Low carbon and embodied carbon

The Renewable House demonstrates whole life sustainability

As the UK builds more low energy buildings, the increased levels of insulation and additional technologies employed in such buildings produce higher levels of embodied carbon. Studies by the University of East Anglia (Monahan and Powell 2010) found that an average low energy new house made with conventional materials contains the equivalent of 50t CO₂ as 'embodied carbon'.

This could be significantly reduced with greater use of timber, modern methods of construction and renewable materials. Examples of renewable materials in construction include thatch, cob and renewable materials. Renewable materials offer low embodied carbon properties as the emissions from manufacturing and construction are offset by the sequestered carbon dioxide from the atmosphere. Yet at the same time, renewable materials deliver high levels of performance in insulation, breathability and airtightness.

### Costs

The cost of the Renewable House is demonstrated in the table below. At 2010 prices, the Renewable House has a cost of around £75,000 if up to 10 units are built, based on data provided by the developer C-Zero (www.czero.com). The table below is based on figures for a project in Diss, Norfolk.

**Project:** Denmark Lane Diss; minimum plots 82-110; infrastructure normalised

**Client:** Crossover C-zero LLP

**Architect:** Khoury Architects

**Start date:** 05 July 2010

**Number of units:** 29

**Completion date:** 28 Feb 2011

**Duration:** 34 Weeks

**Total floor area:** 2,283m²

**Main cost headings**

<table>
<thead>
<tr>
<th>Net cost</th>
<th>£/m²</th>
<th>£/unit</th>
<th>£/GJ</th>
<th>Unit</th>
<th>FU rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure &amp; basement</td>
<td>117,628</td>
<td>52</td>
<td>4,056</td>
<td>1,019</td>
<td>m²</td>
</tr>
<tr>
<td>Superstructure (BCD)</td>
<td>1,468,068</td>
<td>643</td>
<td>60,623</td>
<td>2,283</td>
<td>m³</td>
</tr>
<tr>
<td>General external works (E)</td>
<td>213,582</td>
<td>93</td>
<td>7,296</td>
<td>11,481</td>
<td>m²</td>
</tr>
<tr>
<td>Access roads (E)</td>
<td>71,459</td>
<td>31</td>
<td>2,484</td>
<td>194</td>
<td>m</td>
</tr>
<tr>
<td>External services (E)</td>
<td>148,051</td>
<td>64</td>
<td>5,036</td>
<td>29</td>
<td>N</td>
</tr>
<tr>
<td>Drains-general</td>
<td>121,866</td>
<td>53</td>
<td>4,202</td>
<td>29</td>
<td>N</td>
</tr>
<tr>
<td><strong>Sub total</strong></td>
<td>2,136,694</td>
<td>936</td>
<td>73,678</td>
<td>2,283</td>
<td>m³</td>
</tr>
<tr>
<td>Preliminaries (P)</td>
<td>299,178</td>
<td>131</td>
<td>10,316</td>
<td>34</td>
<td>wk</td>
</tr>
<tr>
<td><strong>Building net cost</strong></td>
<td>2,435,832</td>
<td>1,007</td>
<td>157,972</td>
<td>29</td>
<td>N</td>
</tr>
<tr>
<td><strong>Statutory Fee (F)</strong>*</td>
<td>14,278</td>
<td>6</td>
<td>492</td>
<td>29</td>
<td>N</td>
</tr>
<tr>
<td><strong>Profit &amp; Overheads</strong></td>
<td>85,254</td>
<td>38</td>
<td>2,957</td>
<td>29</td>
<td>N</td>
</tr>
<tr>
<td><strong>Contingency (general)</strong></td>
<td>11,971</td>
<td>5</td>
<td>413</td>
<td>29</td>
<td>N</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td>2,547,835</td>
<td>1,116</td>
<td>157,887</td>
<td>29</td>
<td>N</td>
</tr>
</tbody>
</table>

**Notes**

1) Design fees excluded
2) Excludes roads outside site boundary
3) No existing services, drains or easements on site apart from pumped foul adjacent to Denmark Lane
4) LABC warranty excluded
5) Excludes Phase 2 works

### Table

<table>
<thead>
<tr>
<th>Year of construction</th>
<th>Design standard</th>
<th>Walls</th>
<th>Fabric U-values (W/m²K)</th>
<th>Glazing</th>
<th>Roof</th>
<th>Airtightness m³/h/m² @ 50 pascals</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>Code 4</td>
<td>0.19</td>
<td>1.30</td>
<td>0.10</td>
<td>0.16</td>
<td>2</td>
</tr>
</tbody>
</table>

**Construction type**

<table>
<thead>
<tr>
<th>Window type</th>
<th>Building Services</th>
<th>Renewable Energy</th>
<th>Rainwater harvesting</th>
<th>Grey water harvesting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tripled glazed argon filled</td>
<td>Electric underfloor</td>
<td>MVHR</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

**Sequestered CO₂e (tonnes)**

<table>
<thead>
<tr>
<th>Renewable House Code Level 4</th>
<th>Trinity Close, Rackheath Code Level 6 (no renewable material)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-6</td>
<td>0</td>
</tr>
</tbody>
</table>

**Embodied CO₂e (tonnes)**

<table>
<thead>
<tr>
<th>Renewable House Code Level 4</th>
<th>Trinity Close, Rackheath Code Level 6 (no renewable material)</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>50</td>
</tr>
</tbody>
</table>

**Embodied CO₂e balance (tonnes)**

<table>
<thead>
<tr>
<th>Renewable House Code Level 4</th>
<th>Trinity Close, Rackheath Code Level 6 (no renewable material)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>50</td>
</tr>
</tbody>
</table>

The Centre for the Built Environment’s Renewable House is located on the BRE Innovation Park alongside seven other demonstration buildings showcasing sustainable building innovation. The Renewable House is the flagship building for the demonstration of renewable materials in sustainable design and construction.

The BRE Innovation Park was created in 2005 with the aim of testing pioneering ideas before applying them to real communities. The Park’s aim has been to push the boundaries of current knowledge and practice; to educate stakeholders, form new collaborations and drive change across the built environment. See www.bre.co.uk/innovationpark for further details.

Designed by Archial Architects, the Renewable House achieves Code for Sustainable Homes Level 4 at a competitive price. Not only is Code Level 4 achieved, but the design of the house has also significantly reduced the embodied carbon in the materials used.
Materials, MVHR and Energy

Part of the Centre for the Built Environment’s demonstration process involves the monitoring and verification of the following manufacturers’ performance specifications:

**MVHR**

The Mechanical Ventilation with Heat Recovery (MVHR) system is supplied by Airflow Developments Limited – Ventilation Solutions. Airflow Developments was established in 1965 and has been designing and manufacturing Ventilation Solutions for residential dwellings and commercial buildings since then. The product range extends from quiet, stylish extractor fans to high efficiency DUPLEXVENT Mechanical Ventilation with Heat Recovery systems. The products are SAP Appendix Q eligible, Passivhaus Institute approved and BREEAM applicable. The comprehensive ventilation system includes the innovative Airflex PRO with zero leakage and semi rigid ducting. Duplexvent MVHR systems save energy and improve the indoor environment with over 90% heat recovery, by supplying warmed fresh, filtered air to living rooms while extracting unwanted moisture and airborne pollutants from toilets, kitchen and wet rooms.

**Thermafleece™ loft insulation**

The insulation is Thermafleece™, which is made from the wool of British hill sheep. Natural insulation doesn’t mean sacrificing performance for principles.

It can at least match the market-leading mineral materials in terms of providing effective insulation. Natural materials can also offer several additional benefits including reduced greenhouse gas emissions, ease of handling and good acoustic insulation properties.

**Energy**

The heating of the house is supplied by Warmup Plc, a leading electric floor heating brand. The system is a Code for Sustainable Homes Level 4 + 8 heating system. This is based on:
- Complete solution – no radiators, more space, no air currents, no overheating.
- Easy to install – no screeding, drying time or specialist trade involvement. The 1.5mm wire is placed above the screed and insulation layer, directly below the floor surface.
- Precise heat control with Warmup’s SIE energy-monitor thermostat. The market leading SIE energy monitoring thermostat has been tested against leading competition to have the most precise algorithmic control systems to stay closer than competitors to the desired temperature.
- Cost effective – competitive pricing structure, maintenance free, lifetime warranty.
- For all floors – marble, ceramic, wood, laminate, vinyl and carpet.
- Energy efficient – fast heat-up time, low usage, low CO₂ - very low embodied CO₂.

- Quality – thinnest, highest quality cable with the most regulatory approvals.
- Domestic hot water is provided by the Warmup Solar Thermal Collector in partnership with Tisun. These highly efficient panels include a control system which monitors energy production.

**Windows**

The use of renewable materials continues with the high-performance triple glazed timber windows from Jeld-Wen. The windows provide a U value of 1.3 W/m²K and careful attention to detailing has minimised conductivity. The style of the windows has a high percentage of glazing to maximise daylight.

**Fabric**

FSC load bearing timber frame with internal boarding and Hemcrete®, is a material manufactured by Lime Technology that is renewable and sustainable, as well as delivering high levels of insulation, airtightness and vapour permeability.

The 300mm Hemcrete® wall delivers a steady state U value of 0.19 W/m²K and has been designed to achieve an air tightness of 2.0m³/(hr.m²). The monolithic nature of Hemcrete® means this is easily achievable. Hemcrete® is made from the core (shiv) of hemp plants and a special lime based binder (Tradicale® HB); which together form a bio-composite building material. By using Hemcrete® the Renewable House has locked 110 kg/m² CO₂ into its walls.

**Carpet – SmartStrand® with DuPont™**

The carpet in the Renewable House is made by Mohawk using SmartStrand® with DuPontTM Sorona® which is made in part with naturally occurring sugars from readily available and renewable crops.

Thanks to the Bio-PDSTM central ingredient, 37% of Sorona® is made from renewable resources instead of more limited petroleum-based ingredients. This means that the carpet:
- Consumed 30% less energy than an equivalent amount of nylon.
- Reduced greenhouse gas emissions by 63% against an equivalent amount of nylon.
Renewable materials projects

The Exemplar Low Carbon Building
University of East Anglia
- Will host an enterprise centre, teaching and learning rooms – including a lecture theatre with up to 300 seats – in a building of at least 3,000m²
- Facilities for testing the next generation of renewable materials
- Brettstapel timber with hemp and flax batts

Marks & Spencer
Cheshire Oaks
- A new 195,000 sq ft flagship sustainable store designed by Aukett Fitzroy Robinson Architects and built by main contractor Simons Construction Ltd
- Using Hemclad®, an innovative hemp based pre-fabricated wall panel that features Tradical® Hemcrete®, 230 pre-fabricated panels, typically 2.4m high x 4.8m wide and 400mm thick
- The store. Marks and Spencer’s second largest store after Marble Arch in London, is expected to create more than 350 jobs

Hab Oakus
The Triangle Swindon
- The first project by Hab Oakus, a developer part owned by Grand Designs host Kevin McCloud
- Intended to meet Level 4 of the Code for Sustainable Homes with the potential to upgrade to carbon zero status
- Designed by Glenn Howells Architects, it comprises 42 homes
- The scheme was built using Tradical® Hemcrete®, which was cast on-site

Inspire Bradford
Business Park
- 260 thermally efficient, 44cm thick, prefabricated ModCell® straw bale wall panels assembled at the nearby Flying Factory™ located in Dewsbury
- At 2,787m² it is the largest straw bale development in Europe

Renewable House partners

The Centre for the Built Environment (CBE) is part of the Adapt Low Carbon Group. The CBE draws upon expertise from InCrops and UEA to deliver free business support and consultancy services for the Adapt Low Carbon Group.
- t. 01603 591566 www.adaptcbe.co.uk
- Archial has a strong track record of delivering intelligent architectural solutions in the public and private sectors. They keep abreast of, and have led, innovations in sustainability in this built environment. Their expertise covers design and procurement advice and extends to sustainability consultancy, strategic planning and operational and management guidance.
- t. 020 7588 0400 www.archialgroup.com
- BRE is an independent and impartial, research-based consultancy, testing and training organisation, offering expertise in every aspect of the built environment and associated industries. They help clients create better, safer and more sustainable products, buildings, communities and businesses – and support the innovation needed to achieve this.
- t. 01923 666400 www.bre.co.uk
- Archial is a leading producer of the thinnest electric floor heating and radiant wall system, with three EN442-2 compliant test facilities in Germany and a number of monitored houses in Germany and the UK. Archial is the world’s best-selling electric floor heating brand.
- t. 0845 345 2288 warmup.co.uk/comuk
- Warmup is among the world’s most sustainable flooring producers, with carpets such as EverStrand and SmartStrand providing homes and business with a more viable sustainable option. As the world’s largest flooring manufacturer, Mohawk invests heavily in research and development, working with leading suppliers to develop new and innovative solutions that are more responsible for their impact on the planet.
- t. 0845 603 1143 www.limetechnology.co.uk
- Mohawk is among the world’s most sustainable flooring producers, with carpets such as EverStrand and SmartStrand providing homes and business with a more viable sustainable option. As the world’s largest flooring manufacturer, Mohawk invests heavily in research and development, working with leading suppliers to develop new and innovative solutions that are more responsible for their impact on the planet.
- t. 0845 345 2288 www.warmup.co.uk/comuk
Free business support

The Exemplar Low Carbon Building Project was awarded £6.2m from the European Regional Development Fund in October 2011. As a condition of this funding, the Centre for the Built Environment will provide free business support. This support is delivered through a series of bespoke CPD accredited seminars, webinars and other support showcasing the design, build and post-occupancy of the Exemplar Low Carbon Building at UEA which is targeting BREEAM Outstanding and Passivhaus Certification.

For more information or to book a place at a seminar, please visit: www.adaptcbe.co.uk

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Printed on 100% post-consumer waste paper on a waterless printing press powered by green energy at a carbon neutral printers using vegetable based inks
Print: Anglia Print Ltd  Design: Woolf Designs