Low Carbon Homes

13th January 2020
Low Carbon Homes

Welcome and Introduction

Retrofitting your home to low carbon standards, followed by Q&A

• Heather McNeill, Passivhaus Designer, AdPractice Ltd

Discussion and break

Alternatives to gas boilers followed by Q&A

• Simon Robinson, Director, Solinvictus

Discussion and close
Welcome to Our Planet Our Future

Inspiring Action

21 April 2018 | Rothamsted Research | Harpenden

Speaker Videos
Visit www.sustainablestalbans.org or search for Our Planet Our Future on YouTube.

Our Planet Our Future
Inspiring Action

SUSTAINABLE
St Albans
Working together for an environmentally sustainable district
Pledges from some of our previous Our Planet Our Future events
Please add yours tonight!
The silver birch tree was planted by Harpenden town mayor, Cllr David Heritage, in Leyton Green, Harpenden.

The crab apple tree was planted by Cllr John Hale in the William Bell Playground, Marshalswick.

The final tree, a copper beech tree, was planted in Clarence Park, St Albans on 6 February.
Upcoming events:

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9 Mar, Rewilding; 11 May, Leave your car at home;  
13 Jul Sustainable holidays, 14 Sep (tbd), 9 Nov (tbd)

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Retrofitting

to Passivhaus and
low-carbon standards

Heather McNeill
Associate
Certified Passivhaus Designer
BSc(Hons) Dip Arch
heather@adpractice.co.uk
Who am I?

- Local architectural designer specialising in sustainable building and Passivhaus design
- Currently on site with an EnerPHit Plus (Passivhaus retrofit) project in Harpenden (details later!)
- Pre-application advice stage for three new Passivhaus dwellings in St Albans
- Developing a pre-fabricated system for an upcycled sustainable gym in the Harpenden area
- Overseeing the conversion of a Grade 2 listed barn in Harpenden to five low-carbon dwellings using natural sustainable materials
- Designing a low-carbon home in Wheathampstead using natural sustainable materials
So what is a Passivhaus?

Five principles:
- Thermal insulation
- Passive House windows
- Ventilation with heat recovery
- Airtightness
- Thermal bridge free design

It is a thermal comfort standard!
What does this mean?

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Passivhaus</th>
<th>Average UK house</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary energy demand (electricity use)</td>
<td>$\leq 120,\text{kWh/m}^{2}/\text{yr}$</td>
<td>$&gt; 400,\text{kWh/m}^{2}/\text{yr}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(4 x as much)</td>
</tr>
<tr>
<td>Space heating demand (energy used for heating)</td>
<td>$\leq 15,\text{kWh/m}^{2}/\text{yr}$</td>
<td>$&gt; 200,\text{kWh/m}^{2}/\text{yr}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(13 x as much)</td>
</tr>
<tr>
<td>Air tightness</td>
<td>$\leq 0.6,\text{air changes/hr}$</td>
<td>$\leq 10,\text{air changes/hr}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(16 x as much)</td>
</tr>
</tbody>
</table>
Why do it?

Aside from the obvious reduction in energy usage:

- More comfortable!
- No heating bills
- Low energy bills
- Healthy internal environment
- Future-proof
- Good for the planet
- Ideal for ‘lifetime home’ proposals
Low-carbon retrofitting
Typical home energy usage

- Space heating
- Cooking
- Lighting
- Appliances
- Hot water
- Roof
- External walls
- Draughts
- Floor
- Openings
Hierarchy of actions

1. Building location, orientation and form
2. Fabric element design
3. Airtightness and ventilation
4. Renewable technology
5. Appliances and lights
6. Use

Decreasing opportunity to reduce energy use
Building location, orientation and form

Many retrofits involve extensions and internal alterations:

- Reduction in energy usage
- Optimise daylighting
- Create a compact form
- Orientate towards the south

To balance maximising winter solar gains (south) with minimizing thermal losses (north)
Building location, orientation and form

- Winter solar gain vs summer solar shading
- Easier in new build projects but can be implemented in retrofits
Fabric element design

Reduce heat loss and energy use by optimising existing key passive fabric elements, in order of priority based on surface area:

1. External walls
2. Roof
3. Ground/basement floor
4. Windows
5. Doors
Fabric element design – walls

- External insulation is the most efficient way to insulate existing external walls
- Internal insulation requires careful detailing and reduced thicknesses
- Use sustainable materials, such as woodfibre, wherever possible
Fabric element design – roofs

- Often the easiest element to retrofit
- Care must be taken to ensure there are no thermal bridges and that a ventilation gap is maintained
- Consideration should be given to roof coverings
Fabric element design - floors

- Often the hardest and most expensive element to retrofit
- Floor insulation is difficult to do sustainably in a solid-floor property
- It is simple to DIY retrofit your own suspended timber floor
Fabric element design – windows/doors

<table>
<thead>
<tr>
<th>Type</th>
<th>Single</th>
<th>Double</th>
<th>Double low-e, Ar</th>
<th>Triple low-e, Ar</th>
</tr>
</thead>
<tbody>
<tr>
<td>$U_g$ value w/m²K</td>
<td>5.60</td>
<td>2.80</td>
<td>1.20</td>
<td>0.65</td>
</tr>
<tr>
<td>Surface temperature -10°C out; 20°C in</td>
<td>-1.8°C</td>
<td>9.1°C</td>
<td>15.3°C</td>
<td>17.5°C</td>
</tr>
<tr>
<td>Solar transmittance</td>
<td>0.92</td>
<td>0.80</td>
<td>0.62</td>
<td>0.48</td>
</tr>
</tbody>
</table>

Triple glazing with low-e coating and Argon fill is the only way to meet Passivhaus regulations for internal thermal comfort.

Note: high performing double glazed units are also very efficient compared to standard units.
Airtightness and ventilation

- Ventilation is the second greatest contributor to heating running costs in modern homes
- Minimise uncontrolled air leakage
- Good ventilation reduces humidity levels
- With increased insulation in building elements, the losses due to uncontrolled ventilation become significant
Airtightness and ventilation

- MVHR = mechanical ventilation with heat recovery
- Key aspect of Passivhaus and low-carbon energy efficient design
- 95% efficient (trickle vents are 0% efficient!)
- Fresh air 24/7 at room temperature
- Free from pollutants and allergens due to filters in the system
- Quiet!
Airtightness and ventilation

- New windows and doors should not have trickle vents
- Ensure they are correctly installed with all joints airtightness taped
- Common airtightness strategies involve internally sheathing properties with a service void in front
- One of the most common draughts is via the bath waste penetration
Costings

- Often the biggest limitation to the project
- Debatable whether retrofits are economically viable
- Can often be cheaper to knock down and start again (and easier to detail)
- Retrofits are subject to VAT at 20% whereas new builds are VAT exempt
- Sustainable natural insulation materials are often more expensive
Case study
Harpenden Passivhaus Retrofit

- Deep retrofit of a 1960s detached house in Harpenden and the addition of a small rear extension
- Aiming to meet the EnerPHit Plus criteria as well as going 'gas free'
What is EnerPHit plus?

- The upper limit for the total demand is 45 kWh/m² yr
- At least 60 kWh/m²/yr of renewable energy must also be generated, with reference to the projected footprint (the ground covered by the building)
How are we doing it?

- Entire front roof pitch with 8kW solar pv array
- Air source heat pump (ASHP) which provides >300% efficient electric heating and hot water
How are we doing it?

- Curtain walls (non-loadbearing external walls) will be removed and replaced with new highly insulated timber I beam walls with cellulose insulation and clad in western red cedar or grey tiles to match the rear roof slope.

- Rear single storey extension will also be highly insulated timber I beam walls with cellulose insulation and finished with either render or timber cladding.

- Existing ground floor is being removed and replaced with a new highly insulated slab with underfloor heating.
How are we doing it?

- The hallway is flooded with natural light with a window at first floor level and a rooflight at the top of a void running the full height of the dwelling. This also acts as a chimney for stack ventilation.
How are we doing it?

- External wall insulation
- Thermal bridge free junction
- Solar shading
- Reducing thermal bridge as much as possible
How will it perform?

<table>
<thead>
<tr>
<th>Space heating</th>
<th>Space cooling</th>
<th>Non-renewable Primary Energy (PE)</th>
<th>Primary Energy</th>
<th>Renovations (PIE)</th>
<th>Component characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>23%</td>
<td>13%</td>
<td>84%</td>
<td>94%</td>
<td>57%</td>
<td></td>
</tr>
<tr>
<td>2%</td>
<td>0%</td>
<td>0.6</td>
<td>0.4</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>2%</td>
<td>0%</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>2%</td>
<td>0%</td>
<td>-</td>
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<tr>
<td>2%</td>
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<td></td>
</tr>
<tr>
<td>2%</td>
<td>0%</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

*Note: The values given here have been determined following the PIERS methodology and based on the characteristics of the building. The PIERS calculations are subject to verification.*

adpractice ltd
Can we see the progress?

- Follow updates on our website: https://www.adpractice.co.uk/
- I am planning to blog the progress of this project here: https://heatherarchitects.wordpress.com/blog/
- Hoping to arrange site tours as part of this year’s Sust Fest
- We have installed data loggers to collect information on the building’s performance pre- and post-retrofit and plan to produce a report
- Speak to the owners!
Thank you for listening

Heather McNeill
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Low Carbon Bingo!

1. What have you done / can you do to make your home into a lower carbon home?

2. Discuss your ideas in pairs then with the whole table

3. Write them on the paper provided

4. Be ready to share one or two ideas with the whole room

5. Remember to write your pledges on luggage labels and add them to the willow lady
<table>
<thead>
<tr>
<th>Insulate hot water pipes and tank</th>
<th>Photo voltaics installed or other zero carbon electrical generation</th>
<th>Full bleed radiators</th>
<th>Organise your home so you make best use of daylight</th>
<th>Insulate walls – cavity wall, external cladding or internal lining</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central heating room temperature set at 18°C or less</td>
<td>Sign up to 100% renewable tariff</td>
<td>Heat recovery ventilation system</td>
<td>Buy A+ or better white goods</td>
<td></td>
</tr>
<tr>
<td>Enclosed porch</td>
<td>Tuck curtains behind radiators</td>
<td>Replace light bulbs with LED or other low energy options</td>
<td>Insulate under ground floors</td>
<td>Block draughts from chimneys in winter (use for passive stack in summer)</td>
</tr>
<tr>
<td>Insulate home so no heating is required</td>
<td>Solar thermal hot water</td>
<td>Draught proof doors, including letter boxes and key holes</td>
<td>Natural shading through planting</td>
<td></td>
</tr>
<tr>
<td>Effective heating controls, such as zoning, thermostatic radiator values</td>
<td>Keep rooms cool in summer by drawing curtains</td>
<td>Draughtproof windows</td>
<td>Low or zero carbon heating system</td>
<td></td>
</tr>
<tr>
<td>Use appliances efficiently, amount of water in kettle etc</td>
<td>Modern electric cooker</td>
<td>Turn off all items on standby</td>
<td>Use a smart meter (and take note of what it tells you!)</td>
<td>Insulate loft, including loft hatch</td>
</tr>
</tbody>
</table>
Alternatives to gas boilers

Simon Robinson - Solinvictus
Gas boilers – the good bits

• Efficient
• Light
• Require no fuel storage
• (Relatively) cheap to run
So what’s the fuss all about?

• Gas is a dwindling resource
• Price will inevitably rise as it runs out
• Produces high levels Carbon Dioxide Equivalent (CO2e)
But it's India or China who's to blame, isn't it?

- High income countries output the most CO2e
- We all have a personal responsibility
- 35% of our carbon footprint typically comes from our home
The chart shows the CO₂e per person (tons) and population (billions) for various countries, categorized by income level—High-income country, Middle-income country, and Low-income country. The chart also includes emissions from land-use change. Sources for greenhouse gas emissions in 2005 are from WRI 2008, augmented with land-use change emissions from Houghton 2009. Population data is from the World Bank 2009c.

Note: The width of each column represents population, and the height represents per capita emissions, so the area represents total emissions. Per capita emissions of Qatar (55.5 tons of carbon dioxide equivalent per capita), UAE (38.6), and Bahrain (25.4)—greater than the height of the y-axis—are not shown. Among the larger countries, Brazil, Indonesia, the Democratic Republic of Congo, and Nigeria have low energy-related emissions but significant emissions from land-use change; therefore, the share from land-use change is indicated by hatching.
The alternatives

- Electric boilers
- Heat pump (air source & ground source)
- Biomass boilers (pellet, chip & log)
- Log burning stove/boilers
- Hydrogen boilers
- District Heating Mains
Electric boilers

• 100% efficient
• Produce the same flow temperatures as gas boilers
• Small & light

• Four times more expensive to run
• Approximately 50% more CO2e emissions than gas
Heat pumps (air source & ground source)

- One unit of electricity in, 2.5 – 5.0 units of heat out (Coefficient of Performance or CoP)
- Approximately 50% less CO2e emissions than gas
- No fuel storage issues

- GSHP require large amount of land for ground loops (or bore holes)
- ASHP sit close to house so there can be aesthetic and noise issues
- Don’t integrate with existing CH systems very well - both work best with low heat output temperatures (35 – 45 degrees C)
Biomass boilers

- Same flow/return temperature as gas boilers
- Approximately 75% less CO2e emissions than gas
- Entirely renewable fuel source

- Large floor mounted boiler & possibly requires large capacity buffer
- Space required to store 2-5 tonnes of fuel
- Emit small amount of particulates
Hydrogen boilers

- Similar in size/capacity to gas boilers
- Low CO2e emissions if hydrogen produced using renewable energy
- No current hydrogen supply network
- Huge CO2e emissions if hydrogen produced using conventional energy resources
The cost of energy

Price per kWh (pence)

Source: Nottenergy cost comparison – Dec 2019
CO2e emissions

Kg of CO2e per kWh

Source: Nottenergy cost comparison – Dec 2019
Heat pumps look great, when can you start?

• Tomorrow - but we should be careful, heat pumps need careful planning

• Underfloor heating is the best way to distribute the low temperature flow & return
• Radiators often need to be increased in size by three or four times
• ASHP - can you live with an ‘air-con unit’ in your back garden?
• ASHP - can your neighbours live with cold air being blown at them?
My house has solid walls and single glazing

• Don’t fit a heat pump (at least not yet)

• Fit biomass boiler if there is enough space
• Install internal or external insulation
• Fit double glazing
Insulate, insulate, insulate

- Whatever form of heating you employ, insulation will improve it
- You can’t have too much
- It reduces running costs and CO2e emissions simultaneously

*(Build a Passivhaus – they really understand the value of insulation)*
A good German boiler manufacturer’s joke

- ‘Let’s just rebrand our commercial boilers and sell them for the UK domestic market’

(Many German/Austrian boilers are 5, 7 or 10kW - most UK boilers are 20, 30 or even 40kW)
Example: 1920s country farmhouse

- Switch from oil to biomass
- Retain existing CH system & comfort levels
- New boiler will be more efficient than old oil boiler so cheaper to run
- Reduce CO2e by nearly over 80%
- Fuel comes from entirely renewable source
- Enjoy income from the Renewable heat Incentive (RHI) for 7 years
Example: 1970s detached house with land

- Improve cavity wall filling, top up loft insulation, improve draft proofing
- Install underfloor heating downstairs, enlarge radiators upstairs
- Switch from gas to ground source heat pump
- Slightly more expensive running costs (1.2p per kWh)
- Reduce CO2e emissions by almost 60%
- Enjoy income from the Renewable heat Incentive (RHI) for 7 years
Example: 1990s semi detached house & garden

- Top up loft insulation, improve draft proofing
- Use existing UFH and enlarge radiators upstairs
- Switch from gas to air source heat pump
- Slightly more expensive running costs (3.17p per kWh)
- Reduce CO2e emissions by almost 50%
- Enjoy income from the Renewable heat Incentive (RHI) for 7 years
What about the other alternatives?

• Log stove/boilers – well worth adding to an existing gas installation as the replaced fuel is carbon neutral
• Hydrogen boilers – Baxi plan to start a live trial in 2020 but the supply network might take a decade to arrive
• District Heating Mains – successfully adopted in Scandinavia and could work well in the UK if there was sufficient demand at a local level
I’m not certain, I think I’ll put it on hold for a few years
Don’t, we need to do something about this now.
A young Swedish lady has famously insisted:

*Humanity is facing an existential crisis due to climate change*

The current generation of adults is responsible for this

*Climate change will have a disproportionate effect on young people*

Too little is being done about the situation
Discussion

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