTA) model, Talent Bank will use an innovative commercial model to deliver solutions supporting skills development at all levels across the four nations, with a particular focus on ensuring the supply chain can benefit from the opportunities on offer. Talent Bank will provide the following range of services:

**Partnership Service:** Talent Bank will identify and pool demand for training outcomes (including Apprenticeships), then broker collaborative arrangements between cohorts of employers to fund trainee costs and share the risk of recruitment.

**Recruitment Service:** Talent Bank will drive down the costs associated with wide scale recruitment whilst ensuring all participating employers have access to high calibre candidates. This will be achieved by: a) harnessing best practice from across the sector to design, implement and manage robust assessment centres and associated materials; b) providing a centralised application processing service relieving organisations of time consuming administration; and c) creating sector attractiveness marketing campaigns based on industry specific value propositions.

**Employment Service:** Carrying unproductive trainees on headcount can be prohibitive for employers, particularly in high risk recruitment scenarios (for example, where contracts are yet to be allocated). This can prevent investment in much needed trainees. To overcome this, Talent Bank will have the capability to act as the direct employer of trainees until successful completion of their training.

**Learner Management Service:** Talent Bank will provide each trainee with a Learner Manager responsible for coordinating their learning plan and managing work placements. Additionally we will offer pastoral care designed to enhance trainees experience, provide support and guidance, a HR service and ensure that opportunities to maximise employability skills are taken.

**Education and Skills Provider (ESP) Management Service:** Talent Bank will source and manage training provision contracts on behalf of employers; negotiate best prices; ensure non-accredited provision is fit-for-purpose and meets industry standards. Talent Bank will ensure all Education and Skills Providers complete EU Skills’ Quality Assurance and Recognition of Learning Programmes accreditation to ensure they are both a high quality provider and deliver courses in an industry specific and contextualised way.

The initial target is that Talent Bank will support 400 new Apprenticeship places and the training of 400 higher level learners by 2015. The sector requires a minimum of 32,000 new entrants into the sector by 2016 and the Talent Bank is seen as a key vehicle to driving this growth. Additionally, Talent Bank will be able to support employers in attracting graduates, facilitating placement and sponsorship programmes and providing up-skillling opportunities for existing staff.

Effective engagement with ESPs – across both Higher and Further Education - will be a critical element of the project’s development. We will work with our existing networks and seek to develop these further in order to develop the range and quality of provision needed in order for our industries to meet the challenges ahead. Importantly, Talent Bank will seek to stimulate and aggregate demand, making cohort sizes viable for specialist provision and enabling providers to engage with more employers, particularly SMEs.

Our employers see the Talent Bank as a vehicle to collaboratively overcome future skills demands that they cannot resolve as individual companies. We have received support from across the energy and utilities sector with major companies such as; E.ON, National Grid, Scottish Power, Severn Trent and Viridor being supporters of this Talent Bank.

Tim Balcon, Chief Executive of EU Skills states: “Receiving the funding to develop this Talent Bank will have a very positive impact on the energy and utilities sector. Without a resource efficient gas, power, waste management and water sector the economy, and indeed society cannot effectively function. Employers are very clear that the Talent Bank addresses issues that are common to the sector and cannot be solved by individual companies alone.”

Currently in the development phase, Talent Bank will start its first cohort of learners in September 2012. For further information, please contact Richard.johnson@euskills.co.uk or angela.edwards@euskills.co.uk.
Eco-wand ComfoMeter – Heating and Ventilation Review’s Sustainable Product of the Year 2011

Alex Gardiner, Kyle Electronic Design Ltd

"Eco-wand ComfoMeter - Although it doesn't save energy, this product uses a computer display to show building occupants where savings can be made and advises on steps to reduce energy usage without sacrificing comfort. Praised for its simplicity, creativity and effectiveness, the inexpensive instrument allows easy investigation of a building’s performance and will help educate the occupants about how to achieve effective energy management. The judges praised this clever piece of kit for its ease of use, usefulness and the contribution it could make to energy and cost savings” … Judges Citation*

Just what is the ComfoMeter?

The ComfoMeter itself is a low cost USB module that measures temperature and humidity. Plugged into a PC it becomes a powerful energy saving tool. The overall system is shown in Figure 1.

Why is it needed?

While heating and ventilation engineers understand the concept of Comfort Zone, the average office worker and home owner does not. We all know when we are comfortable and we know how to achieve it – turn the heating up – but we have little understanding of the relationship between comfort, the factors that effect comfort and the economies of comfort.

Some Examples

A neighbour had his house insulated recently and, since he thinks he now has a low loss house, has turned his thermostat to 25°C and leaves it there all year round – this is in a suburb of Glasgow where it got down to -18°C during the last two winters.

A local Estate Agent has a corner site with big plate glass windows on two sides. On the coldest day last winter, the staff were sitting inside in their shirt sleeves.

A car showroom I was in was the same – big window, staff in their shirt sleeves. As well as bad energy management, this was bad customer relations as, within minutes I was lashing with sweat being dressed for the conditions outside.

In a meeting room in an office complex in an industrial estate, the temperature on the conference table was cycling between 20.5 and 22°C as might be expected with the thermostat set to 21°C. At our feet, the temperature was 15°C – bad circulation.

In a University teaching laboratory, there was a 3°C difference between a seat at the window and one at the other end of the room.

I was pitching for an award in an accountant’s office last winter. All the judges were sitting in shirt sleeves.

One major UK company I was at directs that all thermostats be set to 21°C, another that 19°C should be the setting.

These are personal experiences in and around Glasgow. Almost everywhere I go I find examples of poor heating systems or uneconomic heating practice.

None of the householders or office managers seems to have any idea on how to be comfortable economically. The ComfoMeter tells them how to.

Personal comfort in the home and office

In the 1960’s the average temperature of a house was 12°C, it is now 18°C. Our expectations are much more nowadays but these expectations are based on experience when energy was cheap and the global warming and energy cost crises had not been foreseen.
Figure 2. Comfort Zone

So, what contributes to our feeling of comfort and how does it impact economically? Figure 2 shows a typical Comfort Zone, this one is for somebody wearing medium clothing – suit for a man – and still airflow.

At the measured humidity, the lowest comfortable temperature, i.e. the one requiring least energy to achieve, is 20.2°C. The measured temperature is in fact 21.8°C, so the room is 1.6°C too hot.

The advice given is to turn the thermostat down to the ideal level which will save quite a lot. But the system has also been told that the occupier is wearing medium clothing so advises that more energy will be saved if more clothes were put on. In fact, with heavy clothing and still air, the ideal comes down to 18.9°C and with very heavy clothing it comes down to 17.5°C.

So, if you follow the advice, you can become energy efficient without being uncomfortable. Incidentally, the ideal temperature for someone in shirt sleeves is 21.5°C, i.e. allowing the thermostat to be reduced by 2.6°C by putting on heavier clothing.
In all, to cover the range of clothing and airflow in both heating and cooling situations, the eco-wand software can produce 25 different comfort zones and, to cater for differences between people, there is also a personal adjustment available.

The Comfort Zone is not the only display available. Figure 3 shows the Comfort Meter Display and Figure 4 the History Display.

**Figure 3 – Comfort Meter**

The Comfort Meter shows the current measurements with the Comfort range for the current humidity shown in green. Other features shown are Hi/Lo limits on each channel with optional e-mail alerts, min/max markers and Dew Point display. Not shown is the Heat Stress warnings which only activate when the temperature is above 28°C.

**Figure 4 – History Chart**

The History Chart shows what has been happening. Sampling can run at 3 rates giving histories over 8 hours, 2 days or 8 days. If left to run over a day, the householder can use the history to optimise the timer settings of a heating system and to assess the effectiveness of the building’s insulation.

Using the ComfoMeter system, householders and office managers can live and work at the most economically comfortable temperature for the conditions.
Monitoring Performance in Commercial Properties

From the examples I have given, almost everywhere I go I seem to find examples of poor heating systems or uneconomic heating practice. Mostly these have been in commercial properties.

The comfort of the staff is important as an uncomfortable staff is an inefficient staff but an overheated room is wasting energy, money and carbon.

Whether or not there is a building management system in place, management need to monitor the micro-climate to resolve disputes, to check the performance of the heating/cooling system or to see where the energy is going.

To help management monitor the micro-climate, there is an additional function of the eco-wand system – Data Logging. Any desk with a computer becomes a monitoring station that can be set up in minutes and starts giving information instantly. Data can be logged locally or centrally.

A useful energy saving tool for domestic and commercial use.

The ComfoMeter has been designed as a low cost (£29.99 + VAT) tool to help building managers, office managers, office staff and householders reduce their energy bills and learn the relationship between comfort and economy.

Contact: Alex Gardiner
    T: 0141 584 9445
    E: abg@eco-wand.com
Cross Laminated Timber Construction in Scotland

Stephen Miles and Jonathan McQuillan
Anderson Bell + Christie

Mass timber construction (specifically Cross Laminated Timber or CLT) is a relatively new system to the UK construction industry. It has been adopted on a large scale in southern England for use on projects from schools to 10-storey apartment blocks.

A CLT panel is formed from layered timber sections. The grain in each layer runs perpendicular to the next. The arrangement becomes a panel when it is treated with a resin and high pressure to bond it together. Effectively CLT is a very large sheet of plywood.

For Architects CLT is an exciting material; it presents a host of design opportunities. The large panel sizes and its inherent structural capacity allow large spans and cantilevers to be achieved if applied intelligently. The monolithic nature of the panel allows freeform shapes to be cut out of the panel without the need for lintels and secondary structural items. In essence it is like building an architectural model from card, it is a liberating and joyful experience.

CLT also has a wide range of technical benefits. Its success in southern England is largely due to its potential to provide similar qualities to masonry construction. The main difference is time, as projects can be erected significantly faster than a comparable masonry build as there are no wet trades. The CLT panels provide excellent acoustic properties as well as inherent thermal mass and fire protection. The panels are fabricated off-site to exact requirements and are delivered in sections optimised to road haulage efficiencies.

The uptake of the system in Scotland to date has been limited. This is perhaps due to two main factors. Firstly panels are produced in mainland Europe. So whilst southern England is relatively accessible to the European market the additional road mileage to Scotland adds cost to the product.

The other is our heritage of timber frame building. Mass timber will not be compared to masonry construction in Scotland, its direct comparator is lightweight frame technology.

This type of lightweight construction at present offers similar levels of speed and is fully compliant with current building standards.

There will be a cost increase on Scottish lightweight timber frame, so mass timber does not appear to be threatening its arrival in the Scottish market. So what makes it of interest to the Scottish construction industry and why are demonstration projects required?
Changing building standards legislation is a major driver for innovative construction systems. The Scottish Government has a target for all new buildings to achieve net zero carbon by 2016. This represents a massive step change for the industry and requires a new way of thinking about construction. Timber frame construction in its current guise has a limited shelf life and manufacturers are researching alternative solutions.

Adapting lightweight construction to suit upcoming legislation requires significant number of additional components and materials. This in turn increases the number of operations in a build and places greater reliance on the quality of workmanship.

The simplicity and accuracy of CLT detailing generates very airtight buildings with minimal effort. This omits the need for additional gaskets, membranes, tapes and mastic. In turn this simplifies the build and allows greater consistency in construction.

The depth of the CLT panels also creates a large amount of thermal mass within the building. When insulation is applied externally a “tea cosy effect” is created that locks heat or coolth into the CLT panels. This assists in regulating the indoor temperature.

Finally CLT panels have a large quantity of embodied carbon that will become a significant factor in achieving net zero carbon. A typical CLT constructed dwelling contains 30-40m³ of timber, equivalent to around 32 tonnes of CO₂.

CASE STUDY: Raploch Road

Raploch Road is currently on site, being constructed by Cruden Homes East, based in Edinburgh and is due for completion in February 2012.

Anderson bell + Christie Architects commissioned by Raploch URC – an urban regeneration company, were given a brief to design a new innovative mixed use development following the clients recent study trip to Freiburg. The project is being funded by the Town Centre Regeneration Fund.

A further case study is currently being prepared, alongside a microsite by SUST, for publication in Spring 2012. The key agenda is to look in detail at the specific challenges in designing and constructed low carbon developments with reference to current legislation, technology and local skillsets.

Raploch Road is a purpose-built "towards zero carbon" mixed use development, comprising of commercial shop units at the ground floor with residential accommodation above. This is intended as a "car free" development which takes advantage of its location at the heart of the new Raploch village centre. The new shop units sit at the back of an existing pavement, helping to frame and shape the adjacent public space.
The Sullivan report, which was commissioned by the Scottish Government to review the carbon efficiency of the building industry in Scotland suggested that the 2010 building regulation’s Section 6 (energy performance and carbon dioxide emissions) requirements should demand a 30% reduction in Carbon as calculated against the 2007 regulations. Our proposals as currently designed are targeted towards 60% reduction which is towards the suggested 2013 standard.

The proposals consist of commercial shop units at the ground floor with residential accommodation above. The development will be clad in Zinc at the upper level residential units, and will utilise rainscreen cladding to the lower levels. It is intended as a “car free” development which takes advantage of its location at the heart of the new Raploch village centre. The new shop units sit at the back of an existing pavement, helping to frame and shape the adjacent public space.

From the very outset, Anderson bell and Christie adopted a ‘fabric-first’ approach to the design. It was important that given the nature of the client and the tenant that the innovation of the project was simple and holistically integrated.

Our recent experience in massive timber design from the BRE proposals – particularly looking at CLT (Cross Laminated Timber) again informed the ‘fabric first’ proposals. The CLT that we have utilised was manufactured by Storaenso in a bespoke factory in Austria using European spruce. CLT has a huge number of inherent properties which are innovative yet simple. The CLT has been designed to be left exposed within the living areas of the three apartments. A higher quality fair-faced finish was applied.

Using CLT allowed us to resolve a number of challenges that arose during the design, statutory approvals and construction. A few of the key properties are:-

**Air-tightness** – Due to the ‘massive’ nature of the timber with cross-lattice lamellas, and simple construction jointing we expect the timber structure to achieve an air tightness value of around $< 0.05 \text{ m}^3/\text{h.m}^2 @ 50\text{pa}$. This is hugely more efficient than currently required within the technical standards. This informed the SAP results and LZCT (Low or Zero Carbon Technologies) design.
Structure - The CLT frame, has great ability to create large spans and free cut opening due to the nature of the cross lamination. Each panel acts compositely as both a column and a beam. The removal of other ancillary items such and lintels, trimming and any allowance for shrinkage simplifies the design, and partners with precision off-site manufacture for true lean construction. The building is easily erected with wall panels being built directly from a slab level, with floors being sat directly on top. This simple style of building could be compared to building a “cardboard model”. This makes detailing interfaces much simpler, as the inherent structural capacity within the laminated panel allows freedom for creating openings.

Fire – The most onerous technical situation within the Scottish building standards is the conversation between non-domestic and domestic, and particularly relates to the specific term ‘non-combustible’. Through partnership with Napier's Wood Studio we were able to demonstrate that CLT when designed properly through use of Eurocode 5: Scottish Market.

Design of timber structures to demonstrate charring rates and structural integrity in fire. Anderson Bell Christie successfully challenged the sub-clauses within the technical standards and gained ministerial consent to construct the whole structure in timber, most importantly including the protected enclosure which is a key challenge when looking at the future of timber construction within the Scottish Market.

Thermal Mass – By calculating the ‘U-Values’ dynamically, understanding the ability of the CLT to trap and retain heat – we were able to efficiently design the wall assembly for the best performance.

Insulation and assembly – By insulating externally we were able to completely remove repetitive thermal bridges through the wall assembly, which aided greatly the energy performance of the building. The ability of the CLT to also act internally as a moisture buffer is exploited by removing all ancillary ‘plastic wraps’ such as VCL (Vapour control layers) and Breather Membranes. CLT has the ability to aid regulation of seasonal variation of indoor humidity which was tested using Wu-fi dynamic calculation methods.
**Carbon Capture** – At 587m² Raploch’s CLT frame effectively captures approximately 141 tonnes of Carbon from the atmosphere. Whilst not yet recognised under the technical standards – SAP ‘A’ rated development will have an annual carbon footprint of approximately 2 tonnes. This effectively means that Raploch Road could be classified as a true ‘Carbon Neutral’ building for the first 70 years of its lifecycle when compared against non-timber construction methods.

**Off Site Manufacturing** – Due to the high level of precision design, undertaken by Eurban Timber engineers, the timber frame which was manufactured in Austria, the site construction time was massively reduced over more common building methods in Scotland such as traditional masonry or timber frame. The whole CLT structure was erected, air tight and water tight in 8 working shifts – with some panels as long as 15m being lifted directly from the lorry to an elevation. The ability to construct quickly greatly reduces site management fees and preliminaries, as well as reduces human error building key construction details. Where the CLT is being exposed internally, services routes and locations were factory routed into the structure before it arrived on site.

In essence, the CLT has been designed to perform a number of functions, it is a weathering line, a structure, and regulator and fire stop as well as being a natural carbon sink. Although typically more expensive than more common construction types in Scotland – when balanced against lifecycle energy performance, holistic performance and rapid construction it is much more readily comparable. The whole CLT structure is easily demountable and fully recyclable.

**Services and LZCT’s** - In order to achieve the brief, a passive approach was taken when considering the building service strategy. Reducing consumption before trying to offset it with renewable energy was key. Natural ventilation and a high daylight factor were a focus. Detailed comfort calculations were carried out to assess the viability of natural ventilation. The external walls were constructed to specifications which are recognised for their advantages in terms of sound absorption and transmission, air-tightness and thermal conductivity.

With the high levels of air-tightness and low u-values heating demand is minimised. When heating or hot water is required it will be supplied by solar thermal panels and an air source heat pump. The heat pumps extract latent heat from the air. This system has been designed to heat the apartments even on the coldest days of the year. The heat pumps can have an efficiency of 300%. This means that for every one unit of electrical energy 3 units of heat energy can be produced. The result is less primary fuel consumption and reduced CO₂ emissions. No chimneys, fuel tanks or gas connections are required. Its main components are a roof mounted solar panel, an outdoor unit and an indoor storage cylinder.

The indoor cylinder is then connected to low temperature radiators which are connected to sensors in the various spaces to control the room temperature to the occupants requirements. These controls allow for more flexible and responsive room heating so the desired amount of room heating can be delivered when and where it’s wanted. This system therefore is low energy, low carbon and low cost.
The ventilation of spaces was provided by natural ventilation where possible. Natural ventilation provides a low cost, passive approach to fresh air supply. In the commercial units in the summer months the fresh air will leave through the high level grilles connected to the roof openings. These natural ventilation shafts can be opened and closed as required.

The bathrooms have heat recovery fans. These fans extract the air from the space. This air is passed over a heat exchanger then extracted to the outside air. This warm air heats the exchanger. The incoming air passes over this heat exchanger thus supplying warm fresh air into the bathrooms subsequently reducing the heat demand in the space.

A Building monitoring system was also specified to allow users the opportunity to control the heating system thereby giving occupants a chance to understand their energy system and allow them the chance to fine tune it to their needs and requirements.

**Value:** £0.75m  
**Completion date:** February 2012  
**Architect:** Anderson Bell Christie Architects  
Stephen Miles, Karen Anderson, Jonathan McQuillan  
**Client and CA:** Raploch URC, Kevin Braidwood  
**Main Contractor:** Cruden Homes East  
**Structural Engineer:** Roy Easton Company  
**Timber Engineer:** Eurban  
**M+E Engineer:** ARUP  
**QS:** Keegans Group
Conclusion

These case studies serve to highlight the benefits and introduce the Scottish construction industry to CLT. However this is only part of the story. To understand the true potential of CLT in Scotland it is important to understand why CLT was first made. On the continent CLT was first derived as an innovative way of using offcuts from the sawmilling industries. The layering and bonding process creates a panel whose collective strength is greater than that of its component parts. On the continent CLT is a very cost effective building material as it is close to source. It is widely used and there is a well established industry that is rapidly evolving the technology.

In Scotland a similar situation could exist. Scotland’s forests are largely populated by trees which are fast growing and produce low structural grade timber. This timber is largely felled for use as paper pulp, fencing and transportation pallets.

In 2009 Scottish woods value share of the UK market was only 5.1% (FCS SFS Progress Indicators 2011). Scottish forestry is a substantially under exploited resource.

If Scottish timbers could be used to form a CLT panel then there is a potential competitor to lightweight frame construction as well as European imports. This would allow an industry to be created in Scotland which could generate jobs, infrastructure and additional revenue from our natural resources. We are excited by this prospect and are keen to see the Scottish construction industry realise CLT as a solution to the challenge of 2016 building standards.
The Art of Building

Bruce Newlands
Dip Arch (Aberdeen) RIBA ARIAS FRSA

Bruce Newlands studied at The Scott Sutherland School of Architecture and at the Illinois Institute of Technology, Chicago. His work also includes Phase F of the Crown Street Regeneration Project, small sustainable rural housing developments, a Primary School for Children with Moderate Learning Difficulties and a Turning Point Rehabilitation Unit in Glasgow. Bruce also teaches on a part-time basis at The Scott Sutherland School, Aberdeen and is a visiting critic at The Architecture Department, Northumbria University.

Kraft

Kraft was established a little over three years as an attempt to explore & practice within the space between academia, engineering, product development and architecture.

A wide & perhaps unusual brief for an architectural practice but one that we've found has thrown up many overlaps and exciting new trajectories into other fields.

The practice’s ethos aligns closely with Alvar Aalto’s sentiments on the art of building.

“…Building art is a synthesis of life in materialised form. We should try to bring it under the same hat, not a splintered way of thinking, but all in harmony together....”

We aim to produce elegant practical design that occasionally delights. For the past three years our research & product development activities in conjunction with a wide range of collaborators has taken the office in a variety of directions, introducing new layers of understanding that are perhaps unusual to mainstream architectural practice.

In this article, we hope to give an overview of our modus operandi by briefly discussing a range of ‘projects’ that are currently live including sustainable product development, design for manufacture, designing for zero carbon and developing post occupancy evaluation are being tackled by Kraft through practice.

For the initial case study we’ve looked at a component that architects specify routinely in almost every project, namely insulation. It’s a generic component that is increasingly critical in achieving a ‘fabric first’ approach to building envelope design not just in terms of thermal insulation but also in terms of vapour diffusion, heat capacity and the embodied energy of the material itself which can account for up to a metric ton of material in every typical two up two down house.
1. Thermobond

We wanted to develop an insulation product that maximises the ‘reduce, reuse and recycle’ agenda whilst competing on price with mineral fibre market leaders. We were targeting both new build off site timber frame manufacturers and public sector retrofit of older ‘breathable’ buildings.

The technical challenge we faced was how to ensure that insulation, a key component in all lightweight new-build building fabric and increasingly the first component of both public sector and private sector retrofit work can meet and surpass the performance requirements of emerging markets created by current & forthcoming carbon target legislation.

A nine month research programme was undertaken with the assistance of a Scottish Enterprise SMART Award, CIC Start Online Consultancy and Dr Paul Baker at Caledonian University we embarked on a programme of research and development of a natural fibre insulation that utilises waste fibre streams.

Waste fibres were identified as a key component as SEPA estimates the volume produced annually in Scotland is around 40,000 tonnes alone, utilising this for the purposes of insulation would not only close the waste loops but given that the fibres are largely natural wools, cottons etc, would also create a building insulation that was non-irritant and hydroscopic.

Initial work was undertaken to establish links with sources of waste fibre ranging from wool mills to social enterprises dealing with recycling. After finding reliable sources, a review of available processes and production was undertaken and two European partners identified who supply machinery capable of producing the quality of product required. There are two UK production lines but both have limited capacity, output formats and technical flexibility for trialling new products, we also went to Europe to avoid any commercial conflict with the existing UK producers of natural fibre insulation and because one of the commercialisation goals was and is to establish a production line for these products in Scotland, none currently exist.

We undertook some initial trials using Scottish waste wool at various densities and blends, thermal conductivity testing was then undertaken by Caledonian Universities Centre for Indoor Air Quality. This initial scoping identified that a thermal performance of between 0.030-0.035 W/mk was achievable and technically feasible.

This work informed a further small trial production run of 1 metric ton of material at a specific density and blend which was then submitted for thermal conductivity testing at the UKAS Accredited BBA Laboratories in Watford. The Heat Flow Method of ISO 8301: 1991 and BS EN 12667 : 2001 using the BBA single specimen symmetric test facility designated K4 was used. An independently heated zone at the perimeter of each plate provided the edge guarding and apparatus wall temperatures were controlled to match the mean specimen temperature. The specimen thickness was measured in accordance with BS EN 883.

These results confirmed a thermal conductivity at the higher end of the range 0.034 W/mk.

The next key objective was to determine the performance of the waste textile insulation when tested utilising the principles detailed in with BS 5803: Part 4: 1985 Section 2, Flammability Test and Section 3, Smouldering Resistance Test. When tested the combustion zone was not observed to extend to within 25mm of any part of the timber surround. The product, as tested, therefore complies with the requirements.

When tested to BS 5803: Part 4: 1985 Section 3, Smouldering Resistance Test, smouldering or flaming was not observed to extend to more than 150mm from the centre line of the cylindrical ignition source. The product, as tested, therefore complies with the requirements.
Fig 3. Initial Thermal Conductivity Test Results

Fig 4. Fire Testing

Fig 5. Moisture / Vapour Testing
Further testing in accordance with CUAP Edition June 2003, endorsed at 46th TB meeting: Factory made thermal insulation materials and/or acoustic insulation materials made of vegetable or animal fibres. Section 4.1.1.2 and Annex E, the samples showed little onset of corrosion and no perforation with copper but some corrosion with zinc.

This data will be further reviewed and will inform COSHA and fixing advice. Water Vapour Diffusion testing was also undertaken which confirmed the properties of the natural fibre insulation.

The key outcome of the work has been to prove the technical feasibility of the waste fibre specification, blends and manufacturing process.

We are now in discussion with a Glasgow based investor about establishing a small manufacturing line capable of producing 600 tonnes of insulation annually.

The establishment of a Scottish production line also enables further optimisation of the product through further testing and development of other fibres such as cellulose, wood fibre and other waste fibre streams.

We have identified the need to enhance the following characteristics of the natural fibre insulation product to help achieve the advanced performance requirements:

1. Trial additional fibres including cellulose, wood, cotton, PLA, polyester, feathers and coconut fibre.
2. Enhanced Specific Heat Capacity which has an role in reducing heating / cooling loads in lightweight construction by enhancing the buildings thermal mass.
3. Enhanced Thermal Conductivity to significantly improve upon industry wide performance, current testing indicates a performance of between 0.031-0.034 W/mk. The aim of the feasibility work in this area is to make an approximate 10% improvement to below 0.029 W/mk.
4. Enhanced Bi-Polymer binder like PLA (Polylactide Fibres) can significantly improve the energy used in the manufacturing process, leading to lower embodied energy & potentially achieving a ‘100% Recycled’ or ‘100% Natural Fibre’ product.
5. Enhanced FR by establishing an ecologically benign method of achieving the FR performance through the material characteristics itself and/or by introducing trace components of non-toxic materials into the production process. The existing product achieves basic fire resistance performance for use in timber frame buildings but this may be enhanced to allow for it's use in more demanding situations and as part of a ‘100% ecological specification’.

We are currently in discussion with Dr Mike Jarvis at Glasgow University and Dr John Liggat at Strathclyde University about a number of these issues going forward.
2. kII System

In tandem with the development of Thermobond, kraft embarked on the product development of structural components for a fully ‘homegrown’ timber superstructure system that could achieve a very low linear thermal bridging co-efficient whilst remaining suitable for closed panel off-site manufacture.

Our key technical objective was to demonstrate through test data the use of C16 Homegrown Timber through Eurocode 5 testing. Whilst also undertaking Thermal, Structural, Fire, Vapour Diffusion Testing to establish feasibility of system

We were also very conscious of the need for any system to be manufactured offsite to help reduce wasteage and achieve higher standards of construction tolerance, we decided to include a review of the system for compatibility with a local OSM Production Line.

The resulting kII project is a collaboration with Napier Universities Institute for Sustainable Construction, principally Dr Robert Hairstans and Kenny Leitch working closely with staff at the Scottish Building Performance Centre at Glenrothes and CCG (Scotland) Ltd.

Fig 8. Timber Frame Test Rig

Fig 9. BPAC Testing of kII Panels

Fig 10. Test Panel Failure Results
Our initial investigations focused on the performance of a low lambda soleplate connection for the kII closed panel wall system. A variety of details were quantified & tested with regard to strength and stiffness. This iterative process was extended to undertaking a series of racking tests using different sheathing including OSB, Woodfibre and Gypsum Fibreboard materials.

The behaviour of wall types under load was also determined and brittle failure mechanism identified. These results have been cross-correlated the draft method for racking design in Eurocode 5 and it has been identified that Engineers using this method would overestimate the racking capacity of these wall types. This is a fairly major finding which is invaluable for the specification of kII wall types in practice. Further racking tests on kII candidate wall types manufactured using ‘homegrown’ timber are now underway to further build the data set for live testing performance.

In tandem with this work we are also developing these approaches based on creating TEDDS software proforma in order to allow Structural Engineers to readily calculate racking resistance and soleplate capacity in accordance with the new Eurocode 5 method. Eurocode 5 had not yet been released and so the cross-correlation work being undertaken was ahead of the level at which the industry is typically currently operating at, effectively future proofing the system for 2013 onwards.
This work has resulted in a prototype product with patent pending on the key component named ‘thermostud’.

The thermal break incorporated in the stud uses no connecting components, resulting in zero repetitive thermal bridges in the wall assembly and contributes to very low linear thermal bridges when combined with the kII top and bottom rail components.

The kII system is being manufactured in one of the UKs largest and most sophisticated automated production lines for closed panel timber frame operated by CCG (OSM).

This will help eliminate the inherent inefficiencies and waste within standard construction practice but also deliver larger panels, quicker installation, higher tolerance with fewer follow-on trade interfaces leading to a potentially reduced construction period.

The first live demonstration of kII system will be on three terrace dwellings at the Fife Innovation Showcase project.

The system is currently being manufactured and erection is due to begin January 2012.

Find out more at www.futureaffordable.co.uk
3. Fife Innovation Showcase

Future Affordable is a collaborative project to deliver a sustainable & affordable housing system for the social rented & private market. The development of the system has involved Developers, Manufacturers, Architects, Academia & Material Suppliers working collaboratively to produce a housing system that supports these aims through the use of homegrown C16 timber, thermal mass, recycled materials, high thermal performance, excellent built quality and low to zero carbon emissions using appropriate innovative construction techniques that are readily adoptable by the house building sector.

The Fife Innovation Showcase will be the first demonstration of the future affordable concept.

Organised by Kingdom Housing Association the showcase aims to demonstrate off site manufacturing techniques and affordable house models that show incremental improvement in line with future regulations.

The design, orientation & layout of the housing itself is predetermined as part of the wider Oliver & Robb Architects masterplan for Dunelin Drive, Dunfermline but there is still a significant opportunity to demonstrate a number of technologies and building performance concepts.

Our terrace of three homes will demonstrate how to achieve 2013 Low Carbon & 2016 Zero Carbon whilst including a ‘control’ 2010 compliant house for comparison.

Our partnership is with Springfield Properties, Napier University, David Blaikie Architect, Living Solutions a local social enterprise sawmill and BSW Timber, supplier of the mainstay of home-grown timber.

C16 has been used for the kll external & internal walls but it has also been incorporated into the intermediate floor cassettes, which use a floor truss design and the 'room in the roof' attic roof trusses.

The use of home-grown timber, recycled materials & design for deconstruction ensures that the system is also very low in embodied carbon. David Blaikie Architect has designed prefabricated massive timber bathroom pods called e.Core, these lend thermal mass to the whole structure and provide a potential moisture buffer.

Together the systems should combine the best of both home-grown framing and massive timber construction.
The Future Affordable concept is aligned with Scottish Building Standards Section 7.

The system generally surpasses the UK Zero Carbon Hub definition for zero carbon fabric standards (FEE) and therefore meets the Section 7 fabric standards. Section 7 demands percentage onsite renewables, which the future affordable concept aims to demonstrate in an integrated way through the use of efficient but affordable technologies.

We are particularly interested in measuring the real impact of fabric standard and renewables on running costs for tenants.

Our initial SAP 2009 analysis using NHER Plan Assessor, which includes a crucial allowance for, unregulated energy usage to give a ‘whole house’ assessment suggests that by carefully balancing fabric performance with investment into integrated renewables, there may be an affordable route towards the zero carbon 2016 target.

When modelling total energy usage it is important to consider unregulated energy. The NHER assessment includes cooking and electrical appliances, the degree-day region, displaying energy usage, fuel running costs and carbon dioxide emissions per year broken down by usage.

Our projections are based on actual market tariffs.

---

2010 ‘Bronze’
£400 Annual Cost

2013 ‘Silver Active’
£200 GBP Annual Cost + Feed in Tariff of £200 Annual

2016 ‘Gold Active’
£Zero GBP Annual Cost + Feed in Tariff of £600 Annual

All of the homes are destined for tenancy so there is a very real opportunity of getting some valuable post occupancy evaluation undertaken both on the occupants, the systems and the building fabric.
Fig 18. Post Occupancy Evaluation

Our terrace of three homes offer a unique opportunity to test and better define the performance of 2013 Low Carbon & 2016 Zero Carbon designs against a ‘control’ 2010 compliant house using the same fabric but also against a more typical timber frame house built to the Scottish Building Standards accredited details, this will be completed by Kingdom Housing Association on a neighbouring site to provide a benchmark for all system exhibited in the showcase.

Further details of the other systems being exhibited can be found at the following website link:

www.housinginnovationshowcase.co.uk

A variety of post occupancy evaluation measures are proposed for the Future Affordable plots including the use of the Scottish designed Ewgeco Energy Monitor, one of the few affordable and consumer accessible real time monitoring systems for gas, electricity, water and renewables available.

Ewgeco can display energy consumption from up to three different sources including any combination of Electricity, Water, Gas and any micro-renewable source including Photovoltaic (PV) in our 2013 and 2016 dwellings.

The system also provides a means for off site monitoring of both the power generation and the different energy usage using a data analysis portal.

It allows occupants to store, monitor & share their energy usage, providing tools to make savings through identifying trends in behaviour - daily, monthly and across the year.

We will also be including temperature, humidity and co2 data loggers in the properties and carry out post construction airtightness testing and thermographic imaging.

We anticipate publishing results in 2013.

Fig 19. SBEM Calculation Certificate
4. BRE Innovation Park Visitor Centre

The BRE are in the process of developing an Innovation Park on the site of the former steel works in Ravenscraig, Lanarkshire. The 1125-acre Ravenscraig site is being regenerated into a new town, featuring 10,000 houses, sports facility, town centre, community spaces and transport links.

There are plans to exhibit up to twelve demonstration buildings, which will showcase products, and technologies, which meet the future energy requirements for Scotland.

A small BRE Visitor Centre will also be situated on the site which it is hoped can also operate as a community meeting & educational space, engaging with local groups such as school children, young adults and FE colleges.

Kraft has been involved with the design & specification of the visitor centre of the project.

The off site building system specified surpasses the UK Zero Carbon Hub definition for zero carbon fabric standards (FEE) and therefore surpasses the Section 6 & 7 fabric standards.

The BRE have stipulated a challenging BREEAM Outstanding and Carbon Neutral Emission Target, these very high aspirations present interesting opportunities for a novel non-domestic post occupancy evaluation tool that can both monitor and manage a variety of renewables including Solar PV, Thermal & Heat Pump.

It is planned to use the building as the focus for a Building Performance Monitoring Demonstration Programme supported by European Research Funding and piloting the Energy Warden System.

Energy Warden is a European FP7 project, aiming at the development of tools for monitoring and control of energy resources, including renewables, deployed in the building domain. It’s inclusion in the BRE Visitor Centre will be it’s first implementation anywhere in the world and will provide a platform for optimisation.

Energy Warden will monitor and feedback into the various renewable energy sources propose don the building and control the usage of energy for immediate usage, export and storage in fuel cells.

We believe that this small non domestic building will be a very valuable test bed for Energy Warden which we hope if successful will lead to it’s adoption in larger more complex construction projects helping to manage energy conservation and usage in a smart, efficient and sustainable way.
This article presents the eco-friendly house built by Kingdom Housing Association in Pittenweem in Fife that won an award as the National Green Champion for Scotland at the 2011 National Green Apple Environment Awards Ceremony which was held in London at the House of Commons.

It provides an overview of the Kingdom Housing Association’s Passivhaus – The Kingdom House, as built, and in particular the Modern Methods of Construction and Sustainability features incorporated into the design as part of the Fife Housing Association’s Alliances ongoing research into appropriate systems for delivering affordable rented property.

One of Kingdom Housing Association’s strategic objectives is to continually improve their products and services delivered to their customers. Through building this house the Association have contributed to this objective and are able to monitor for further development the approach and systems that will become part of the mainstream programme for the Fife Housing Associations Alliance projects.

In addition to being designed to Housing for Varying Needs, Secured by Design and Passivhaus Institute Standards, the project also achieved a very good rating for Ecohomes.

Before commencing the design it was necessary to understand the energy usage in the typical home so that the areas of highest usage could be targeted. The Midlothian Innovation Centre has collected such data over several years and have reported the following:

- Space Heating 60%
- Water Heating 24%
- Light 13%
- Cooking 3%
- White Goods Minimal
- Leisure Appliances Minimal
- IT/Communication Minimal
The Project

The dwelling is a 5 per son 4 apartment two storey family home located on the northern side of Pittenweem, one of the idyllic East Neuk of Fife villages. It has a gross indicative floor area of 104sqm including 4.5sqm of storage.

Benefiting from a southerly aspect the plot is within a development where a mix of tenures has already been provided. There is an eclectic mix of styles of varying heights.

The Benefits of Passivhaus

Why use the Passivhaus standard for the basis of the design? A Passivhaus is a design methodology and rigorous, voluntary performance standard for energy use in buildings.

It results in a building that requires little or no energy for heating or cooling, has excellent levels of internal air quality and minimises overheating through advance thermal modelling. By providing a constant level of comfort through summer and winter and supplementing primary energy use with renewable energy technology, the Passivhaus has an ultra low heating demand meaning that the space heating costs are greatly reduced. A Passivhaus can protect tenants against fuel poverty.

Passivhaus have basic parameters. For the Kingdom House the following have been achieved (Passivhaus minimum standards in brackets):

- Space Heat Demand 14kwh/m² per annum (≤15kwh/m² per annum)
- Primary Energy Demand 85kwh/m² per annum (≤120kwh/m² per annum)
- Air Change Rate n50≤ 0.58 h⁻¹ (≤ 0.6h⁻¹)
- Thermal Bridge Free Design
- Efficient Mechanical Ventilation and Heat Recovery (≥ 75%)

System with efficiency of 90%
The Approach to the Design

Optimising the Design

The building form has been kept deliberately ‘compact’ which minimises surface to volume ratio that in turn increases the thermal efficiency of the envelope. It has been orientated so that all the habitable rooms are located on the southern side, each with a large opening to maximise solar gain and to allow daylight penetration deep into the floor plan. On the north, east and west elevations openings are minimised to reduce overheating and heat loss.

Super Insulating the Building Fabric

Extremely low wall and roof U-values of 0.09 w/m2K are achieved using Scotframe’s Supawall System, which is a BBA Certified closed timber frame panel system comprising of 140mm timber studs sheathed both sides with Oriented Strand Board and factory filled with Polyurethane which itself has a BRE Green Guide ‘A’ Rating. This kit was erected, wind and water tight within one working day and is supplemented by a mechanically and adhesively fixed JUB Jubizol S External Wall Insulation System that provides an additional 160mm insulation. The render contains the latest nano technology that provides a self cleaning surface with high resistance to the effects of ultra violet and other modern atmospheric factors. The insulated concrete ground floor has a U-value of 0.12 w/m2K. The building has been carefully detailed and constructed to ensure that it is thermal bridge free.

Windows are often the weak point in any building. Nordan N Tech Passive windows with a triple glazed argon filled cavity system have been installed. The complete window has a combined U-value of 0.7 W/m2K with no trickle ventilation providing an installed u-value of 0.8W/m2K. The high thermal performance ensures that draughts and cold spots often associated with conventional windows are eliminated.

Reducing Ventilation Heat Loss with an Airtight Fabric

The air permeability through the fabric of the building has been designed to below 0.6ach-1 @ 50Pa. This performance is 6-10 times better than standard UK Construction and is guaranteed by an air pressure test on completion of the construction. Without good air tightness the effectiveness of thermal insulation can be reduced by up to 70%.

Quality Indoor Air

Continuous fresh air is provided by a Paul Novus 300 mechanical ventilation heat recovery unit. The unit conserves energy by recovering 90% of the heat from the extracted air and transferring it to the incoming fresh air without contaminating it. This works both ways so if the outside temperature is higher than inside the exchanger will cool the incoming air and help maintain a comfortable internal environment. The fresh supply air is distributed to the rooms by ductwork and similarly the stale, moist air is extracted by ducts from areas such as the bathrooms and kitchen. The carefully balanced system and positioning of grilles ensures that there is adequate cross ventilation throughout the house. This system still allows windows to be opened should the tenants wish to do so.

Greatly Reduced Heating Demand

The heating load required for this house has been reduced by c. 90% compared to a standard house of the same design. Combined with the elimination of draughts and cold spots next to windows this means the capital cost of the heating system can be significantly reduced. To cater for the vagaries of their tenants, Kingdom Housing Association opted for proprietary water borne low temperature under floor heating with insulated track system to both ground and first floor. This provides a constant heat source throughout the room and avoids cold and hot spots traditionally associated with radiators. Usable wall space is also maximised. To further enhance the efficiency and ensure a quicker response time to tenants demand the underfloor heating is set in a Fermacell dry flooring system as opposed to a conventional wet screed.
**Renewable Energy**

Due to the ultra low heating demand of the Passivhaus renewable energy technology is not strictly required though it can be used to compliment the thermally efficient design. Kingdom Housing Association have explored the further benefits that renewable technology provides and also the associated tariffs.

**Photovoltaics**

An estimated 2.16KW of electricity will be produced by 12 Yingli Solar semi-integrated Photovoltaics modules, which are less obtrusive than the more commonly used ‘above roof’ solutions. Any electricity generated will be used by the house with excess being sold back to the National Grid. Estimated Solar PV generation is 1800 kWh per year.
Air Source Heat Pump

As the domestic space heating demand is lower the whole system can be heated by a Mitsubishi Ecodan W50 air source heat pump. With conventional boilers 1KW of input energy provides less than 1KW of output energy or heat. With Ecodan, every 1KW of input energy is converted into an average of 3.6KW making it over three times as efficient. The system is also supplemented by water heated by the solar thermal panels. This highly effective and efficient system means that the house does not require a conventional gas boiler. As a direct requirement of having no gas, an induction hob and an A rated electric oven have been provided.

Estimated savings calculated from the MCS Scheme formula / SAP 2005 Calculation would suggest estimated Air Source Heat Pump generation of 3408 kWh per year.

Solar Thermal Modules

To further reduce the primary heating demand 4.6 sqm of Wagner Euro C20 ‘in roof’ mounted solar thermal modules have been installed. These are connected directly to a twin core Geldhill 300 litre stratified solar cylinder and is used as the prime source for heating domestic and hot water. This is supplemented when required by the air source heat pump and as a last resort by a 3kW immersion.

Estimated savings calculated from the MCS Scheme formula / SAP 2005 Solar Water heating Calculation would suggest the following estimated Solar Energy captured 1137 kWh per year.

Renewable Control Strategy

The Association has implemented a Control Strategy to make best use of the renewable energy sources and therefore minimise the use and cost of the non renewable carbon energy sources.

Governments Tariffs

To ensure eligibility for the FIT and potential RHI tariffs, the installers of the air source, photovoltaic and solar thermal systems are accredited with the Microgeneration Certification Scheme, the products themselves are also MCS/Solar Keymark certified.

The Outcomes

A comparison study of the energy performance using SAP 2005 calculation has been made between the as built Kingdom House, the Kingdom House with no renewable and gas boiler as primary source and the standard specification used in Kingdom Housing Association’s new build programme.

The outcomes are as follows:

<table>
<thead>
<tr>
<th></th>
<th>Standard</th>
<th>Passivhaus with gas only (no renewables)</th>
<th>Passivhaus with renewables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Efficiency Rate</td>
<td>B(83)</td>
<td>B(87)</td>
<td>A(98)</td>
</tr>
<tr>
<td>Environmental Impact (CO2) Rating</td>
<td>B(82)</td>
<td>B(88)</td>
<td>A(101)</td>
</tr>
<tr>
<td>Energy Use</td>
<td>117 kWh/m2 per annum</td>
<td>81 kWh/m2 per annum</td>
<td>14 kWh/m2 per annum</td>
</tr>
<tr>
<td>Estimated Fuel Costs</td>
<td>£451 per annum</td>
<td>£377 per annum</td>
<td>£91 per annum</td>
</tr>
<tr>
<td>Carbon Dioxide Emissions</td>
<td>2.2 tonnes per annum</td>
<td>1.4 tonnes per annum</td>
<td>-0.1 tonnes per annum</td>
</tr>
</tbody>
</table>

The estimated fuel costs for the Kingdom House of £91 per annum assumes a reduction of £175 from that determined as a fuel energy saving in the SAP 2005 calculation, and which is derived from the Energy Saving Trust calculation.

Therefore it is clearly demonstrated that the Kingdom House reduces energy consumption by over 88% and is carbon neutral. Fuel costs are predicted to be reduced by c. 41% but this will be dependent upon the tenant’s life style. Further cost reductions are possible if the Government’s ‘Feed In’ and ‘Renewable Heat Incentive’ tariffs are realised.

From the Passivhaus PHPP calculation it has been verified that the design achieves the Passivhaus Standard.
Ecohomes / Code for Sustainable Homes

The house is more than an exercise in thermal envelope and renewable energy, Kingdom Housing Association have taken on board both the BRE’s Ecohomes and Code for Sustainable Homes environmental impact rating systems. An Eco Homes Very Good rating has been confirmed by the BRE. Over and above the excellent thermal performance of the building and the adoption of renewable technologies the Kingdom House also includes the following features:

- Internal and external recycling provision.
- External water storage in the form of a water butt connected to the rainwater system.
- Provision of covered and secured cycle storage for two bicycles.
- Dedicated low energy light fittings internally and externally. The former will only take a 4 pin PL low energy lamp which in this case 18w fluorescent bulbs are used which is equivalent to a 100w traditional bulb.

Due to the construction method higher ceilings are achievable creating light, airy spaces. This in itself has allowed fanlights to be introduced above doors allowing borrowed light to be brought into the hallway, reducing the need for artificial light to these areas.

Summary of U-values

<table>
<thead>
<tr>
<th>Component</th>
<th>U-value (W/m²K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof (pitched)</td>
<td>0.13</td>
</tr>
<tr>
<td>Roof (flat)</td>
<td>0.07</td>
</tr>
<tr>
<td>Wall</td>
<td>0.09</td>
</tr>
<tr>
<td>Ground Floor</td>
<td>0.12</td>
</tr>
<tr>
<td>Windows</td>
<td>0.7</td>
</tr>
<tr>
<td>Windows (installed)</td>
<td>0.8</td>
</tr>
<tr>
<td>Door</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Monitoring Strategy

The two main objectives that require to be accurately monitored are:

a) Space heating demand of less than 15kWh / m² / year
b) Primary energy use of less than 120 kWh / m² / year

In order to ensure that the house concept is successful, both the space heating energy requirements, and the overall energy use require to be accurately monitored over a minimum two year period. This will be achieved by the use of energy monitors for each of the following systems.

- Incoming Electricity Meter
- Solar PV System
- Solar Thermal System
- Electric Immersion Heater
- Air Source Heat Pump System
The Association has arranged for all the monitoring to be done remotely. The data will be sent via modem to the Meter Manager Internet site where the data will be collected for analysis. It is also hoped that funding will be secured to allow a more detailed post occupancy evaluation to be carried out.

**Conclusion**

The ultimate test will be how the building performs when it is occupied by the tenant and how that tenant manages the renewable energy sources within. The Project Team will also have to review the design and construction phases of the project and, through Kingdom Housing Association, monitor the performance of the building in relation to the materials selected, energy consumed and any ongoing cost items such as maintenance. Once this exercise has been completed Kingdom Housing Association will have a sound basis on which to take forward selected technologies to their mainstream developments.

---

**Kingdom Housing Association Ltd**

Saltire Centre, Pentland Court
Glenrothes, Fife, KY6 2DA
Phone: 01592 631661
Fax: 01592 631991
Email: kingdom@kingdomhousing.org.uk
Web: www.kingdomhousing.org.uk
Registered Scottish Charity Reg. No. SCO 000874

---

**Funded by**

Housing Association Grant
Renewable Construction Programme
CARES Funding

---

**Main Suppliers / Products**

- **Scotframe**
  - MMC Closed Panel System
- **Nordan**
  - Windows & Doors
- **JUB**
  - External Insulation & Render System
- **ROK**
  - Yingli Solar Photovoltaic System
  - Wagner Euro C20 Solar Thermal System
  - Mitsibushi Ecodan W50 Air Source Heat Pump
  - PAUL Novus 300 Mechanical Ventilation Heat Recovery
  - Myson Underfloor Heating
3D visualisation methods can be used in stakeholder participation of masterplanning to raise awareness of sustainable development issues. Sustainable development can be considered as a common sense approach to balancing the social, economic, environmental and ethical aspects of proposed developments. Traditional participatory methods often fail in communicating these complicated and interconnected issues.

Abertay has previously developed 3D virtual worlds for designing and monitoring the sustainability of urban and rural developments. From a simple 2D designer view that allows users to select, drag and drop features in order to spatially organise urban and rural components, a 3D immersive, navigable world is created (Fig 1).

Figure 1. 2D master plan, imported into 2D designer view; the components of the urban landscape are colour coded in the key, the mouse is used to size the component, converted to a 3D physical view. Finally, different indicators are superimposed onto buildings to compare two scenarios of building usage and impact on economics, energy usage, and acceptability.
The platform allows for real-time moving of buildings, alteration of features or changing management options and the effect on sustainability is immediately realised via underlying computational models and novel visualisation techniques. This coupling of visualisation and computational modelling is only possible as we use optimized rendering techniques initially developed by the video games industry for rendering and this is only possible by developing our own customizable software infrastructure. The platform will convert this 2D view into a 3D view that contextualises the area being designed in the wider landscape and shows impact on water quality and biodiversity.

We have used this platform for both urban landscapes (Figures 1 & 2) and larger rural catchment areas (Figure 3). The principles of seamless simulations (computational model) with interactive 3D visualisations providing a sustainability assessment are common in both applications. For the rural catchment model (Phiz) there are a set number of water treatment management options explored (to reduce level of pollutant) informed by water authorities, however for the urban visual simulation (S-City-VT) there are no set scenarios and the users can investigate a large number of user defined scenarios.

Figure 1. The design in 3D contextualises the design in a wider landscape.
Currently this type of scenario comparison cannot be done using any other software in real time, i.e. results of computational models transformed into textures and rendered as soon as they are computed. Games engines have also been used previously for rendering the physical landscape but again these are not tightly coupled to computational models predicting the consequences of certain actions on environment. Abertay are the first group to demonstrate that urban sustainability data can be conveyed to a number of stakeholders using a novel integration of computational modelling and 3D visualisation.

Figure 3. Phiz managing water quality on a catchment. Colour indicates water quality, spider diagrams give detailed information on each reach. Videos of the platforms can be seen on [http://save.abertay.ac.uk/](http://save.abertay.ac.uk/) and [http://www.scityvt.co.uk](http://www.scityvt.co.uk)

For more information, please contact [j.isaacs@abertay.ac.uk](mailto:j.isaacs@abertay.ac.uk) and access the links:

[http://dl.dropbox.com/u/5753007/Phiz_Promo.wmv](http://dl.dropbox.com/u/5753007/Phiz_Promo.wmv)
Paper on a feasibility study undertaken through CIC Start Online published in *International Journal of Low-Carbon Technologies*

**Exploring the adoption of low carbon technologies by Scottish housing associations**

**Mohamed Abdel-Wahab**, Heriot-Watt University, School of the Built Environment, Edinburgh, UK;  
**David Moore**, Scott Sutherland School of Architecture and the Built Environment, Robert Gordon University, Aberdeen, UK;  
**Seonidah MacDonald**, Aberdeen Business School, Robert Gordon University, Aberdeen, UK

Housing associations (HAs) are responsible for building and managing approximately one-third of affordable homes in Scotland. The adoption of low carbon technologies (LCTs) by HAs presents an area that could potentially help towards reducing the carbon footprint of affordable housing and the fuel poverty of tenants. This research thus explores the issues pertaining to the adoption of LCTs from the perspective of two Scottish HAs. Semi-structured interviews were conducted with selected members of the management team in both HAs. The empirical findings revealed that HA-related issues (such as organization culture, being a learning organization and training) and tenant-related issues (such as social cohesion, change in behaviour and training) can both impinge on the adoption of LCTs in HAs. It is contended that there is a piecemeal adoption of LCTs and if mass adoption is to be realized, this will require a nationwide programme that is aimed at supporting the adoption of LCT, in addition to building the skills capacity of the construction industry which is seemingly ill-prepared.

Link to the paper in *International Journal of Low-Carbon Technologies*  
http://ijlct.oxfordjournals.org/content/early/2011/10/18/ijlct.ctr031.abstract?keytype=ref&ijkey=S95l8SEBYkb9xG

Link to the CIC Start Online video recording of the above webinar:  
http://www.cicstart.org/content/webinarrecordinglogin/234,213,22/
Architectural Design Principles and Processes for Sustainability

Dr David Grierson
University of Strathclyde Glasgow

The paper is related to the video presented at CIC Start Online 2011 conference.

Introduction

Buildings consume energy and resources and generate waste on a huge scale. Current construction methods tie us into future patterns of resource and energy use, waste emissions and environmental damage. When poorly designed our buildings leave a lasting legacy for the next generation that extends adverse social, economic and environmental impacts throughout their life cycle. The Scottish Executive’s *A Policy for Architecture in Scotland* acknowledges that the complex and challenging sustainability agenda requires fundamental change in our understanding of the nature and purpose of buildings and the role of building design (Scottish Executive, 2006).

There are many definitions of what makes a building sustainable with respect to social, economic and environmental issues (commonly referred to as the ‘triple bottom line’); social in terms of adding to the quality of life for people, economic in terms of enhancing wealth, and environmental in terms of reducing the impact that buildings have on the natural environment. However the ‘triple bottom line’ of sustainability is open-ended and ecological aspirations vary widely, more recently focussing on aspects relating to transport, water conservation, and biodiversity. A current significant focus is being placed on the energy and environmental performance of buildings, with specific key goals involving the reduction of associated carbon emissions and energy costs. Identifying and developing more sustainable building materials and construction techniques that can minimize waste and are non-polluting is recognised as an important aspect of sustainable building design.

Design parameters for sustainable buildings have therefore increased to encompass more complex performance related criteria, and the architect must adopt a more holistic perspective when designing. Sustainable buildings remain, however, far from the mainstream products. Indeed there are a limited number of contemporary exemplars and demonstration projects from which to learn good practice, although this number has expanded in recent years. The construction industry can be viewed as large and fragmented and slow to respond to change, preferring the ‘tried and tested method’. The drivers to a more sustainable built environment will be increasing legislation and rising energy costs, if not ethics.

The architect’s role is central to the building design process: the most energy efficient and environmentally friendly building must also be functional, durable and aesthetically pleasing. It is now vital that the architect has a comprehensive understanding of all the facets of sustainability in order to be able to engage with a wide range of disciplines and specialisms.

Sustainable buildings must be resilient to climate change and be adaptable, flexible and durable in order to increase a building’s life-span. This ‘cradle to cradle’ approach refers to a building that is designed to be deconstructed and where materials are capable of being recycled.
Towards a Typology

Research into the implementation of environmental management systems (International Organisation for Standardisation, 1996) within the wider context of sustainable development has raised issues of fundamental importance to the understanding of the concept if appropriate action is to be taken. In particular, consideration has been given as to how a practical realisation of such a system might be applied to the lifecycle of a building, including the design phase (Grierson, 2009). We need visions of a more sustainable future that can provide the current generation of designers and planners with sufficient motivation without impairing their capacity to learn what might be the best direction for change. At the same time we urgently need to improve the energy and environmental performance of the global built environment. An improved building design process aided by appropriate management tools and regulatory frameworks that address sustainable development issues has been suggested as a way forward, and is the subject of ongoing research (Grierson, 2009). The objectives of this part of the research are to investigate the design principles and processes for sustainability and to explore them in action within current practice. These components were used in the analysis of exemplar case studies from practices. A study, which aimed to gain the practitioner’s perspective, was undertaken as dissertation work within the Masters of Research programme in Building Design and Management at the Department of Architecture, University of Strathclyde Glasgow during 2010 (Moultrie, 2010).

This was achieved by engaging with a small sample of Scottish architectural and multi-disciplinary practices actively involved in sustainable design and by considering exemplar buildings via a case study analysis. The methodology was qualitative, involving face to face interviews and observational visits to the case study buildings. A context was established by reviewing literature focusing on the global environmental perspective, UK and Scottish legislation, sustainable principles, blueprints, sustainable processes and evaluation. Analysis of the practitioner and client interviews, in combination with the case studies, allowed for discussion and response to a number of research questions. To conclude the study a series of mapping exercises were carried out to allow for comparison and cross-referencing. An example within the paper describes the ‘Principles Matrix’ which shows the overlapping principles from selected literature (Table 1). Key components of a sustainable design process are identified as the environmental brief, parameters, environmental strategies, evaluation and tools and techniques. These components were used in the analysis of exemplar case studies from practices. Table 2 maps the sustainable process onto the Royal Institute of British Architects (RIBA) Outline Plan of Work. An example of a case study building summary table, indicating relevant processes and applicable principles is given in Table 3.
<table>
<thead>
<tr>
<th>Principles</th>
<th>Ecological Design</th>
<th>Green Architecture</th>
<th>One Planet</th>
<th>Adapting Buildings for Climate Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authors</td>
<td>S. Van der Ryn, S. Cowan</td>
<td>B. Vale, R. Vale</td>
<td>BR, WWF</td>
<td>S. Roof</td>
</tr>
<tr>
<td>Environmental</td>
<td>-making nature visible</td>
<td>-holism</td>
<td>-natural habitats and wildlife</td>
<td>-not destroy fragile biodiversity and ecosystems</td>
</tr>
<tr>
<td>Environmental</td>
<td>-design with nature</td>
<td>-conserving energy, -working with climate</td>
<td>-zero carbon</td>
<td>-use as little energy as possible through good design, -provide that energy where possible from clean, renewable sources that will not pollute nor run out</td>
</tr>
<tr>
<td>Environmental</td>
<td>-ecological accounting</td>
<td>-minimizing new resources</td>
<td>-local and sustainable materials, -sustainable transport, -sustainable water, -zero waste</td>
<td>-reduce waste in construction, operation and demolition</td>
</tr>
<tr>
<td>Social</td>
<td>-everyone is a designer</td>
<td>-respect for users</td>
<td>-health and happiness</td>
<td>-promote the health of all, -ensure that people are comfortable and can survive even in extreme weather within them, -be built with goods and materials that produce minimal pollution</td>
</tr>
<tr>
<td>Economic</td>
<td>-solutions grow from place</td>
<td>-respect for site</td>
<td>-culture and heritage</td>
<td></td>
</tr>
<tr>
<td>Economic</td>
<td></td>
<td></td>
<td>-equity and fairtrade</td>
<td></td>
</tr>
<tr>
<td>Economic</td>
<td></td>
<td></td>
<td>-local and sustainable food</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Principles Matrix

Context

Sustainable development was described in the 1987 Bruntland Commission’s report (WCED, 1987) as, “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” In achieving social and economic goals the commission recognised that ecosystems must be safeguarded and the depletion of natural resources minimized. At the same time investing in skills and the advancement of knowledge for the benefit of future generations must be prioritised.

The European Union Energy Performance of Buildings Directive was published on the 4th January 2003 (EU, 2003). The overall objective of the Directive is to promote the improvement of energy performance of buildings within the Community taking into account outdoor climatic and local conditions, as well as indoor climate requirements and cost-effectiveness.

Each EU member state was required to transpose the Directive into law by the beginning of 2006 with a further three years being allowed for full implementation of specific articles.

The UK Climate Change Bill (2007) set challenging targets for carbon reductions across the UK with a commitment to a 50% cut in carbon emissions from the built environment by 2020. Under the EU commitment the UK must deliver 15% of total energy from renewable sources. The zero carbon new building programme is seen as an active driver towards the renewable target. The UK policy is for all new homes to be zero carbon by 2016, all new schools zero carbon by 2016, public sector buildings by 2018 and potentially all new buildings by 2019. In August 2007, the Scottish Government appointed a panel of experts to make recommendations to improve the performance of buildings.
### Table 1: Sustainable Design Process Matrix

<table>
<thead>
<tr>
<th>Outline Plan of work</th>
<th>Sustainable Principles</th>
<th>The Environmental Brief</th>
<th>Parameters</th>
<th>Environmental Strategies</th>
<th>Evaluation</th>
<th>Tools &amp; Techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Appraisal</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B Brief</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C Concept</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D Design Development</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>E Detail Design</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>F Production /Tender</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>J/K Construction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>L Occupancy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Case study, Principles and Process Summary

<table>
<thead>
<tr>
<th>PRINCIPLES</th>
<th>PROCESS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ecological Design</strong></td>
<td><strong>Environmental Brief</strong> - carbon reduction, energy efficiency, flexible working environment</td>
</tr>
<tr>
<td>solutions grow from place design with nature ecological accounting everyone is a designer</td>
<td><strong>Parameters</strong> - grade B listed building, budget</td>
</tr>
<tr>
<td><strong>Green Architecture</strong></td>
<td><strong>Environmental Strategies</strong> - passive design to achieve natural ventilation and improved thermal performance. Renewable energy source for heating, biomass boiler. Landscape work to promote biodiversity</td>
</tr>
<tr>
<td>working with climate conserving energy respect for site minimising new resources</td>
<td><strong>Evaluation</strong> - BREEAM 'excellent'. Energy, water, CO2 monitoring to be continually carried out</td>
</tr>
<tr>
<td><strong>One Planet</strong></td>
<td><strong>Tools &amp; Techniques</strong> - environmental modelling</td>
</tr>
<tr>
<td>culture and heritage sustainable water natural habitats and wildlife zero carbon</td>
<td></td>
</tr>
<tr>
<td><strong>Adapting Buildings for Climate Change</strong></td>
<td></td>
</tr>
<tr>
<td>use as little energy as possible through good design reduce waste in construction operation and demolition ensure that people are comfortable &amp; can survive even in extreme weather within them</td>
<td></td>
</tr>
</tbody>
</table>
The outcome was *A Low Carbon Building Standards Strategy for Scotland*, widely known as *The Sullivan Report* (Sullivan, 2007). The intention of the report is to drive a step change in legislation, design and construction practice with the aspiration to move to total life zero carbon buildings by 2030. Legislation and policies may be drivers for sustainable buildings. However the level of ‘greenness’ of a building often depends on client aspirations and the approach taken by the architect and the design team.

**Sustainable Principles & Processes**

The aim of the research has been to examine the architectural design principles and processes that underpin sustainable building design as an emerging typology as described in selected key texts that can help identify a spectrum of approaches to sustainable design, and a series of related but distinct principles involving social, environmental, and economic factors.

In *Ecological Design* (1996) Van der Ryn and Cowan set out 5 principles formulated from their many years of research and practice. In their view the transformation to a more sustainable world encompasses a renewed approach to the design of buildings and products and will incorporate an understanding of ecological principles. The application of these principles involves an engagement or integration and sharing of knowledge across many sectors.

The concept of an individual dwelling that can be self-sufficient with regard to its own energy and resource needs, by for example harvesting rain and recycling waste, was described in the seminal book *The Autonomous House* (Vale and Vale, 1975). Some years later, in *Green Architecture* (1991) the authors described 6 principles as a basis for the ‘green’ design process. The Hockerton Housing project was designed by the Vales following these defined principles and is intended to be self-sufficient. The earth-sheltered terrace of five dwellings was built by residents and completed in 1998. A south facing glazed conservatory provides a passive solar heating source to the house, and surrounding land is used for growing crops and keeping small animals. The development is described as one of the first “zero energy” residential schemes in the UK (Hockerton Housing project, 2010).

The changing climate and the importance of designing resilient buildings that mitigate damage to the environment and that are capable of adaptation, leads to a crisis planning scenario in *Adapting Buildings and Cities for Climate Change a 21st century survival guide* (Roaf, 2004). The author of the book describes the need for buildings to be resilient to climate change and be designed for longevity with low embodied energy.

An holistic approach to sustainability reaches beyond buildings to encompass sustainable communities and lifestyles. The environmental group BioRegional and the World Wildlife Fund (WWF) have developed the One Planet principles to enable sustainability to be embedded into any process. One Brighton (2005), designed by the architect Fielden Clegg Bradley Studios, is a mixed use residential development, funded by a mainstream developer Crest Nicholson along with BioRegional. It is the first development to use the One Planet principles and is aiming to be both ‘zero carbon’ and ‘zero waste’. The linear blocks comprise 172 residential units above community and business units. An on-site car club, community centre, crèche and café is shared by all. There are mini allotments within the sky-gardens and terraces to encourage residents to grow food on site (Clegg, 2007). As a summary a Principles Matrix (Table 1) was produced to show the alignment of principles reviewed. The matrix indicates that a core set of principles align across all four sets. Additionally, the One Planet Principles outlines social / economic principles that are applicable to resident lifestyle choices, for example, with respect to food and fair-trade.

The transformation of design and construction process towards more sustainable practices will be supported by the identification of a classification system that can clarify issues at various stages of the process. In the UK, *The Outline Plan of Work* (RIBA, 2007) is a framework devised by the Royal Institute of Architects to structure these design and construction processes. It is widely used by architects and clients today as a management tool. The design and construction sequence, from appraisal to post practical completion, is broken down into a series of stages that can be arranged to suit different procurement methodologies. The phases involve a common set of tasks with outcomes related to the stages of pre-design; concept design; schematic design; detail design; post-occupancy evaluation.

Kwok (2007) aims to set out strategies at the schematic stage in *The Green Studio Handbook*. The sustainable design strategies are form giving and therefore influence the building design concept. Given that green buildings are an important step on the path to a more sustainable society Hyde (2007) attempts to set out a systematic design delivery design process in *The Environmental Brief, Pathways for Green Design*. The author argues that clients, designers and contractors are more interested in sustainable building design as knowledge increases of the benefits and the processes to deliver are better understood.
The environmental brief encapsulates economic, social and environmental issues and is continuous throughout the design process. The environmental briefing system encompasses the following:

1. Aspirations: sustainable principles, outline brief
2. Divergence: establishing environmental objectives, functional requirements
3. Parameters: site and climate, environmental criteria, whole life costing, legislation
4. Environmental Strategies: resource producing, passive/active systems design, material specification, healthy environment, etc
5. Applications: design testing
6. Outcome: project brief

It is recognized that environmental briefing is a continuous process, responding to detail decision and value engineering throughout the design process. The system is viewed as a way of mapping sustainability onto the traditional design process. A process model has been developed from the literature reviewed and is here used for the case study format. The Sustainable Design Process Matrix (Table 2) maps the principles, environmental brief, parameters, environmental strategies, evaluation, tools and techniques onto the RIBA Outline Plan of Work. It indicates a spread from setting sustainable principles at the outset (Stage A) to post-occupancy evaluation of a building in use (Stage L).

Results and Analysis

The adopted research method for the study was investigative, exploratory and descriptive. The five architectural and one multi-disciplinary practice that formed the research group range in size from small to large and operate across a variety of sectors. The larger practices have a sustainability team within the office that provides in-house support and external consultancy services.

A series of interviews were conducted with senior professionals of the practices and the case study client bodies. The face to face semi-structured interviews provided an overarching view of the practice ethos and the design process. The case study buildings from the practices are from social housing, education, commercial office and private developer housing sectors and are both new build and retrofit. To explore the design process in detail interviews were held with the project architect/engineer. Visiting the buildings provided an opportunity to interview the client on site to gain their perspective and allow for a descriptive element of the final product – the building itself.

The analysis and description framework for the case studies includes principles, environmental brief, parameters, evaluation and tools and techniques, identified following the literature review. Moving towards a typology of sustainable building design is a recent phenomenon for most architectural practices as the research has shown. All the research group practices have a sustainability policy in place.

These policies describe a commitment to sustainable design as an integral part of their design philosophy. The general intent is that sustainability overarches the design process for every new project. The triple bottom line of sustainability ‘social, economic and environmental’ is a recognized mantra across all the research group practices. The divergence occurs in going beyond the triple bottom line and composing a set of principles. The research group was split between those having a set of principles in place and those currently developing principles. As every practice is unique, having developed a different architectural ethos, attempting to define where a practice sits on a ‘sustainability spectrum’ was seen as a useful starting point, from which a set of principles could then be developed to express their particular focus. An exercise was carried out to suggest alignments between the practice group and the philosophy and principles from key texts (Table 1).

One of the practices has been a pioneer in ecological design for a number of years and therefore could be said to align broadly with all the principles. Another of the practice has a strong social/community ethos therefore the core principles of One Planet align well (Bioregional and WWF). Adapting Buildings for Climate Change (Roaf, 2004) involves the performance of buildings and is aimed at architects and engineers. The principles overlap with those of the global multi-disciplinary practice. A holistic approach and an emphasis on place making and people described by another of the practices fits well with the ideals of Green Architecture (Vale and Vale, 1975). In Ecological Design (1996) Van der Ryn and Cowan express a deep green philosophy and in Ecological Design Redux (2008) the authors examine how many of the principles have been embraced by others in the intervening period. Connections are, for example, made with the emerging practical application of the One Planet principles. Additionally within the research group the principles of ‘ecological accounting’, ‘designing with nature’, and the concept that ‘everyone is a designer’ are evident in one practice in particular which balances green ideals with a pragmatic approach, while engaging well with the end users. Creating intelligent buildings that exhibit low carbon footprints, while also being comfortable and attractive places for people to inhabit, was an aim of a larger practice which had an in house sustainability group.
The developing ideas also mirror the ethos of the principles in *Adapting Buildings for Climate Change* where the value of the resilience of buildings is emphasised. The practical application of the principles and process was evidenced through the case studies. These examined what principles (from Table 1) were directly applicable and summarised the key processes involved. One of these case studies – the refurbishment and extension of a modernist 1960’s office building is given by way of illustration (Table 3).

In this case, the office building was no longer seen as fit for purpose with an inflexible working environment and lack of space. In 2005, Historic Scotland listed the building as Grade B due to the modernist design. The environmental brief was to refurbish and extend the existing building to create a building that was energy efficient, low carbon and fit for new ways of office working while creating an attractive comfortable working environment. The redevelopment was to reflect the client’s environmental ethos and act as a showcase of their work. The environmental strategies included passive design principles, intelligent active energy systems, component design, and sustainable material choice. A renewable energy source for the heating and hot water was provided by way of a biomass boiler. Working with the constraints of the existing building and surroundings set the design parameters. It was not ‘sustainability at any cost’: appropriate solutions for the scale of the project were identified to deliver best value.

At the design stage the building has achieved an Energy Performance Certificate rating of A. A BREEAM ‘excellent’ rating was achieved and a post occupancy evaluation was undertaken as soon as the building was occupied, monitoring all energy use and the building systems in use.

**Discussion**

Evidence of the demonstration of sustainable principles and processes within the case study buildings vary and can be attributed to many factors; the timeline of the buildings, the client’s sustainability goals, the environmental brief and budget and the architect’s creative response to the design intent and criteria. Buildings are often recognizable as belonging to a certain practice or architect through architectural style. Sustainable design is evidenced more within a philosophical approach that involves the application of principles at various stages of the design process. The research material gathered from the practice interviews, client interviews, and case studies indicates that, for example, aspects of passive design, sustainable material choice, and the use of new technologies are having an impact in driving the form and envelope of many of today’s buildings.
Although the design processes within the research practice group are different key common elements are evident. The framework takes the new environmental brief as the starting point. The specific design criteria for the project are established and goals are set at the briefing stage. Parameters or filters are then applied which influence the environmental strategies. The environmental strategies are developed to meet the design intent. There are many sets of principles that cover the holistic sustainability spectrum although no one common set of metrics exists (Jencks, 1997). Principles have similar core elements and it could be assumed by now that all architects would accept that buildings should deliver value to the community, environment and the end user (Sassi, 2006). It is of value to have a set of principles in place for a number of reasons, not least because they offer a useful guide or checklist. At a higher level however principles can reflect the ethos of a practice – the practice view, for example, on community issues or ecological issues. The principles can therefore be used to articulate and explore client aims and sustainability goals in structured, possibly facilitated, conversations among key stakeholders.

Sustainable principles alone however do not set a project brief. The sustainable design process must include an analysis and synthesis of a whole new sub-set of social, environmental, and economic goals, with specific criteria set alongside functional requirements. As the case studies have indicated in the current study, clients often have specific sustainable design objectives and balancing them with functional goals has to be considered at the outset. These include those that relate to the site constraints which determine that each building, even repeat type standard buildings are unique because of their location. Each site exhibits different physical characteristics that have an effect on the building at least in terms of location, micro-climate, access and physical ground conditions. Within sustainable buildings the response to the site context is more acute and is one of the major determinants on the development of sustainable strategies involving a response to micro-climate, topography, adjoining neighbours, local community and local planning policies. These can be regarded as opportunities or constraints.

The study demonstrates that an integrated approach is needed from the outset to set sustainable strategies as early as possible. All practices stated the desire to avoid bolt on visible displays of ‘green technology’ such as solar panels or wind turbines (i.e. the ‘eco-bling’ factor). Rather the common approach adopted focused on passive design issues (i.e. site orientation, form, building envelope), combined with active design elements (i.e. intelligent service design to minimise energy consumption), and then finally to reduce carbon emissions further considered renewable energy sources.

Common strategies adopted within the case studies within an integrated design process involved; lighting, heating, ventilation and cooling, energy production, water, materials, conservation, biodiversity and waste.

**Evaluation Systems**

Post occupancy evaluation (POE) of sustainable buildings is important because it is only when a building is occupied that the design intent can be ultimately tested. The views of building users or occupiers can then provide valuable feedback on the design quality, functionality and comfort. Analysing energy and thermal performance in use against design intent benchmarks will help inform future design strategies. POE is particularly important for sustainable buildings in monitoring how the building performs in terms of energy use, CO2 emissions and water consumption. Sustainable buildings don’t always perform as well as intended. This can be put down to a variety of factors including the use of new technology, control and monitoring systems and not least the human factor. Exemplar buildings and demonstration projects, increasingly with a sustainable design focus, provide blueprints for informing building briefs and design work. Post-occupancy evaluation results that are published as case studies are a way of advancing sustainable design however confidentiality is an issue and revealing faults in buildings is not regarded as good publicity for the designers and building owners. Architects often refer to exemplary buildings to develop a solution set for sustainable buildings. The danger of modelling strategies on a building that has not had POE carried out is that mistakes can be repeated.

**Conclusion**

The study supports the proposal that a new framework can help inform a move towards a typology of sustainable building design that in turn can help practitioners develop and refine their approaches to sustainability. The building case studies and detailed examples described in this paper demonstrate identifiable elements within the framework as sustainable principles, the environmental brief, parameters, environmental strategies, blueprints, tools and techniques and evaluation systems. The Design Process Matrix (Table 3) shows these elements mapped onto the traditional RIBA outline plan of work.

The practice group revealed common approaches through their principles, processes and design work. Passive design as a primary approach to reducing energy consumption in a building was evident across all the case study buildings. A more integrated process is also viewed by as vital to the process. The design processes described in the case studies show architects, environmental engineers, prefabrication subcontractors and other specialists engaged in a collaborative process.
The result is a common grouping of strategies for sustainable building design. There are overlaps or general themes in the principles that underpin the strategies as indicated in Table 1. The principles can be more than a useful checklist and can define a sustainable philosophy for a practice. Having a defined set of sustainable principles in place is a valuable tool and some of the practice group have developed sets of their own. The barriers in practice appear to be knowledge and evidence. Architects and engineers require a more comprehensive knowledge of legislation, new technology, materials and environmental design to engage in the integrated design process. Sharing results of the POE of sustainable buildings is one way of promoting best practice and learning lessons in order to avoid repetition of mistakes. The blueprints for future designs should be based on real evidence that original design intents have been met. The building occupants are often the best judges of buildings and provide valuable feedback in addition to any energy monitoring undertaken.

The research group of practices studied are committed to sustainable building design of architectural quality. Currently the focus is on zero carbon, delivering reduced running costs, reducing water and waste and specifying sustainable materials. In future, other aspects of sustainability may be given more coverage; the impact of materials on the health of occupants, for example. There is some evidence that a wider holistic view of sustainability is gaining ground, with the One Planet principles offering a template for developments. Moving sustainability into the mainstream is still, however, a significant challenge ahead. For architectural practices to move forwards, the authors argue that the starting point is the definition of a philosophy and the establishment of a set of guiding principles reflected within a typology of sustainable building design. While the sample group was small it is clear that all are already transforming their approach to sustainable building design. The methodology of the study could be developed to allow practices to further develop a philosophy and refine principles. A Principles / Practice Matrix is being developed as a method of evaluating a practice’s approach against well documented sustainable design philosophies that have practical application. This self-reflective approach would take the form of facilitated structured conversations among key stakeholders focussed on identifying various systematic classifications of sustainable design principles that can clarify issues at various stages of the process, and the alignment of these with the design philosophy of the practice involved.

References


DESAI, P. 2010. One Planet Communities, Chichester, John Wiley & Sons Ltd.


HYDE, R., WATSON, S., CHESIRE, W., THOMSON, M. 2007. The Environmental Brief, Pathways for Green Design Oxon, Taylor & Francis, p77-91

International Organisations for Standardization, ISO 14001, 1996


CIC Start Online Webinar Sponsorship

The outcomes of our feasibility studies are documented in a final report, and disseminated by means of a seminar which is also broadcast online as an interactive webinar. You can sponsor a webinar with one of three packages:

<table>
<thead>
<tr>
<th>Webinar Sponsorship</th>
<th>Description</th>
<th>PRICE</th>
</tr>
</thead>
</table>
| Webinar Basic Sponsorship            | • Company logo on email communications for webinar  
• Company logo on screen during webinar  
• Single slide shown at beginning and end of webinar containing company logo, brief description of services, and a website link | 250.00 |
| Webinar Personal Sponsorship         | • As above PLUS:  
• Opportunity to promote your products/services IN PERSON at the beginning of the webinar (2-3 minutes)                                                                                                     | 350.00 |
| Bespoke Webinar Sponsorship          | • As above PLUS:  
• Working with you to produce of a short video to promote your products/services – to be shown during the webinar and also for your own use on your website and marketing                                           | 450.00+|

We also offer our webinar service to businesses to promote their products and services. You will lead the entire presentation; there are various options for inviting delegates (physical and online) and managing the event.

<table>
<thead>
<tr>
<th>Member to Member</th>
<th>Description</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bespoke Webinar Day</td>
<td>• Webinar for promoting your business</td>
<td>450.00+</td>
</tr>
</tbody>
</table>

Our bespoke packages are priced after discussion of your requirements.

**Subscription**

To subscribe to free quarterly Innovation Review and monthly CIC Start Online E-News, please register by accessing the project website at [www.cicstart.org](http://www.cicstart.org) or the following link **Registration**.

Benefits of free registration also include the following:

- Publish information on products and services for sustainable building design and refurbishment offered by your business (free for Scottish small to medium size enterprises).
- Receive a free headset with a microphone to listen to forthcoming CIC Start Online webinars.
- Free information on sustainable building design and refurbishment for Scottish small to medium size enterprises.

**Marketing**

To advertise products or services for sustainable building design, construction or refurbishment by companies registered in Scotland, please contact **admin@cicstart.org** for the full price list.

**Articles**

Submission deadline for the articles for the fifth issue of Innovation Review is 15th February 2012. To discuss the article that you would like to submit, please contact us by email or telephone on the contact details provided below.

Innovation Review is published by CIC Start Online project.  
**Contact:** [Branka@cicstart.org](mailto:Branka@cicstart.org), +44 (0)141 273 1408