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2. Life Cycle Analysis with Sturgis Carbon Profiling

BRE Watford, UK Passivhaus Competition 2012 Stage 2 - Chestnut House

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1a. Life Cycle Analysis with Sturgis Carbon Profiling

"The embodied carbon used to create a building may be as high as 62% of its total whole life emissions for some building types"[1]

At bere:architects we always aim to design to Passivhaus standards and adopt its methodologies where possible, because this allows us to rigorously quantify and verify the performance of our buildings in terms of operational energy use. Up until now have had to rely on intuition and limited information in order to specify materials, processes and products which we believe to be inherently low in embodied energy. As a result we have found it increasingly frustrating that we are not able to rely on a similar standard of assessment in order to ascertain the most appropriate options for each given project. We wished to find a way of generating and understanding embodied energy figures in the same way that we currently do for operational energy data.

To this end we approached Sturgis Carbon Profiling (SCP) to perform a Life Cycle Analysis of Chestnut House[2] because we believe their development of a Carbon Profiling methodology provides the clearest picture of a buildings embodied energy emissions.

Sturgis' report was produced in line with their RICS paper, 2010[3], which introduced and described their Carbon Profiling methodology in detail. The ultimate aim being to provide a common metric with which it is possible "to evaluate all emissions generated by buildings with respect to time"[4].

This new approach to building energy analysis is arguably one of the very first attempts to provide extensive and conclusive information about a buildings true emissions. As such we thought it essential to appropriate this methodology for this project in order to accurately and comprehensively calculate the buildings embodied energy emissions. With this information we are then able to analyse how it may be possible to reduce the, already low, emission figures and ultimately aim for Zero Carbon status for both embodied and operational carbon emissions.

1 Lane, T., 2007. Our Dark Materials. Building Magazine, 2007, Issue 45. (As quoted by Simon Sturgis and Gareth Roberts of Sturgis Associates.)
2 Refer to the appendix for a copy of the full report.
3 RICS Research, 'Redefining Zero: Carbon Profiling as a Solution to Whole Life Carbon Emission Measurement in Buildings', 2010.
4 RICS Research, 'Redefining Zero: Carbon Profiling as a Solution to Whole Life Carbon Emission Measurement in Buildings', 2010. p.8.

1b. The Importance of Life Cycle Analysis (LCA)

"Life Cycle Analysis will increasingly become part of our lives as the UK responds to climate change through evolving legislation."[5]

LCA seeks to help us understand how much energy our buildings use throughout their entire life-span by employing a calculation methodology which can break down all emission sources that can be indentified over the life of a building into categories and sub-categories for easier analysis. As introduced by the new CEN/TC350 calculation methodology this typically includes four main categories which can be summarised as follows:

- Product Manufacture (carbon arising through production process)
- Construction (carbon arising through site works etc.)
- In Use (carbon arising through heating, lighting, cooling and repair/replacement)
- End of life (de-construction only, not including any recycling potential values) [6]

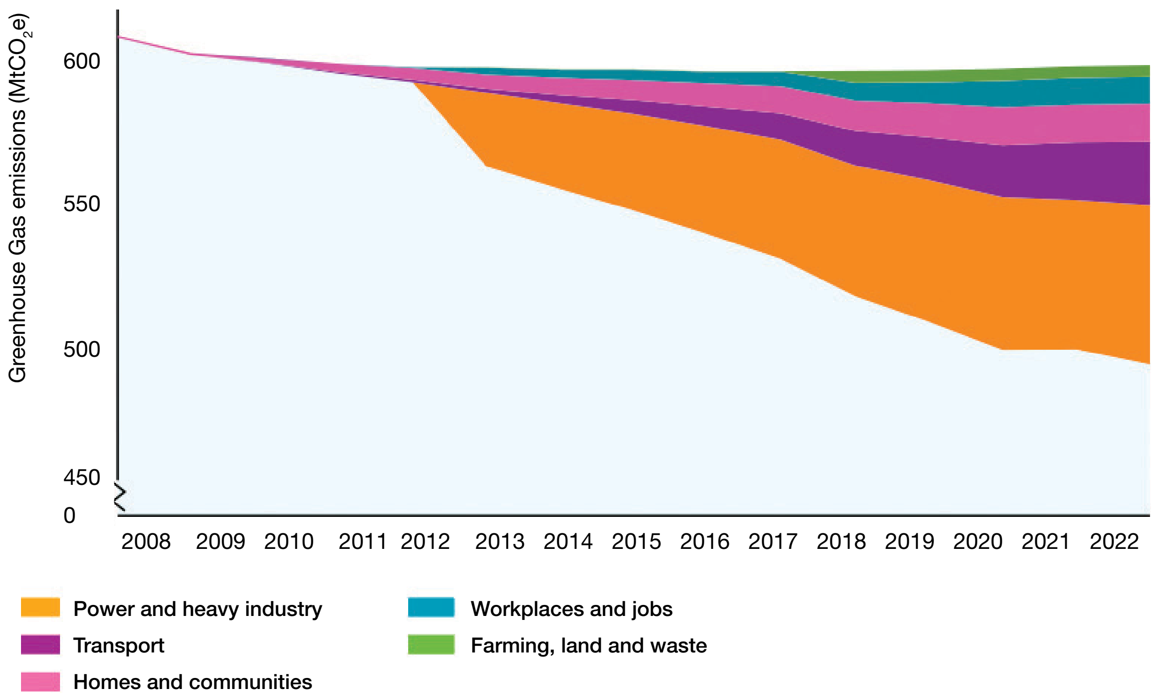
SCP have added a fifth category, Commuting, to their calculations which they argue to be "necessary for assessing office buildings due to the impact a building's location makes on staff commuting carbon emissions."[7] This category does not factor into the results for this scheme, but it is useful for highlighting the varying importance each category can have depending on the type of building.

Using these categories and their sub-categories, it is possible to see where most of the energy is concentrated and therefore allow us to focus our efforts in the right places to help us gain the best improvements as effectively as possible.

LCA is important for us to be able to consider and understand the energy usage of our buildings beyond operational emissions and to take into account the embodied energy of the materials and processes used throughout the lifetime of the building. New standards introduced by 'Committee Europe en de Normalisation' (CEN), namely CENTC350, have established calculation methodologies which aim to harmonise the assessment of the sustainability of construction works across Europe. Once legislated this will mean that reporting of all building and product emission sources will be required, in addition to operational emissions (Part L etc.) giving us a more detailed and holistic view of the impact of the construction industry on the environment. As far as the UK is concerned, this move may happen relatively quickly due to recommendations in the 2010 'Low Carbon Construction IGT Report' published by H M Government, "which calls for the UK Government to act and to introduce mandatory Life Cycle Analysis as soon as possible for all buildings."[8]

As the graph below shows, in order for the UK to meet its 20% reduction in CO_2 emissions by 2020, housing has a large part to play in reducing our figures. We therefore see this move towards the employment of a more rigorous and accurate analytical technique as an essential part of our overall emission reductions.

5 'Chestnut House: Life-Cycle Analysis' Report. Sturgis Carbon Profiling, 2011.
6 'Chestnut House: Life-Cycle Analysis' Report. Sturgis Carbon Profiling, 2011. p.1.
7 'Chestnut House: Life-Cycle Analysis' Report. Sturgis Carbon Profiling, 2011.
8 'Chestnut House: Life-Cycle Analysis' Report. Sturgis Carbon Profiling, 2011. p.1.



1c. Conclusion and Response to Report Findings

"Significantly we believe with ongoing development of the LCA and integrating the supply chain more fully it may be possible to create a home that could be "zero" in both operational and embodied carbon.

This would make Chestnut House achieve a level of LCA carbon performance never documented in the United Kingdom."[1]

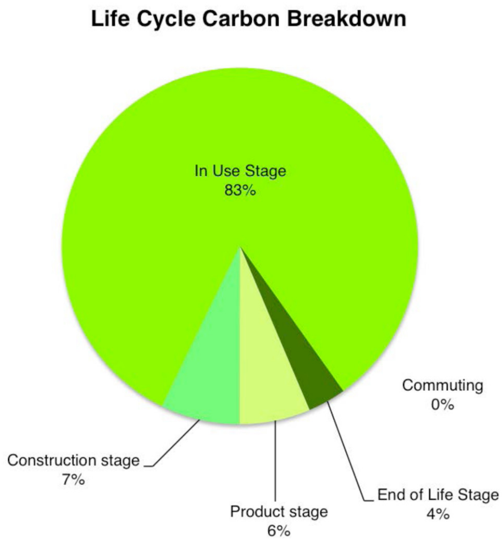
When looking at the Life Cycle Assessment section of the SCP report, it is immediately apparent that the 'In Use Stage' of the 'Life Cycle Carbon Breakdown' chart below contributes a significant proportion of the buildings overall carbon emissions at 63%. The reason for this is explained in part when looking at the 'Life Cycle Carbon Emission of Building Component' graph which shows negative figures for the facade and roof. The captured carbon in the timber cladding and other areas serves to reduce the total embodied emissions relative to the operational figures. Further to this we must note that while the 'In Use Stage' percentages appear significant, the overall emissions figures are so low that ultimately all emissions figures may be regarded as insignificant (see quoted figures below), at least compared to a standard model house, and hopefully nonexistent if 'Zero Carbon' status is achieved.

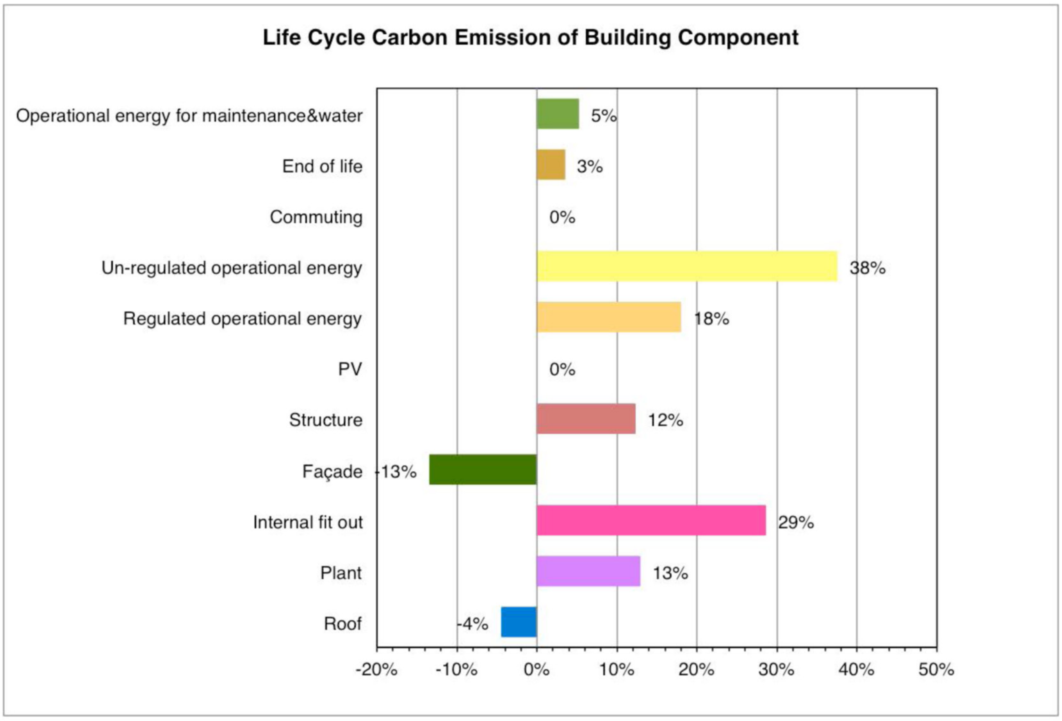
1 'Chestnut House: Life-Cycle Analysis' Report. Sturgis Carbon Profiling, 2011.

Building Baseline Footprint: 2,300 Kg CO2e/msq

Current Footprint: 1,394 Kg CO2e/msq

Potential LCA Footprint: 685 Kg CO2e/msq





This view is supported by SCP as stated in their report: “Our aim is to make this building a truly Zero Carbon home from both operational and Embodied respectively by taking consideration of renewables and sequential benefit.”[1]

Considering transport emissions concerns, we aim to source materials as locally and sustainably as possible, therefore reducing the embodied energy of the materials and products by minimising transportation emissions and road miles. We have included provisions for bicycle storage in order to encourage building users to travel by bicycle and minimise dependency on automobile transportation. These transport considerations have been factored into the SCP report in both the Construction and End of Life Stages.

1 ‘Chestnut House: Life-Cycle Analysis’ Report. Sturgis Carbon Profiling, 2011. p.10.

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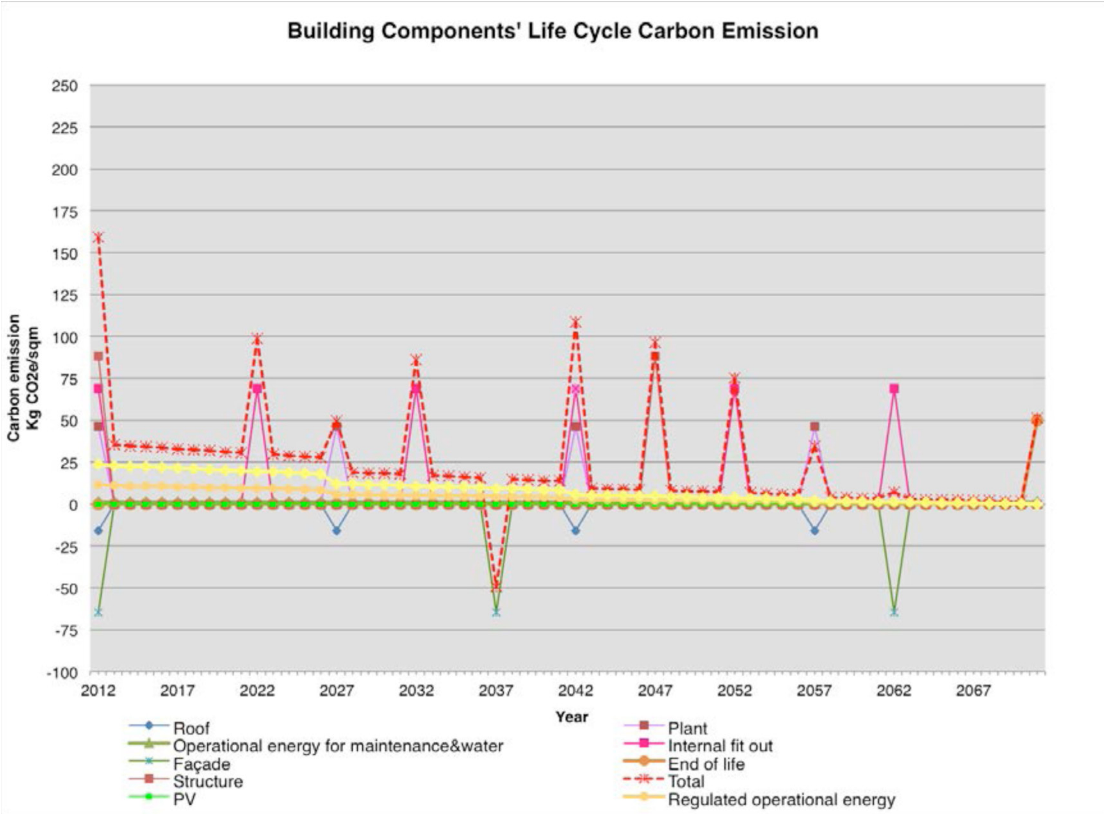
The graph below shows the 'Building Components' Life Cycle Carbon Emissions' relating to the above graph. Here we can see the same emissions data considered throughout the assumed life-span of the building, excluding the un-regulated operational energy data. It is clear from this that most emission peaks coincide with maintenance requirements.



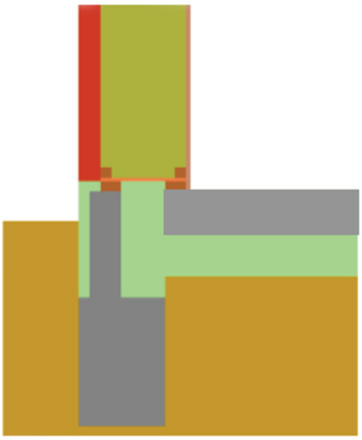
Although construction waste and end of life waste disposal only contribute a relatively small proportion of the overall energy emissions figures, they remain an important consideration. Where possible we have strived to minimise waste through responsible design and procurement of materials and products as detailed in our specification. Richard Whidborne, the Quantity Surveyor for the project has also produced a life-cycle cost estimate which covers disposal and waste management.

SCP included measures by which they believe these emission peaks could be reduced or completely eliminated as outlined in this table:

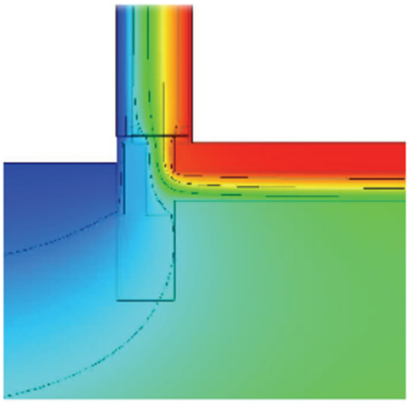
Option	**Saving**
1 Use of Timber Piling to avoid ground disturbance and minimize excavation saves:	27 KgCO2e/msq
2 Substitute XPS insulation saves:	37 KgCO2e/msq
3 Substitute mineral wool and rockwool insulation with alternative materials pending review saves:	5 KgCO2e/msq
4 Substitute plasterboard with timber or similar material saves:	62 KgCO2e/msq
5 Reduce painted surface saves:	57 KgCO2e/msq
6 Carpet replacement saves:	22 KgCO2e/msq
7 Renewables save:	500-550 KgCO2e/msq

Further to this advice and the potential improvements outlined, we can respond as follows:

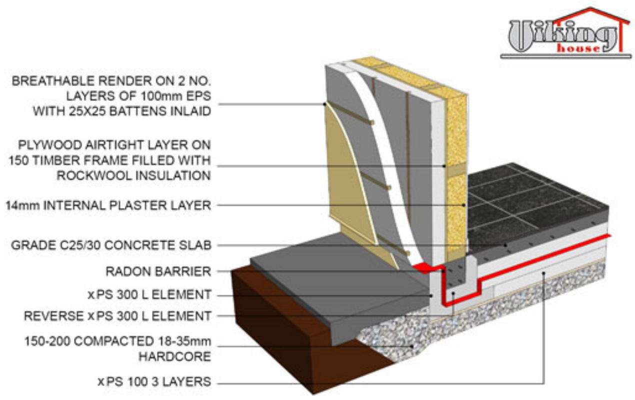
1. Timber piling could potentially be implemented without neccesarily sacrificing performance charicteristics compared to traditional piles. Other options for the floor could include:



Above Left: Foundation detail showing an insulated Ring Beam construction



Above Right: Thermal bridge analysis of foundation detail using 'Therm' software



Above: Detail showing foundation option for concrete ring beam. With this option less concrete would be needed than with a raft. Less excavation would also be needed.

2. The XPS insulation could be substituted along with the concrete slab as shown below:

Detail showing XPS insulation and currently specified concrete slab.

Detail showing the potential to replace with laminated timber and foamglass insulation.

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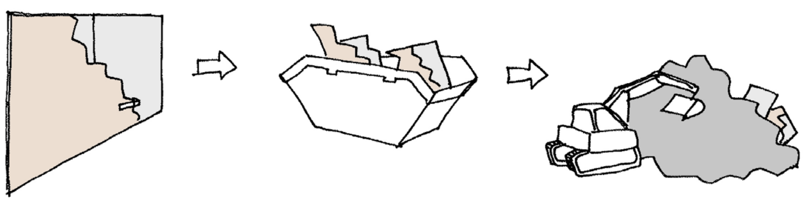
3. The Mineralwool and Rockwool insulation currently specified could be replaced with Woodfibre which is not only less harmful to work with, but also emits no undesirable chemicals once installed and has lower embodied energy:

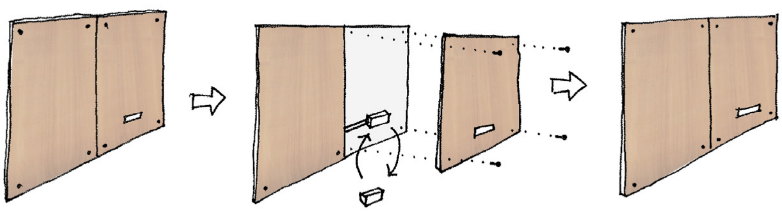
Above: Section detail showing Woodfibre insulation illustrating its natural inert qualities.

Below: Section detail showing traditional mineralwool insulation illustrating its tendency to create dust and irritating particles.

4 & 5. The interior plasterboard wall linings could be replaced with 'Fermacell' and then finished with European birch ply treated with a water-based varnish. This has the added benefit of omitting the need for plaster skim and also making repairs easier and less wasteful:



Traditional plasterboard linings do not allow for easy repair and maintenance and usually need to be replaced.



Timber sheets can be easliy removed, adapted and refitted within minimum effort and wastage.

6. Carpets have been omitted from the scheme and instead we will have exposed ply sheeting finished with a water-based varnish. This will have the benefit, not just of limiting the amount of materials we use, but also allow the spaces to be easily cleaned and maintained.

7. We shall install Photovoltaics if deemed appropriate and if the budget allows (£10,000 has been allocated to the market house in the cost plan):

Illustration showing the possible location and configuration of Photovoltaic panel on the roof of Chestnut House.

If these measures are taken and all necessary steps carried out to eliminate all carbon emissions, both embodied and operational, then we may be able to set a new standard for construction and pave the way for real change and a cleaner, more responsible future.

When this system is employed and embraced widely then we may have a better chance of meeting our CO2 reduction targets in 2020. We hope this project may serve to demonstrate that this potential is already within reach, while also being afordable, flexible and desirable places to live in.

By developing a common metric that can be tested and compared against already well understood operational energy emission figures, such as those that Passivhaus methodology promotes, we hope that we will now be able to make informed and accurately considered desicions when it comes to specifying products, process and materials for our projects.

2. Component Replacement Intervals and Servicing Requirements

Aside from ensuring that we specify high quality products and employ skilled craftsmen in order to reduce the maintenance intervals of the building generally and extend its lifespan as much as possible, we have also more specifically invented a solution to the problem of filter maintenance intervals. In a UK city, we are able to reduced air filter maintenance intervals to two or three years, and allow filters to be changed from outside the house. We are in the process of prototyping a unique product that we propose to install in the house for the first time.

The new Long Life Filter will enable social housing landlords to change the filters without gaining access to the houses, and to carry out maintenance at exceptionally lengthy intervals. Furthermore, the problem of neglected maintenance in the private sector can be overcome with an economical service contract to change the main intake air filter once every two or three years as necessary.

We expect this breakthrough to quickly become established as a normal and essential requirement in both the UK rental and private sectors, and our solution is published for the very first time as part of our entry for this competition.

SOLUTION 1: BOILER + Paul Focus 200 - Compact mechanical ventilation with heat recovery unit.

SOLUTION 2: Drexel und Weiss - Aerosmart M

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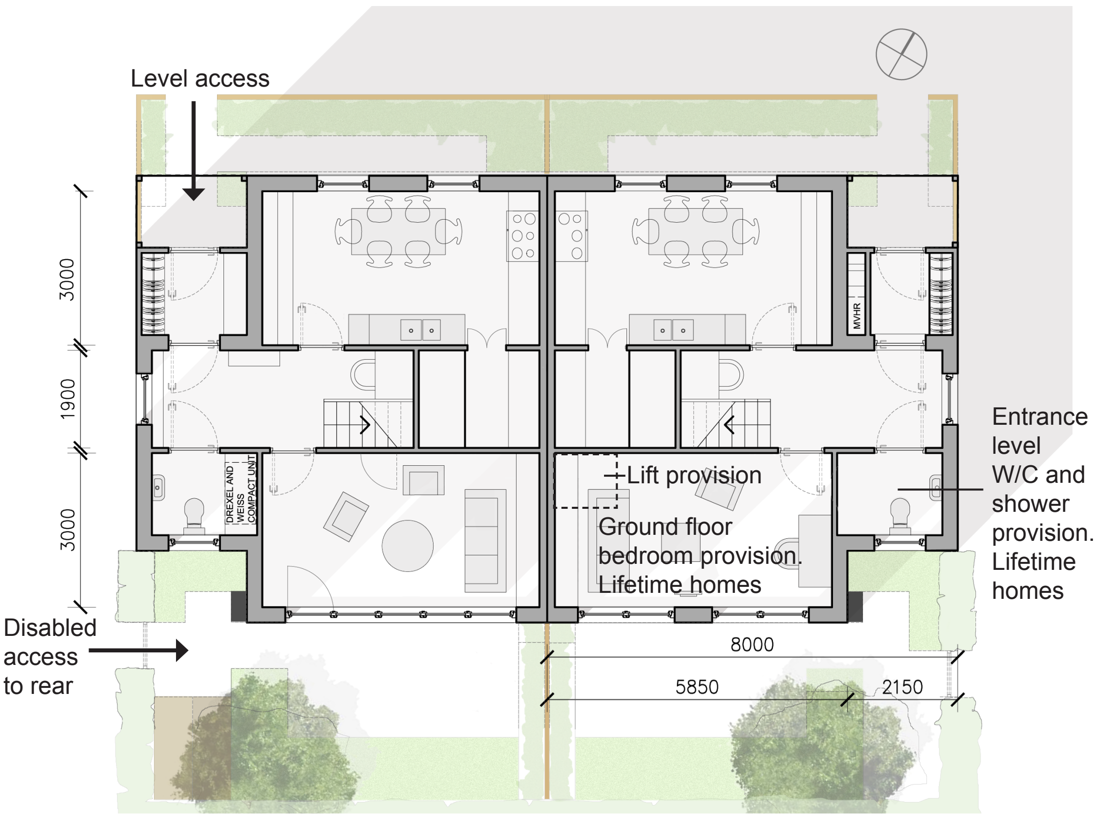
3. Whole Life Adaptation and Disabled Access

The proposed semi-detached house is further adaptable to different sites, orientation, climate and context, through minimal changes to window areas or roof pitch orientation. These are easily verified through the PHPP package to deliver the desired energy consumption. We have produced a terraced house plan, with the front door located on the front elevation, rather than via the side of the house.

The houses can be replicated to accommodate different street layouts, and contribute to a rich neighbourhood and cityscape. The house proposes a responsive architecture which adapts to the natural and the built context. The house has been desinged to 'Lifetime Homes Standards' as shown in the drawing below.

Further to these general allowances we have also incorporated the following details:

- Entrance: All paths are at least 900mm wide, and use porous hard surfacing. They are located so as to provide access to all areas for all ability levels.
-Horizontal circulation: The floors within the new house are level and the threshold between the building and front path are level, providing level access into the house.
- All light switches will be positioned at 1200mm above floor level and door handles at 1000mm.
- Plug sockets will be located 450mm from the finished floor level
- Vertical circulation: Stairs will, where possible, comply with Life Time Homes guidance.
- Bike parking: A bike store has been provided for bikes in the shed at the rear of the house adjacent to the garden side access gate.



4. Sustainable Procurement

The house is designed to be constructed using energy-efficient cost-effective methods employing local skills wherever possible. We have prioritised issues relating to embodied energy and carbon, waste minimisation and disposal, and also end of life recycling and reuse of materials. We will also investigate innovative ways to manufacture materials on or close to the site in order to minimise energy usage and associated embodied energy levels.

All materials and finishes will be specified to Grade A of the BRE's Green Guide to Housing Specification, and will use as much as possible local, sustainable sources, paying attention to end of life recycling and reuse options. Each element within the design has the ability to be amended to respond to local environments, craftsmen and materials. We are investigating alternative supply chains to ensure British materials and local craftsmanship are used throughout.

The exterior chestnut cladding utilises locally sourced finger-jointed timber, highlighting our interest in supporting local companies and craftsmanship. We have chosen to show it painted. The refined detailing reflects the essence of a traditional approach to construction. All timber specified is to be from sustainable local, UK or accredited sources.

The roofing is Monier Redland slates made in Wales from over 60% recycled slate. On top of this, GGBS cement reduces the CO2, NOX and SO2 emissions of concrete by 70% and reduces the embodied energy of the concrete by 40%.

The JJI engineered studs and joists, timberframing, Warmcel insulation from recycled newspaper and chestnut weatherboarding, are all natural stores of CO2. We are interested in promoting local supply chains, so we sourced JJI-joists and studs made by James Jones Joists, for both the floor and wall build up. The company is involved in research projects exploring forestry techniques to raise the structural quality of local timber. (The joists currently use British timber for the web, but Scandinavian for the flanges, whereas the JJI wall studs are made exclusively from UK sourced timber). The use of these all-British made engineered wall studs, using all British timber is an excellent means of achieving a high performance wall build up at minimum cost and with minimum thermal bridging. This is arguably a refinement and improvement upon what we did in the BRE Wales houses.

Alternative cladding materials could replace the chestnut timber without affecting the performance of the building. Other locally sourced timbers may be used, including larch, cedar, oak or painted softwood, as well as entirely different materials that reflect characteristic regional variations such as slate or breathable lime render.
The Passivhaus certified windows are manufactured from FSC certified timber sources local to the producers. We have not yet decided whether to use the Vale Window that was designed and certified as part of the BRE Wales project, or whether to source a more reliable product from our usual partner in Germany, Bayer windows near Freiburg. We are, incidentally, in early discussions with Bayer to transfer production to the UK within 10 years, upon retirement of the factory owners.

bere:architects work is an embodiment of the BS 8903:2010. In line with the intentions of the BS 8903:2010 our commitment to sustainable procurement is based on a sense of public duty which has amounted in sustainably led procurement policy supported and maintained by the people within our organisation. A detailed outline specification is provided separately for more information.

Appendix Document: