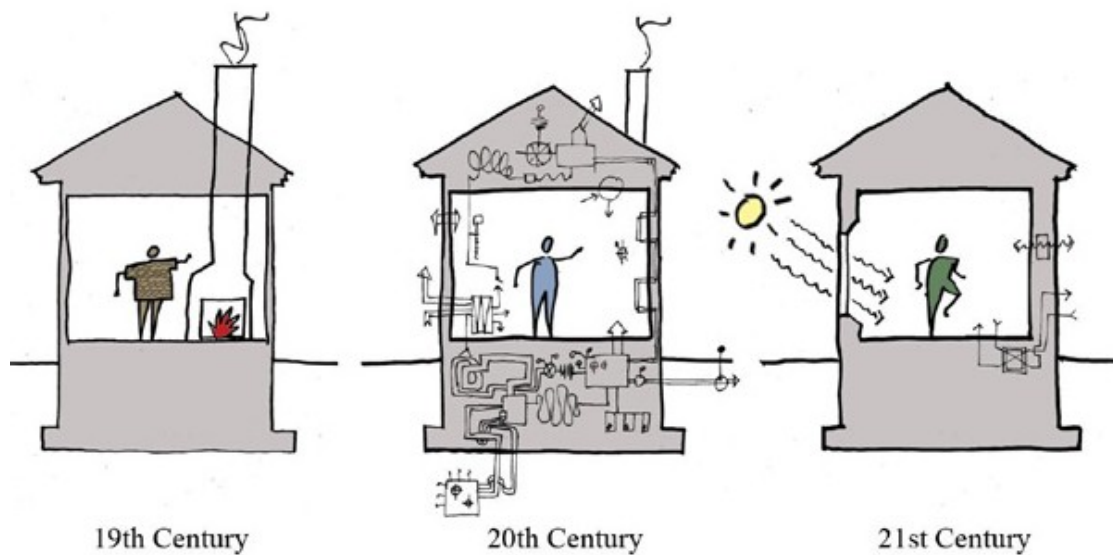


Should Preston City Council adopt the '**Passivhaus**' standards for all new built social housing to alleviate fuel poverty, improve general health and increase profitability within the sector?



## Study Aim:

To evaluate whether building all new social housing in Preston to the Passivhaus Building Standards would help lift families out of fuel poverty.

## Objectives:

1. Understand what is meant by Fuel Poverty
2. Determine the main drivers of fuel poverty
3. Examine who is affected by fuel poverty
4. Understand why Preston is affected more than other cities
5. Look into measures taken by the government to tackle fuel poverty
6. Determine what happens if we do nothing
7. Examine the difference between UK Building Regulation and Passivhaus standards
8. Understand how the adoption of Passivhaus could be used to address fuel poverty
9. Evaluate other associated benefits from building to Passivhaus

## Definitions:

- **Passivhaus:**
  - Good levels of insulation with minimal thermal bridges
  - Excellent level of airtightness
  - Good indoor air quality, provided by a whole house mechanical ventilation system with highly efficient heat recovery
  - Energy from passive solar gains and quantified internal heat sources:
    - Space heat demand:  $\leq 15 \text{ KWh/m}^2/\text{yr}$
    - Space Cooling:  $\leq 15 \text{ kWh/m}^2/\text{yr}$
    - Heating load:  $\leq 10 \text{ KW/m}^2$
    - Primary Heat demand:  $< 120 \text{ KWh/m}^2/\text{yr}$
    - Pressurisation Test Result:  $\leq 0.6 \text{ ACH @ n 50 PA}$

- **Thermal Bridging** Areas with reduced insulation or has higher U –values which allow greater amounts of heat to escape and can lead to condensation with mould growth on adjacent surfaces.
- **Energy in use** The energy required by users of an existing commercial/ residential building or proposed planned building. Primarily consumption through heating internal spaces, heating water and lighting, (and the need to reduce it) (*Sustainable Homes 1999*)
- **MVHR System** Mechanical Ventilation with Heat Recovery System. Air to air heat pump that uses the internal heated air that is being expelled to heat fresh air obtained from outside an airtight property.
- **Fuel Poverty** In England Fuel Poverty is measured using the Low Income High Costs (LIHC) Indicator, calculated by gauging if a household's income would fall below the official poverty line (income below 60% of the median average) after spending the actual amount needed to heat the home.
- **Adequate Heating** In England, this is defined as 21°C in the living room and 18°C in other occupied rooms.

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## 3.0 Introduction

The main focus for this report is to determine whether or not all social housing in Preston should be built to Passivhaus (a more stringent building standard), and identify any associated benefits for the end user and housing providers. The report intends to promote a greater understanding of the Passivhaus Building Standard, comparing its strengths and weaknesses against UK Building Regulations.

Case studies will be the selected methodology used to investigate the success of the Passivhaus Housing Project, focusing on energy consumption taken from several case studies undertaken around the UK. Differences between the designed and actual energy data will be discussed in detail. In order to aid the writing of this report Passive homes will be visited to experience the high levels of air quality and thermal comfort.

### 3.1 Reasoning behind the study:

In 2010 PCC established its 'Affordable Warmth Programme' in line with the UK Fuel Poverty Strategy 2001, in the hope of eliminating fuel poverty as far as reasonably practicable by 2016. The PCC set aside around £70,000 each year from Lancashire County Council Public Health Grant to carry out upgrades to properties that have inadequate heating systems and insulation in a bid to help people stay warm and well in their homes. However in Preston today *"People can be forced to choose between heating their homes and buying meals, with many of all ages turning to food banks in desperation"*. (Lep, 2014). In recent months *"Most big energy suppliers (and a number of smaller rivals) announced standard tariff increases of 8% to 15%, with many coming into effect in recent weeks"*. (The Guardian, 2017) compounding the problem.

Government policy to alleviate fuel poverty is through insulating draughty homes or using monetary handouts, this is not sustainable. A better solution would be to build homes that require significantly less energy, naturally reducing energy demands and thereby alleviating fuel poverty whilst cutting the amount of CO<sub>2</sub> emissions put into the atmosphere.

## 4.0 Literature Review

### 4.1 What is Fuel Poverty?

It wasn't until 1997 that the UK government officially recognised fuel poverty. In part recognition the government set up the winter fuel payments, *"a benefit paid to older people to help them to keep warm in winter"*. (Anon, 2013)

Today fuel poverty is measured differently across the UK, in England it is measured using the Low Income High Costs (LIHC) indicator. Under the new LIHC indicator, a household is considered to be fuel poor if:

- they have required fuel costs that are above average
- were they to spend that amount, they would be left with a residual income below the official poverty line.

The adequate standard of warmth associated with Fuel Poverty is usually deemed as 21°C for the main living area, and 18°C for other occupied rooms.

Fuel poverty does not just affect the elderly it remains a massive social problem across all ages. In 2016 the UK had over 4.5 million families with 2.73 million living in England. 12% of families live in fuel poverty with an estimated 44,000 excess winter deaths attributed in 2015.

The problem in Preston is even higher with 1 in 7 families almost 13% of its residents officially recognised as living in fuel poverty, with families unable to adequately heat their homes.

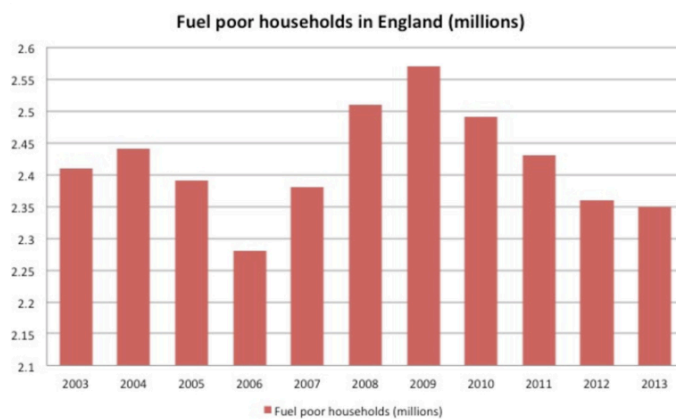


Figure 1 Numbers of the UK's population in Fuel Poverty (Fuel Poverty Statistics, 2016)

The graph illustrates that well over 2 million families are consistently defined as fuel poor even after taking account of grants to improve insulation in poor performing properties.

## 4.2 Who does fuel poverty affect?

### Who are the fuel poor?

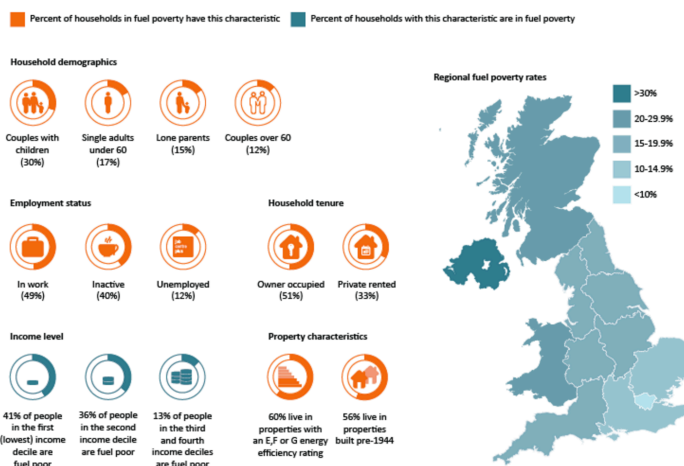


Figure 2 Who are the fuel poor? (Policyexchange, 2016)

Policy exchange confirms in their image above that fuel poverty impacts the whole of society but hits families on the lowest incomes the hardest. The National Energy Action group has "...warned that that

*the current rate of progress in tackling the problem means fuel poverty will not have ended by the time a child born today turns 80....” (The Guardian, 2016)*

#### 4.3 What are the main drivers of Fuel Poverty?

*“The UK is ranked lowest for energy (or fuel) poverty out of the 13 western European countries”, (ACE, 2013)*

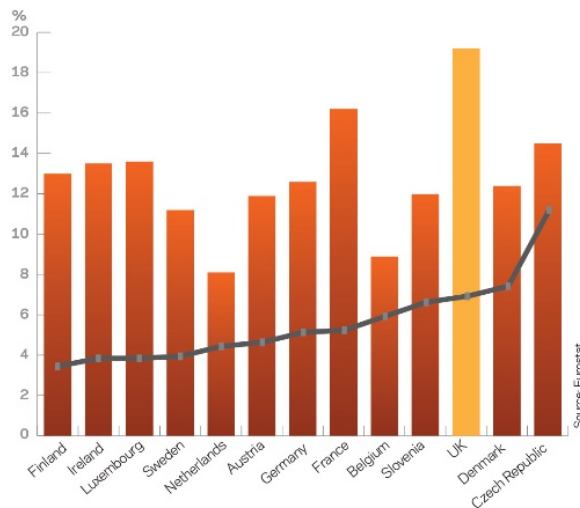


Figure 3 Percentage of population in fuel poverty (Building, n.d.)

Three main drivers of fuel poverty in the UK have been identified as:

- low income
- energy efficiency in our homes
- fuel prices

The poor efficiency of the UK's housing stock has led the UK to be referred to as “*the cold man of Europe*”. So why does the UK have one of the least energy efficient housing stock despite running government backed improvement programmes since 1976, spending "over £2.8bn... installing energy efficiency measures". (BBC News, 2016)



## What makes the UK 'the cold man of Europe'?

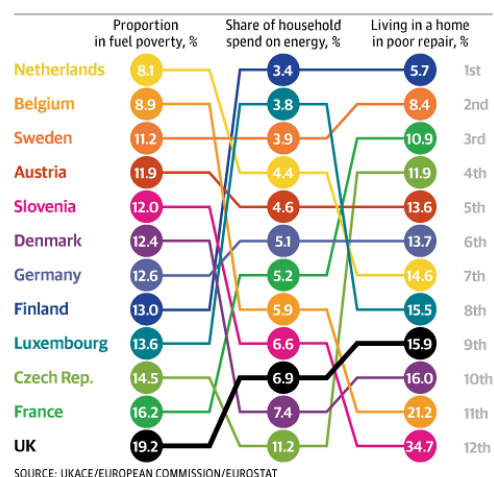


Figure 4 What makes the UK the 'Cold man of Europe' (Building, n.d.)

One reason could be that:

*"Any home built before the mid-1980s was built without any requirements at all for insulation, windows and so on...Building standards are better now...But even now, most homes built do not comply with the standards"... (Carrington, 2013)*

### 4.4 What policy measures is the UK Government implementing to tackle this problem?

The UK Government admits that the best long-term solution is to improve the energy efficiency of households. One of the biggest announcements made by the UK government to resolve this issue is 'The new statutory fuel poverty target for England' which became law in December 2014. The objective of this policy is to ensure that as many fuel poor homes as reasonably practical are taken out of fuel poverty by 2030. In March 2015 the UK government stated that 320,000 fuel poor households in England live in properties rated below band E on the Energy Performance Certificate (EPC) rating requiring them to spend on average £1,000 a year more on energy to heat their home compared to a typical home. The government's ambition is that by 2030 many of these homes will achieve a Band C EPC. New laws will also apply to private landlords who after April 2018 will not be able to rent out energy inefficient homes rated below band E. In addition a minimum energy efficiency rating of Band C will need to be implemented for all social housing by 2030.

### 4.5 Are Building Regulations designed to tackle fuel poverty?

Building Regulations Part L1A continues to improve energy performance and requires energy performance calculations for all new buildings known as Standard Assessment Procedure (SAP). A SAP rating is a desktop exercise designed to calculate the Predicted Energy Assessment for all new dwellings. It is used to provide the annual energy cost based on the structural elements, heating and hot water system, internal lighting and renewable technologies used in the home. After completion all properties are issued with an EPC to confirm the energy rating of the building.

A National Energy Study in 2015 noted that, “SAP itself may not be a perfect guide to energy performance. . . . Homes with higher SAP values were not reducing energy costs as much as might be anticipated. The study indicated that 48 per cent of residents in high-SAP (80-plus) homes still considered them draughty”. (Sustainable Homes, 2015)

EPC's are not designed to take into account the effect of draughts, a major problem particularly for the elderly, as a draught takes heat away from the body causing it to cool. Falling asleep in a draught is a significant hazard for the very young and the very old as it lowers resistance to infections.

*“draughts replaces heated air with colder air, causing greater heat loss and higher bills. . .”*(Sustainable Homes, 2015)

Research into the performance of SAP's revealed a poor track record for predicting energy demand due to the reduced importance given to airtightness, instead relying on high levels of internal gains and renewable technologies. Recent studies undertaken by the Zero Carbon Hub 'Closing the gap between design and as-built performance', showed, “some buildings consumed more than 5-10 times more energy than the compliance calculations carried out during the design stage”. The lack of understanding a building's energy demands will affect the people living in these buildings, trapping households in fuel poverty for decades. It is therefore critical when designing buildings that the actual energy demands can be predicted accurately. Relying solely on Building Regulations makes this a difficult task.

#### 4.6 What is the Carbon Impact?

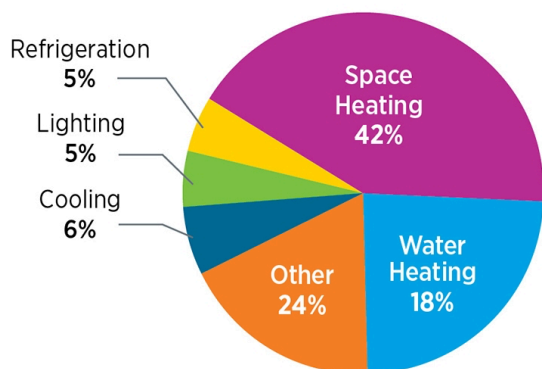


Figure 5 Energy distribution in homes (Your homes Energy Use, 2016)

Increasing energy demands not only have a dramatic effect on people but also on our planet. Household's emissions are responsible for a quarter of the UK's greenhouse gas emissions.

The 2008 Climate Change Act require:

- a 34% cut in 1990 greenhouse gas emissions by 2020
- at least an 80% cut in emissions by 2050

(The UK housing energy fact file, 2013)

Meeting these targets will be unrealistic without changing emissions from domestic properties. Figure 5 illustrates the most significant energy demand in a dwelling is space heating. Without managing the airtightness of dwellings, investments in insulation will remain ineffective.

#### 4.7 What's the cost of doing nothing?

*"It is well documented that the physical impacts of living in a cold home cause unnecessary suffering and premature mortality. Studies have shown that living in a cold home is a bigger killer than smoking, lack of exercise and alcohol abuse. In addition, the financial stress and anxiety over energy bills can cause or exacerbate mental health problems, leading to depression and even suicide". (Sustain, 2017)*

*"The likelihood of ill health is increased by cold homes, with illnesses such as influenza, heart disease, and strokes all exacerbated by the cold. Cold homes can also promote the growth of fungi and the number of house dust mites. The latter have been linked to conditions such as asthma. Ill health can lead to enforced absences from work, and certain types of illness, such as respiratory disease, and may restrict choice of potential employment for those without work". (Preston's affordable warmth strategy, n.d.)*

Each year local health services struggle to cope with cold-related hospital admissions and repeat GP visits. The National Energy Action (NEA) charity estimates "...that every local Health and Wellbeing Board in England is spending, on average, over £27,000 each day, or £10million per year treating patients with health conditions caused or worsened by living in cold, damp housing. Nationally cold homes cost health services...£3.6 million per day, since 2013 over £5 billion of tax payers money has been wasted". (Anon, 2016)

'The economic and fiscal impacts of making homes energy efficient' produced by Cambridge Econometrics and Verco, stated that "an ambitious UK-wide energy efficiency programme could return £3 to the economy per £1 invested by central government; help create a 26% reduction in imports of natural gas by 2030; domestic consumers could save over £8 billion per annum in total energy bill savings; increase relative Gross Domestic Product (country's economic performance) by 0.6% by 2030 ". (Sustain, 2017)

#### 4.8 Why does fuel poverty affect Preston more by than other cities?

##### Household income across the City

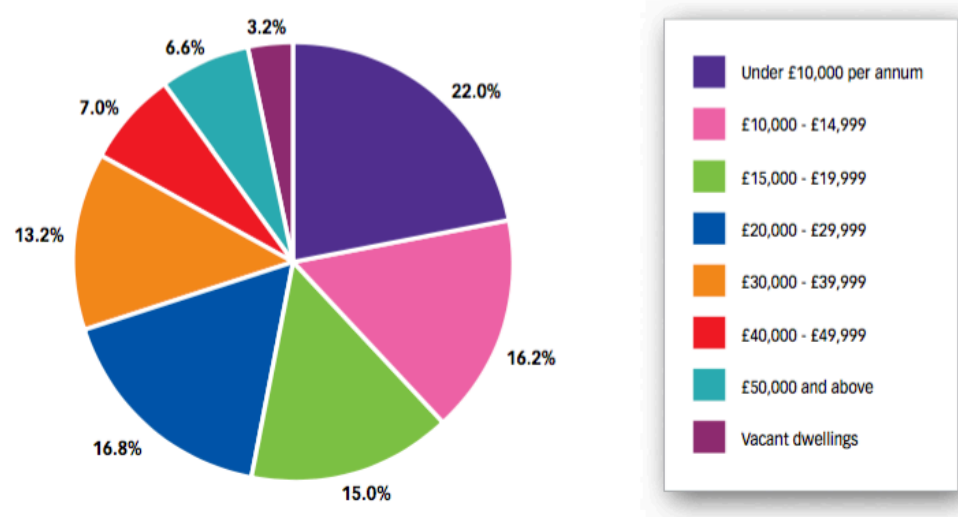


Figure 6 Preston's household income (Affordable-Warmth-Strategy, n.d.)

22% of Preston households have an annual income of £10,000 or less, with 38.2% households under £15,000. In Preston, income is the most influencing factor in fuel poverty helping to rank Preston the 20th most deprived Authority in England.

#### 4.9 How could Passivhaus be used to address fuel poverty in Preston?

Passivhaus is the fastest growing energy performance standard in the world. It's 'fabric first' approach provides occupants with high levels of comfort whilst using very little energy to heat and cool a building, due to its meticulous attention to design and construction detail (Architectural Technology Principles). World wide over 30,000 buildings have achieved Passivhaus certification thanks to their thermal performance, exceptional airtightness and their improved air quality gained through Mechanical Ventilation and Heat Recovery (MVHR) therefore reducing cold draughts. It also sets out very low energy consumption targets for heating, hot water, lighting and appliances that each building is designed to meet. With Passivhaus, energy demands are reduced to 15KWh/M<sup>2</sup>/year much less than current Building Standards. Uniquely this is achieved through the design, orientation and quality of the building's fabric with energy balance calculations established through the Passive House Planning Package (PHPP) software. The object is that energy savings will be achievable throughout the building's life, meaning tenants living in Passive homes will benefit from greatly reduced ongoing costs.

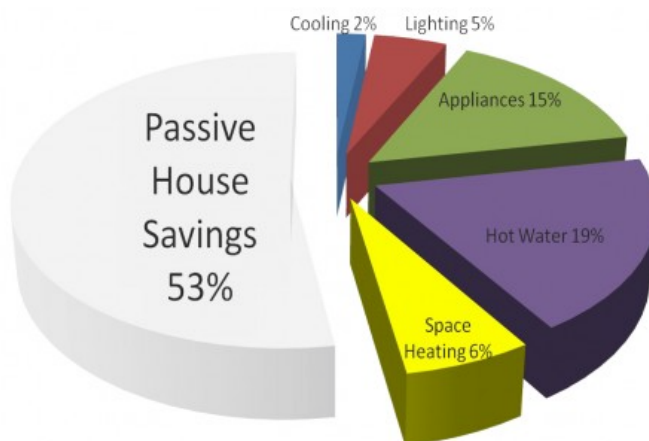


Figure 7 Passivhaus heat distribution (Hyde-Haus, 2017)

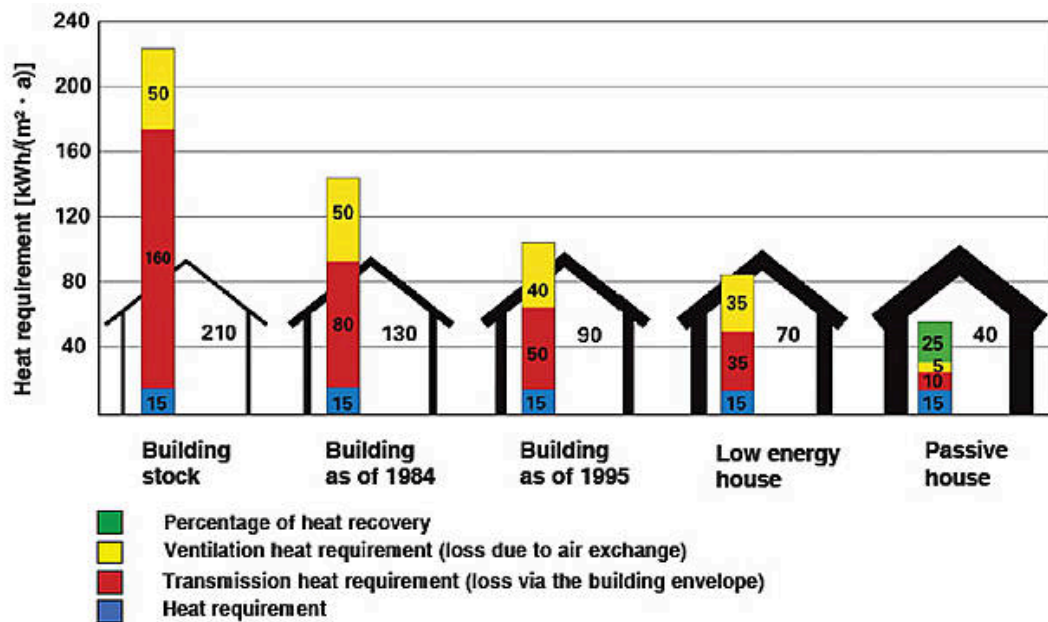


Figure 8 Heat requirements in buildings (Rehva.eu, n.d.)

Figure 8 indicates clearly that building to Passivhaus standards requires significantly less energy to heat, (6% compared with 42% of total energy requirements) than today's energy efficient homes due to the level of airtightness and heat recovered from exhausted air. This would not only permanently eradicate fuel poverty but would collectively reduce UK CO<sub>2</sub> emissions. Passivhaus provides a robust method to reduce space-heating demand by 90%, the biggest energy demand component of dwellings, so could play a key role in assisting the UK reach its Climate Change targets.

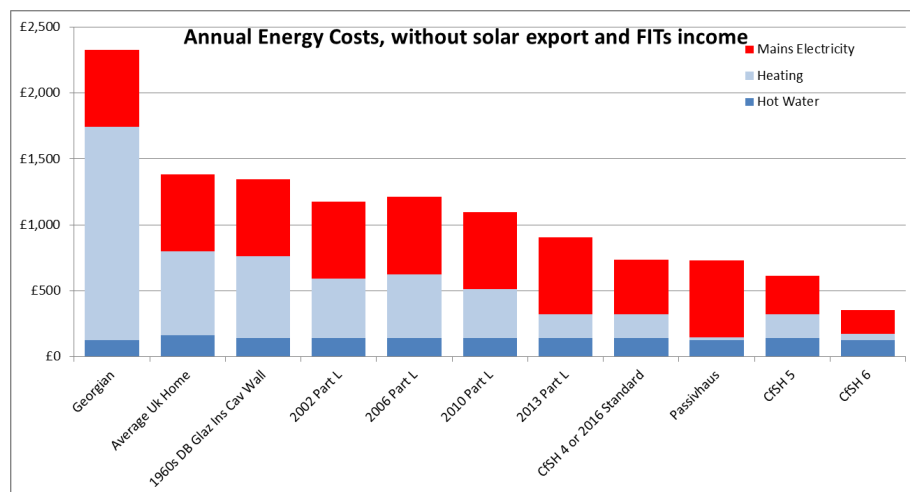


Figure 9 Annual Energy Requirements (Transitional, 2014)

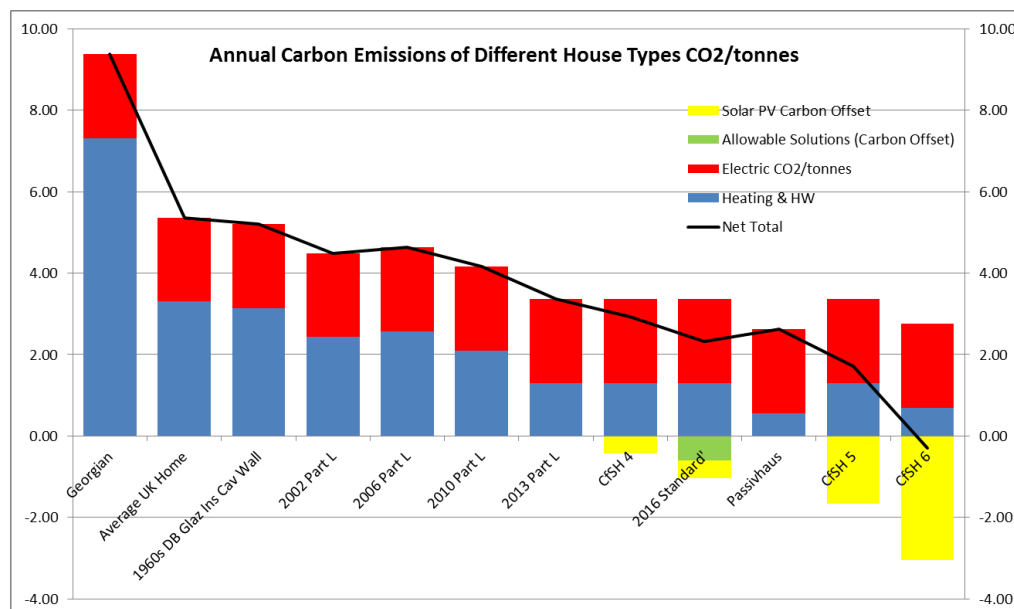


Figure 10 Annual Carbon Emissions (Transitional, 2014)

Figure 10 confirms that the Passivhaus standard consumes the minimum amount of energy and could be net positive if renewable technologies are incorporated. Passivhaus is the best building standard for reducing energy consumption due to its 'Fabric First' approach. This can result in a simpler more holistic route, reducing reliance on expensive, multiple forms of renewable technology.

*Gale & Snowden's recommendation is "to adopt the more rigorous and cost efficient Passivhaus methodology as the Passivhaus standard is tried and tested, rooted in sound building physics and based on more than 20 years research and development. This will ensure a low energy, healthy and comfortable living environment and at the same time minimise carbon emissions and protect users from fuel poverty".* (Code PH Comparison, 2014)

Other professionals including Dr. Boardman's latest research 'Achieving Zero: delivering future friendly buildings' concludes *"that we must eradicate the need for heating systems by making super-efficient homes, and in her opinion the best way of doing this is to make every building in the UK Passivhaus standard".* (Achieving Zero: Delivering future friendly buildings, 2012)

Secretary of State for Energy and Climate Change, Ed Davey, said *"...measures that reduce (energy) demand can contribute in a more cost-effective way to meeting our energy and climate goals than supply-side measures."* (News et al., 2017)

Other councils are now following the Passivhaus approach pioneered by Exeter City Council who built their first Passivhaus housing project in 2009 to eradicate families from fuel poverty. Emma Osmundson, Exeter City Council Housing Development Manager explains *"The reason we moved to Passivhaus was to combat fuel poverty, as a house built to these standards costs about one tenth of the cost of a normal house to heat".* (The Construction Index, 2014)

Councilor Gail Harris, deputy leader of Norwich City Council and cabinet member for council housing, said *"We are very proud to be leading the development of homes with such outstanding eco credentials, which have real benefits for both the environment and our tenants..."* (Council, 2016)

George Ferguson, Mayor of Bristol, said “These really high energy efficiency standards, inspired by the German Passivhaus principles, will mean a significant reduction in bills and improvement in comfort - a vitally important consideration in light of Welfare Reforms which could leave many of our tenants considerably worse off”. (Tenants, 2016)

Tom Russell of Emmett Russell Architects, views on new social Passivhaus housing in Bristol “As Passivhaus dwellings they are designed to minimise any heating requirement whilst providing excellent levels of comfort and indoor air quality. Typically annual fuel use for heating a Passivhaus will be one tenth that of an average home. For the tenants this will mean low energy bills, for the environment this means minimising carbon emissions”. (Tenants, 2017)

John Mitchard, managing director at Melhuish and Saunders, said: “... Passivhaus buildings provide an excellent way for local authorities to create energy efficient, environmentally sustainable social housing...” (Tenants, 2016)

#### 4.10 How does Passivhaus differ from Building Regulations?

Both Passivhaus and Building Regulations both model and predict energy use. Passivhaus uses the Passivhaus Planning Package (PHPP), which has been rigorously designed using the laws of physics to model thermal bridge free designs, whilst Building Regulations Part L uses SAP 2009 relying on choosing a thermal bridge free design from its catalogue. Passivhaus offers a more reliable measure of heat loss as it measures the external walls where as Part L uses internal wall measurements. Internal wall measurements inherently underestimate heat loss resulting in increased energy requirement causing the gap between design and as-built performance.

Passivhaus sets two energy benchmarks, 15kWh/m<sup>2</sup>/yr for space heating and 120kWh/m<sup>2</sup>/yr to include space heating, domestic hot water, lighting, fans, pumps and main appliances. This pushes designers towards more efficient designs minimising heat loss through thermal bridging, maximising air tightness and optimising solar gain through orientation. Cold draughts can then be eliminated to create an environment where a person is warm and comfortable without compensating for a poor atmosphere by turning up the heating thermostat. As a result Passivhaus delivers better human comfort levels. The key technology to manage thermal comfort and air quality within an airtight building is Mechanical Ventilation with Heat Recovery (MVHR), a requirement of the Passivhaus standard.

Part L relies on what is called a ‘notional building’ comparison and stipulates that a building must perform better thermally, than if it were built using the energy efficiency standards of 2002 Part L. Although Part L has a maximum air leakage rate, backstop U values and consideration of summer time overheating, Part L allows you to roll back the air leakage and U values by compensating with solar PV and other supplementary renewable technology, meaning that comfort will not be prioritised.

As a result the energy split in a house is very different:

2010 Building Regulations standards is broadly:

53% space heating  
19% hot water  
28% power  
(Pullin, 2012)

Passivhaus is broadly:

12% space heating  
32% hot water  
56% power

The other big difference between Part L and Passivhaus is the indoor air quality. Much attention has been given to this issue and the associated risks to occupant's health. Poor air quality results in condensation, mould growth, and infestation of dust mites and elevated volatile organic compound (VOC) concentrations which all pose a threat. Bad indoor air quality is caused by inadequate ventilation, not the airtightness of buildings. It is a mis-conception, only highly airtight homes suffer with bad air quality, draughty homes suffer too.

So for this reason the Passivhaus standard requires MVHR. MVHR ensures that the building constantly receives a supply of fresh clean air throughout the building, filtering out any harmful pollutants. Incoming air is pre-warmed (in winter) by passing exhaust air through a heat exchanger to pre-warm incoming air, which typically saves nine times more energy than it consumes.

Part L relies on the indoor air quality being improved through purge ventilation achieved through the opening of windows together with extraction units fitted to bathrooms and kitchens.

Studies have shown that some buildings suffer with 'sick building syndrome', a recent report undertaken into indoor air quality concluded that "*homes with MVHR systems performed better in terms of Indoor Air Quality than non-MVHR homes*". (Mawditt, Gupta and Sharpe, 2016)

#### 4.11 Does Passivhaus deliver more than just significantly lower energy demands?

Emma Osmundsen, Exeter City Council's housing development manager said at a Passivhaus trust conference, "*We know of one tenant whose asthma cleared up after many years of suffering and others who have reported lower stress levels and better quality sleep*". (Passivhaustrust, 2016)

John Lefever from Hastoe Housing association is quoted as saying "*I can confirm that within our 120 Passiv homes there was currently no rent arrears which we put down to the exceptionally low energy costs... these homes require less maintenance than other homes... And residents help each other to get the best from the homes in terms of energy efficiency*". He went on to say that "*for the first time in five years one resident could afford to take her family on holiday thanks to the low energy cost of living in a Passivhaus*" and added "*for the first time they had seen an uplift of around 7% on property values as a direct result of building to the Passivhaus standard*".

The above statement seems to provide evidence that all parties have something to gain from building to Passivhaus. Housing providers win with increased property values and reduced loss of income due to rent arrears and associated administration costs and tenants are healthier and happier thanks to healthier air quality and reduced energy costs.

## 5.0 Methodology

Passivhaus is not just being used to design one off homes for wealthy individuals, councils and housing associations up and down the country are benefiting from building to Passivhaus standards as a way of providing high quality, and affordable living solutions for tenants, including Camden, Norwich, Bristol, Crawley, Tyne and Wear, Rainford in Essex and Leicester city council's. Pioneering Exeter City Council was the first to adopt the Passivhaus



standard in 2009 and has now adopted the standard across all the City's housing schemes, rolling it out into all their community buildings including a newly designed leisure centre.

To help this report evaluate the performance of Passivhaus Buildings, secondary statistical data has been gathered from various external sources and professional bodies including, journals, newspaper, books and websites, as it was not possible to collect primary data.

## 6.0 Investigation

Does Passivhaus perform as designed and alleviate families from fuel poverty?

*"Design is a funny word. Some people think design means how it looks. But if you dig deeper, it's really how it works." - Steve Jobs*

In order to evaluate how well Passivhaus would work to eradicate fuel poverty, a small number of case studies of Passivhaus schemes have been selected in order to evaluate their energy performance, levels of indoor air quality and thermal comfort, highlighting achieved social benefits.

## 6.1 Wimbish Passivhaus

Wimbish Passivhaus Development, designed by Parsons & Whittleby consisted of 14 social housing units. Built for Hastoe Housing Association (HHA), designed to deliver very low heating bills to reduce the impact of fuel poverty for their tenants, with the potential to reduce rent arrears. This particular project was part of a five-year evaluation study, which ran between 1<sup>st</sup> April 2011 and June 2016 providing an insight into the buildings energy performance.



Figure 11 Wimbish Passivhaus development (Ingham, 2016)

This development was so successful it won a UK Passivhaus Award in 2012.

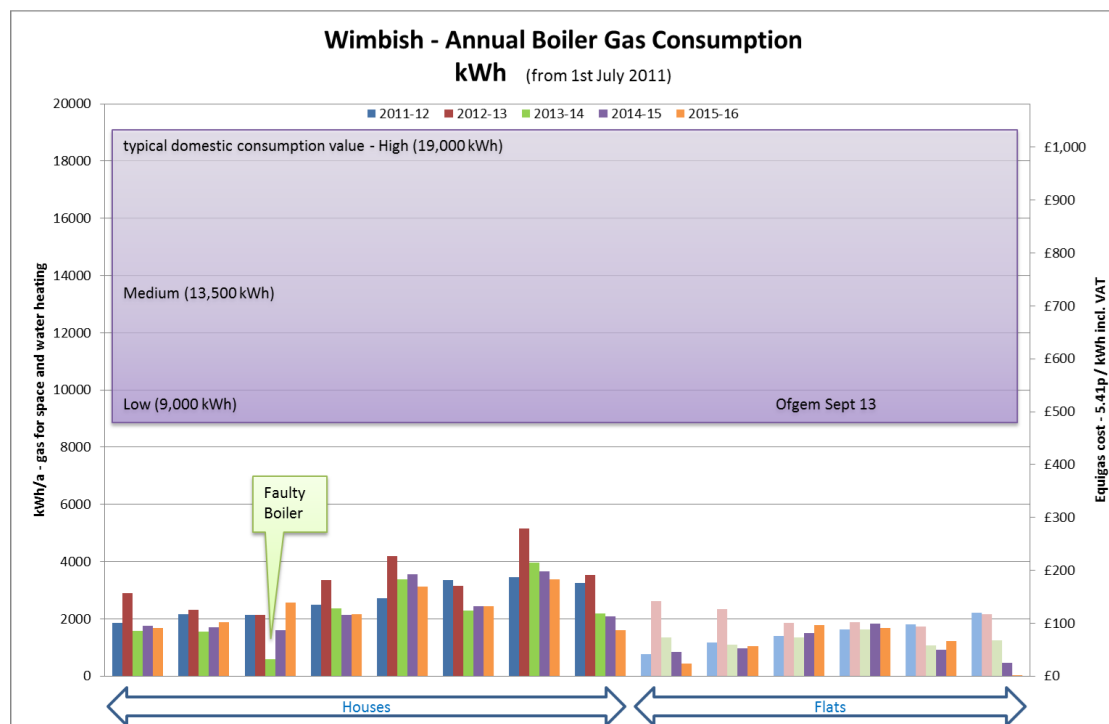


Figure 12 Gas Consumption (Ingham, 2016)

Figure 12 indicates just how low the Wimish gas consumption is when compared against comparable Ofgem typical domestic gas consumption values shown in purple.

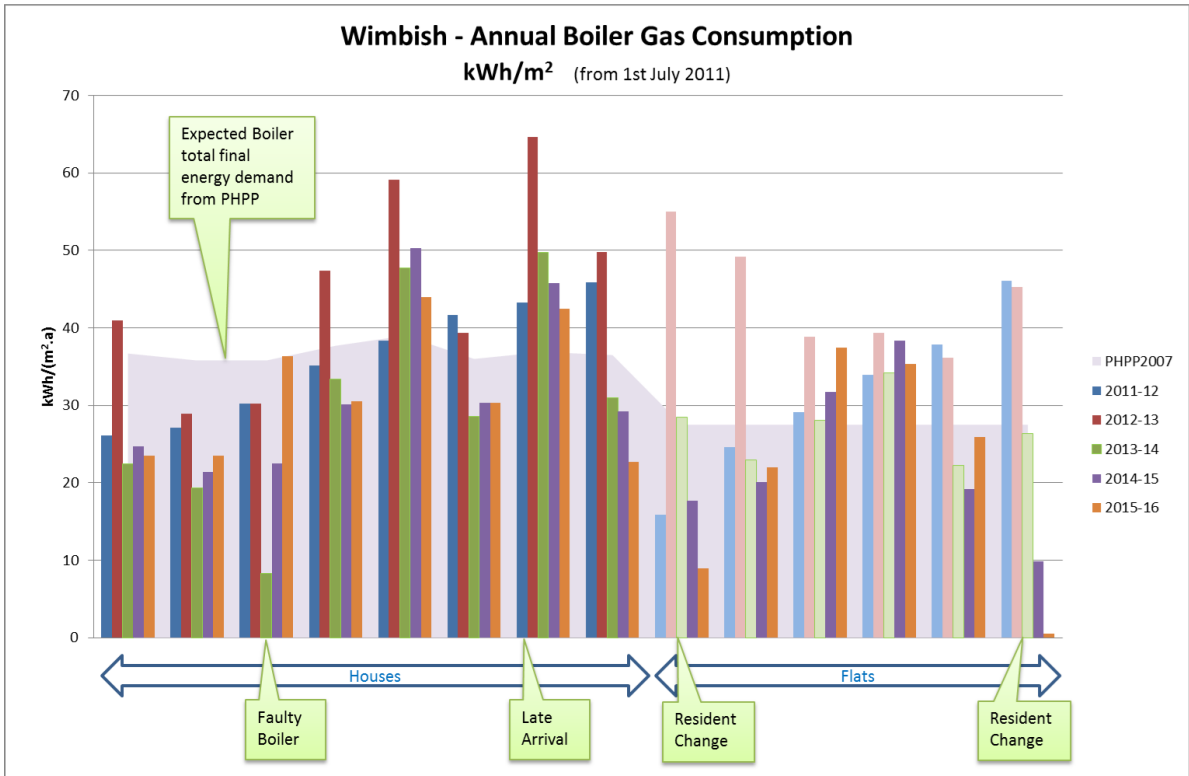


Figure 13 Gas consumption for space and water heating (Ingham, 2016)

With reference to the data from the colder winter 2012/13, the average performance is close to the expectations. There are variation between households due to the difference in levels of occupation and lifestyle.

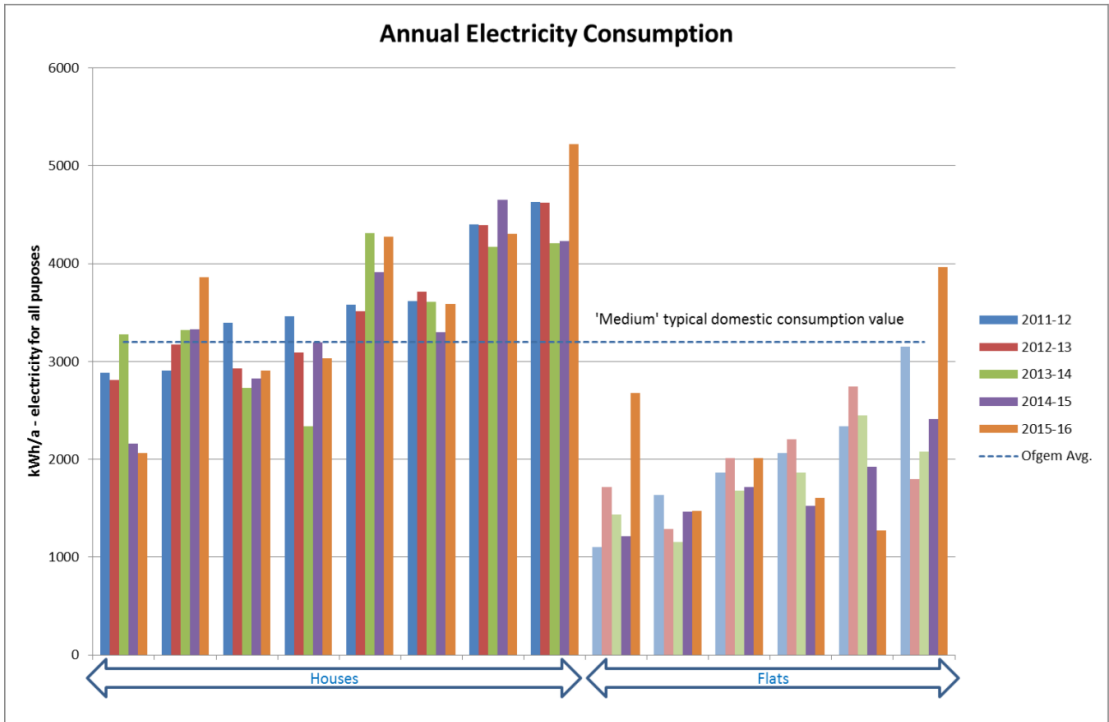


Figure 14 Annual Electricity Consumption (Ingham, 2016)

The annual electricity consumption chart (Figure 14) shows that on average the house consumes a little above the Ofgem medium value, which is understandable if not a little disappointing.

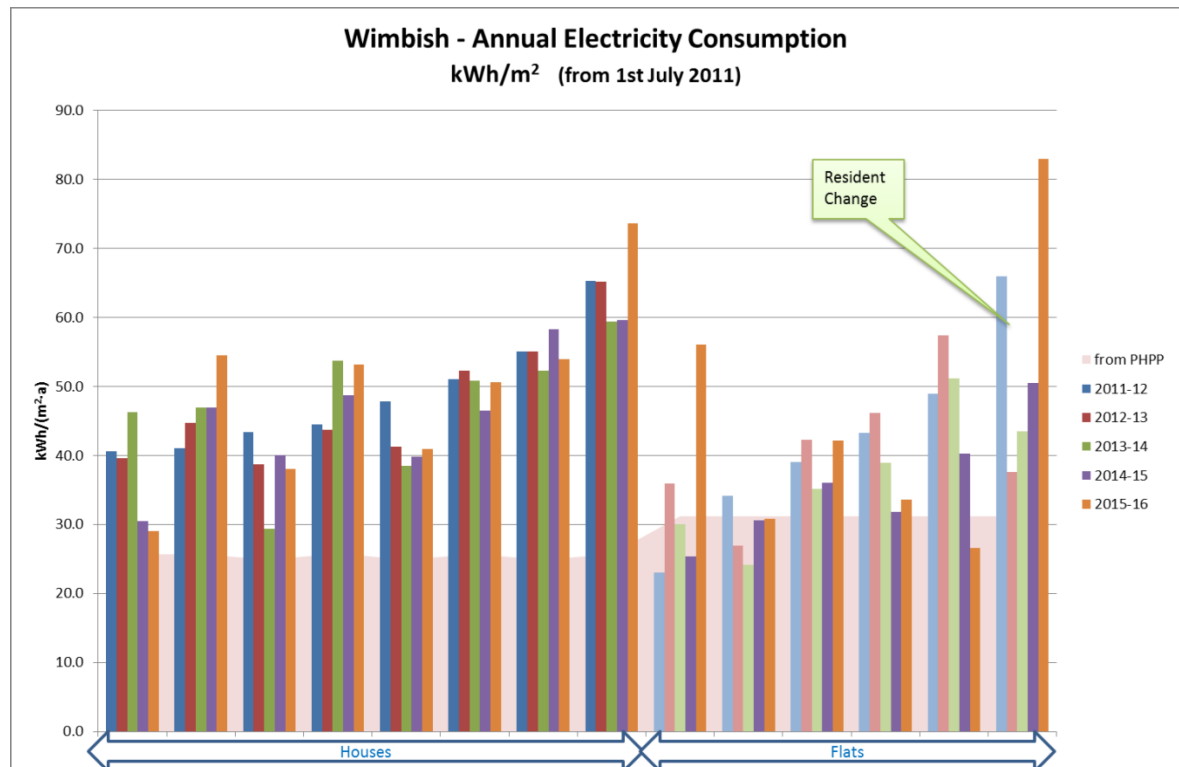


Figure 15 Annual Electricity Consumption/Area (Ingham, 2016)

Plotted against floor area, and in comparison with the PHPP 'allowance' none of the houses, and only two of the flats are meeting expectations. This can be explained by:

- flats well below energy target – largely a result of lower level of occupation
- Houses had a higher levels of occupation than assumed in the design
- Households bringing their existing, relatively inefficient, appliances with them. Where new appliances were purchased the capital cost made a higher priority than efficiency in use.

Electricity consumption caused by tenant's appliances is an area that is outside the control of the designer.

Indoor air quality is a measure using Carbon dioxide levels in a property. CO<sub>2</sub> levels can quickly rise from an ambient 400ppm to 2,000ppm and above, where occupants' concentration levels diminish and fuzzy-headedness starts. Therefore values above 1,500 should be infrequent.

Figure 16 illustrates a typical daily cycle of readings in the three properties, which were monitoring over a week in winter when windows are less likely to be open and air quality is more likely to be an

issue. Even in these conditions the air quality remains acceptable throughout the study.

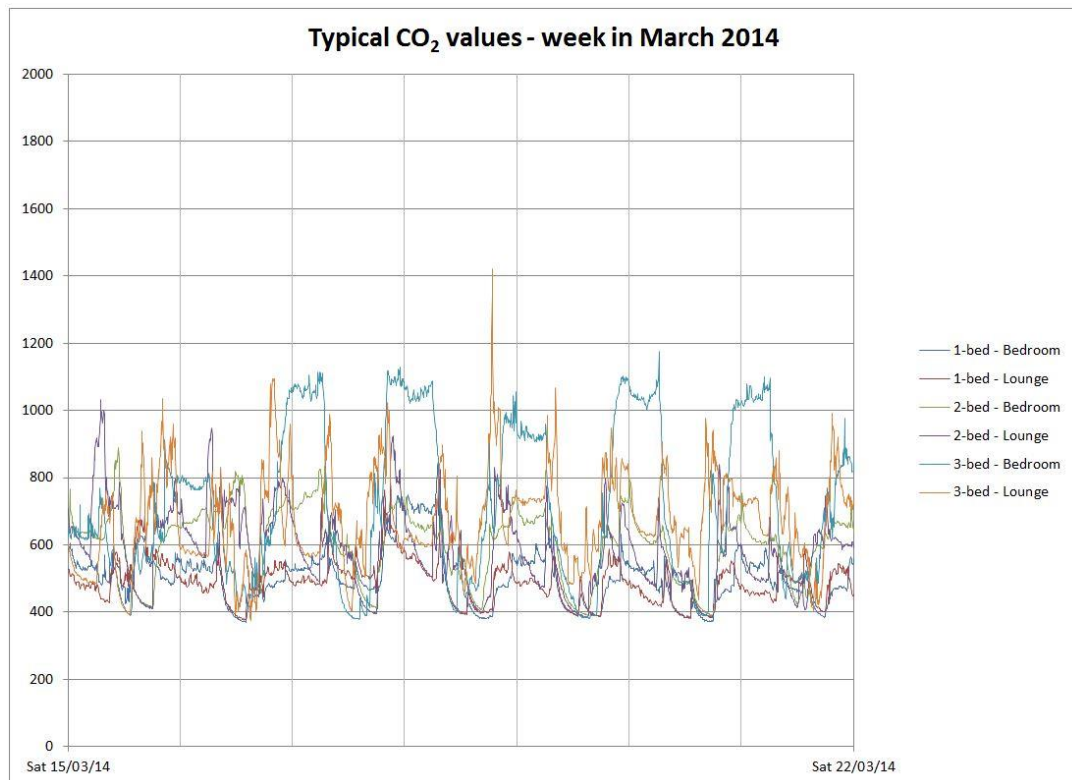


Figure 16 Indoor CO<sub>2</sub> levels (Ingham, 2016)

### Overall the report found that:

*“The study proved that the Passivhaus approach delivers, and this assessment of the first five years confirms that it continues to deliver. Overall, the homes are performing largely as designed and provide the occupants, none of whom had particular prior interest in sustainability or energy efficiency, with homes that they find economic to run, healthy to live in and very comfortable and spacious for the size. Some residents stated that their heating bills were only £30 a quarter. This lack of a ‘performance gap’ is a reflection of the high quality process necessary for Passivhaus development from design to occupation”. (Ingham, 2016)*

An article in the CIBSE Journal on the programme complimented Wimbish as “one of the few that performed well”. (Cibsejournal, 2016)

Reactions from some of the residents confirmed that:

*“Since moving in 2011, my flat is wonderful. It’s light and airy and very peaceful.  
You wouldn’t think that we live on an estate “*

*“Utility bills are much lower, even water bills have been reduced. Gas is very low  
although we are still being charged by companies for the ‘standing charge’.”*

*“Because of the airflow system I think it makes you feel better.”*

*“Clearly living here made me much happier and I feel I can give something back to  
the community.” (Ingham, 2016)*

## 6.2 Denby Dale

Award winning Denby Dale was of the UK's first certified Passivhaus and the first certified Passivhaus to be built using traditional cavity wall construction. Denby Dale pioneered the combination of British vernacular construction methods with the German low energy Passivhaus design methodology. It was designed and built by the Green Build Store in Goldcar, West Yorkshire. A two-year study was undertaken by Leeds Metropolitan University to analyse the occupancy performance between June 2011 and May 2012. Monitoring the environmental conditions, and recording gas and electricity usage used within this 118m<sup>2</sup> property.

In order to experience Passivhaus and to aid with the writing of this report the author visited Denby Dale in early 2017.



*Figure 17 Denby Dale (Green Building Store, 2017)*

Denby Dale: RIBA Yorkshire White Rose Architecture Awards 2010

### **WINNER:**

- Sustainability Award
- Housing award
- Architecture Award (Bronze)
- Client of the Year Award



## Average Daily Energy Consumption/Generation

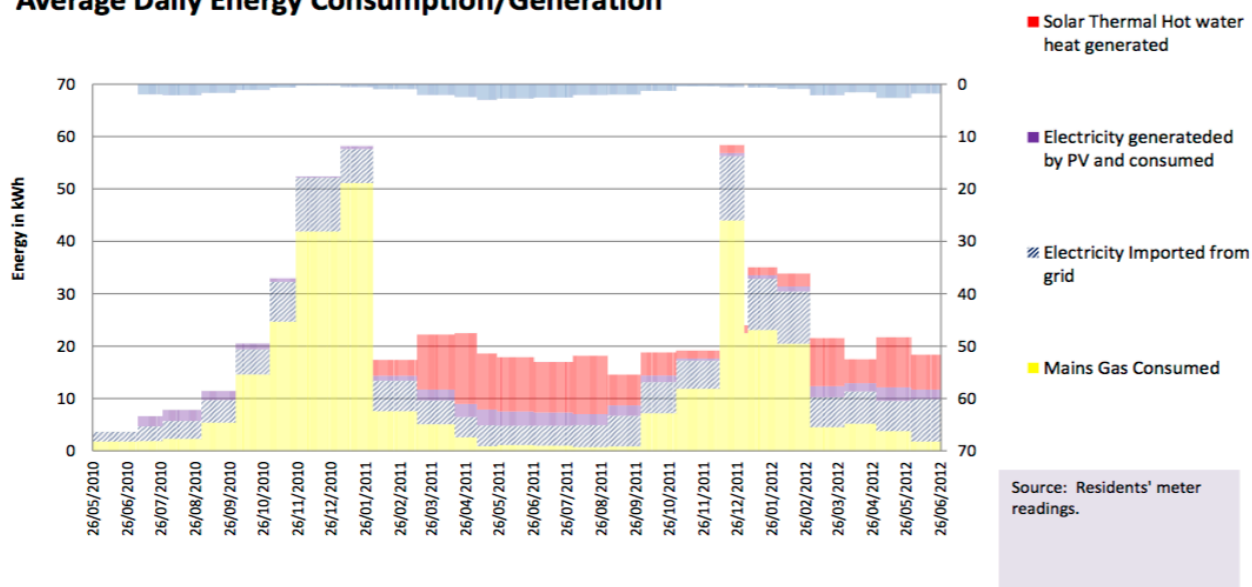


Figure 18 Denby Dale Daily Average Daily Energy Consumption (Passivhaus Trust, 2017)

The above and below table illustrates just how well designing and building to Passivhaus standards reduces energy demands, even before renewable technology is taken in to account.

These figures also take into account additional electricity consumption used outside of the thermal envelope. An electric heater and power tools were used in the garage for long periods throughout winter months. In December 2010/ January 2011, heating was also used in the garage to defrost the MVHR condensate pipe during a particularly cold spell.

	Gas kWh	Electricity imported kWh	Electricity generated kWh	Solar thermal kWh	Total kWh
May 2010-2011	5095.2	1851.9	918.4	938.0	8803.5
May 2011-2012	3471.2	2319.6	1226.0	2260.0	9276.8
Predicted primary energy demand					9082

Figure 19 Denby Dale Annual Energy Use (Passivhaus Trust, 2017)

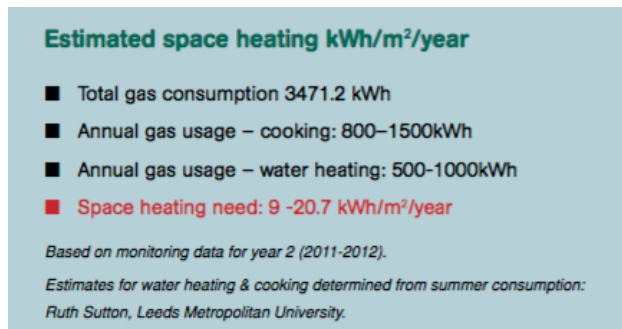


Figure 20 Estimated Space Heating (Passivhaus Trust, 2017)

Denby Dale Passivhaus is performing well and energy consumption is close to that predicted in PHPP (Passive House Planning Package).

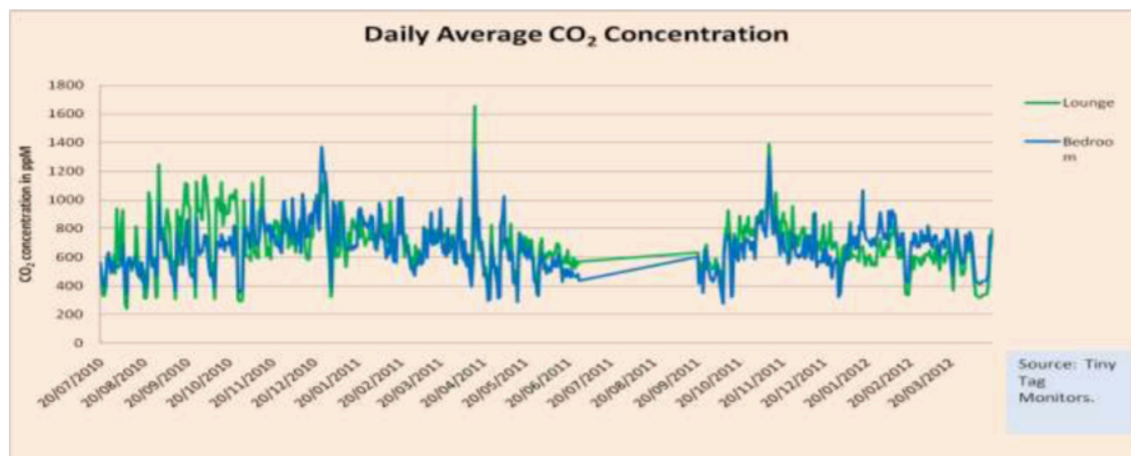


Figure 21 Denby Dale Indoor Air Quality (Passivhaus Trust, 2017)

The study also monitored the indoor air quality both in the bedroom & lounge, recording at 10-minute intervals. The graph confirms that the air quality remained at acceptable levels throughout the study and suffered minimal spikes in CO<sub>2</sub> readings.



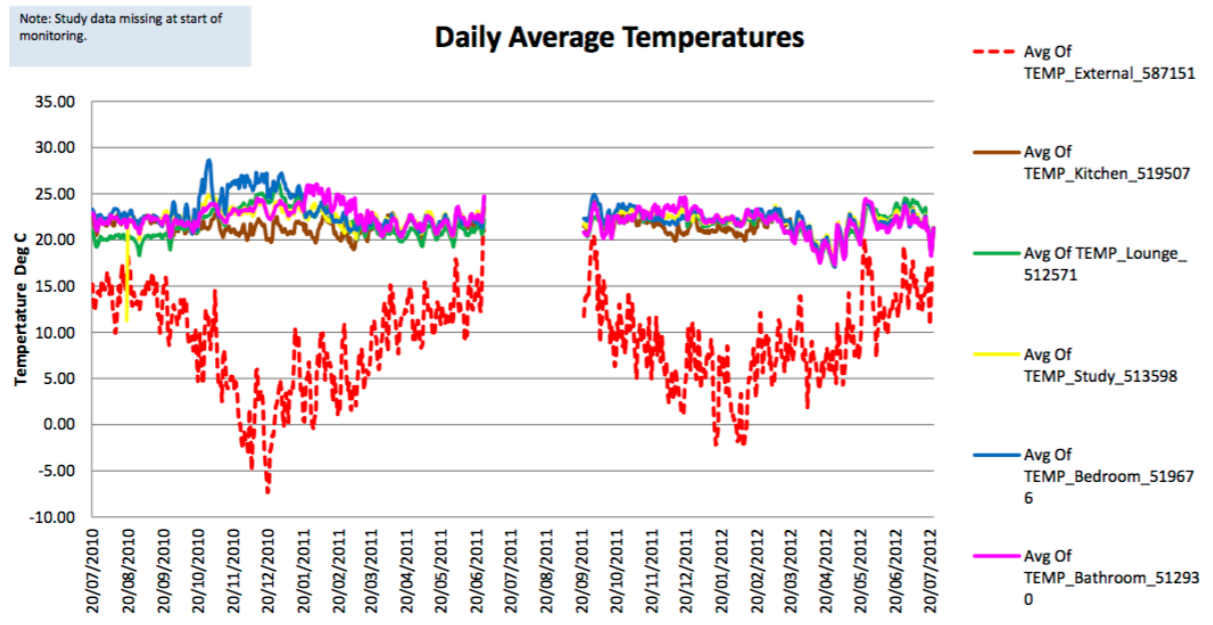


Figure 22 Denby Dale Indoor Temperatures (Passivhaus Trust, 2017)

Occupant preferences meant the mean temperatures in the house remained above 21°Celsius.

### Overall the report found that:

The two occupancy study proved that building to the Passivhaus standards can be achieved using traditional cavity wall construction and that the UK is so familiar with.

*"We wouldn't want to ever live in a non- Passivhaus now. You can sum Passivhaus up in three words: comfortable, sustainable and cost- effective. I don't think that there is anything about the house that we'd change. The whole thing has been a victory for common sense."*

*"Living here has made a significant difference to the outgoings in our household finances – we can really feel the difference. The low utility bills mean that, on a fixed semi retired income, we've got more money to spend on living rather than energy costs."* (Passivhaus Trust organisation, 2017)

### 6.3 Camden Passivhaus

The Camden Passive House was London's first Passivhaus dwelling certified in April 2010. The building's primary objectives were to provide a comfortable and healthy home whilst minimizing energy use. The (predominantly timber framed) two-storey detached house was designed by bere:architects, at 118m<sup>2</sup> gross, or 101m<sup>2</sup> using the Passivhaus method of measuring the heated envelope. A two-year study was undertaken to determine the effectiveness of the design and delivery strategy, real fabric performance indicators are compared with the anticipated performance.



*Figure 23 Camden House (Final Report: The Camden Passive House, 2014)*

The SAP model (using SAP standard weather data) predicted the space heating consumption would be just 593kWh/yr., less than half that calculated, by the PHPP software that aligned to the measured data of 1237kWh/yr. More evidence that SAP does not provide a reasonably accurate prediction of the energy use of buildings.

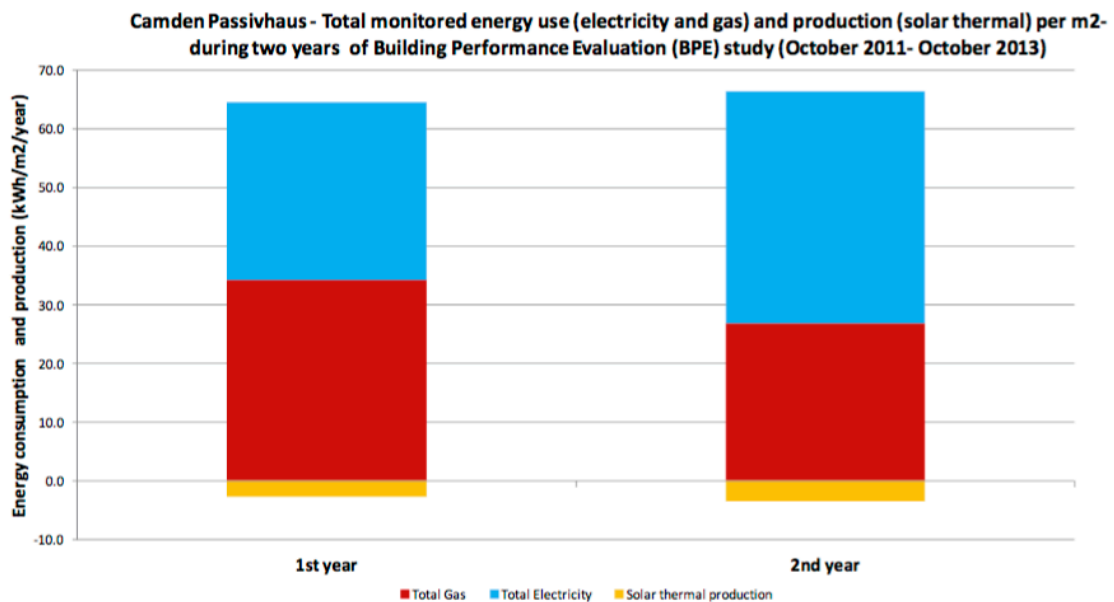


Figure 24 Camden House Annual Total Energy Used and production per m<sup>2</sup>/year (Final Report: The Camden Passive House, 2014)

The total energy consumption for Camden was 6518kWh equating to 64.5kWh/m<sup>2</sup> in the first monitored year (Oct 2011 – Sep 2013) and 6697kWh/m<sup>2</sup> in the second year (Oct 2012-Sep 2013). These figures make Camden one of the lowest energy dwellings in the UK.

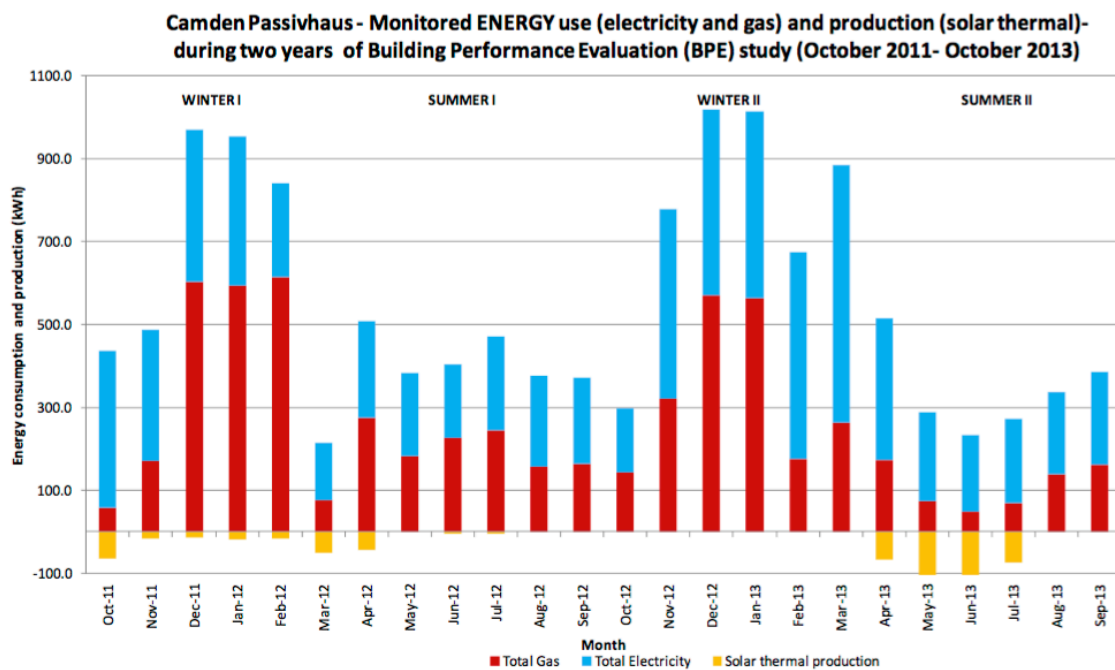


Figure 25 Camden House 2 year Monitored Energy Use e and Production for two years. (Final Report: The Camden Passive House, 2014)

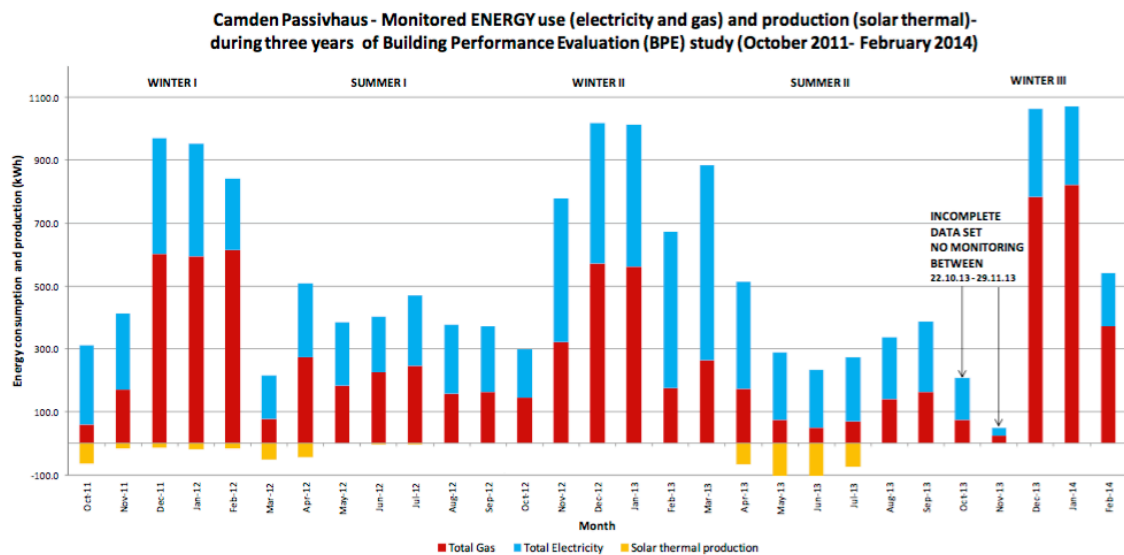


Figure 26 Camden House 3 year Energy Performance (Final Report: The Camden Passive House, 2014)

The report found that the annual primary energy demand was 119kWh/m<sup>2</sup> on the first year, slightly below the 120kWh/m<sup>2</sup> *Passivhaus* target. But for the second year the primary energy demand was 136kWh/m<sup>2</sup>, a 12% increase. This is because, despite a rise in the total energy consumption of only 3%, there was a 30% increase in the electricity consumption and a 22% reduction in the gas consumption.

As expected, more energy was consumed in winter than in summer due to colder temperatures and shorter hours of daylight in winter.

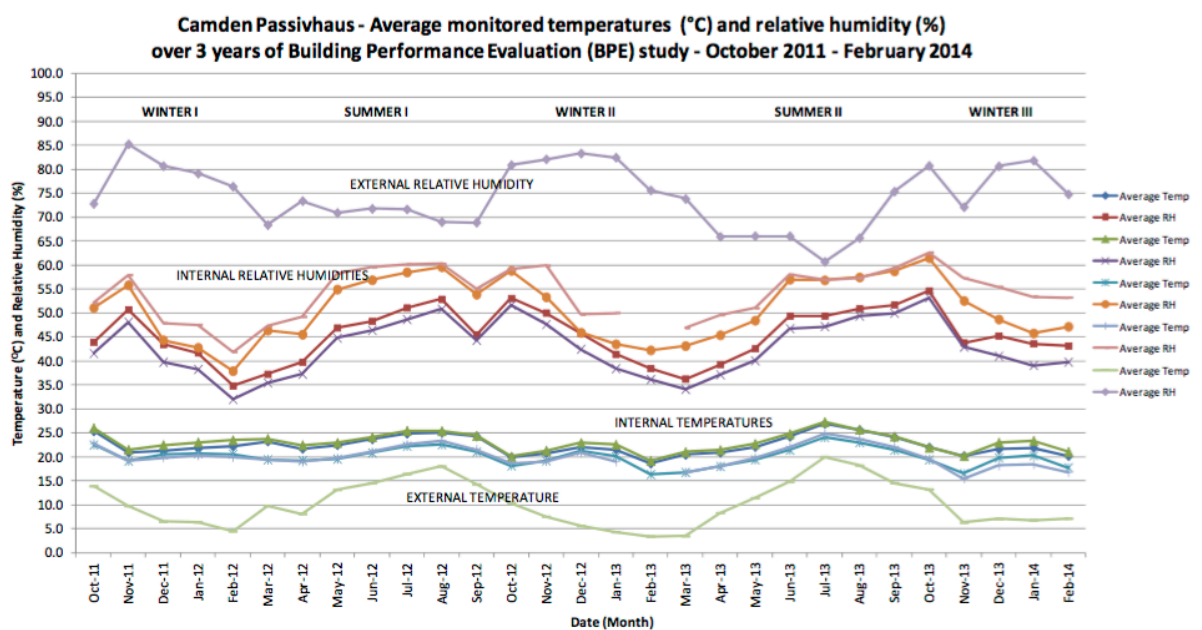


Figure 27 Camden House Average Indoor, External and Relative Humidity Levels (Final Report: The Camden Passive House, 2014)

Throughout the monitored period, average relative humidity values remained within the optimal recommended range between 30% and 60%.

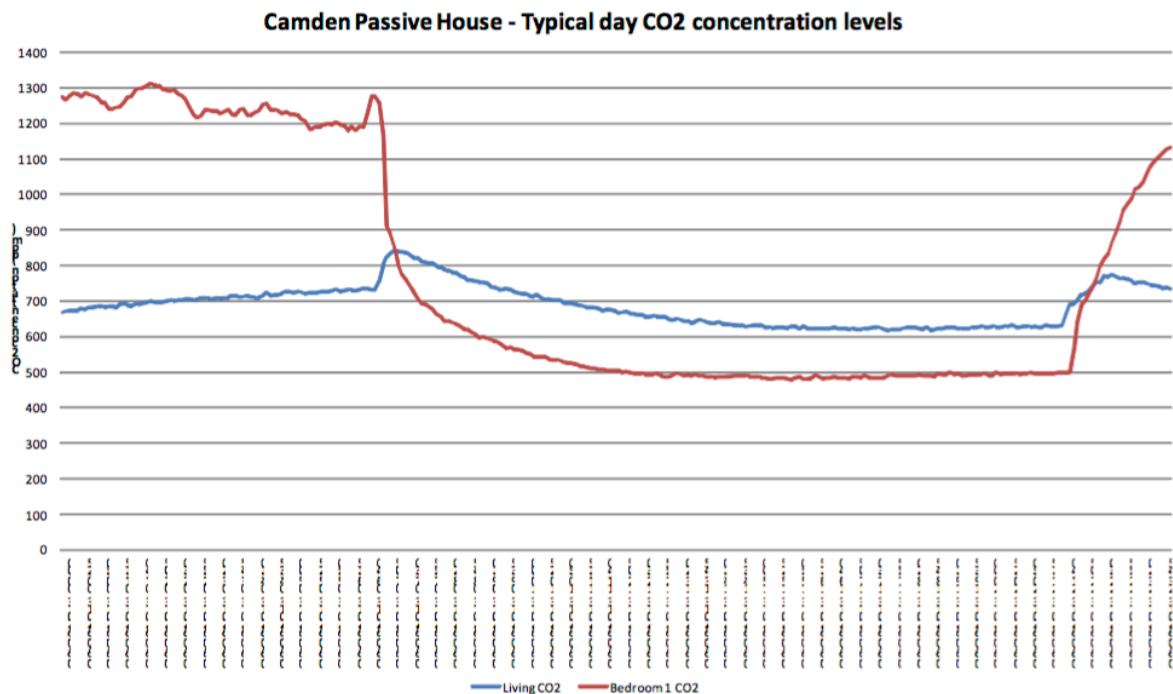


Figure 28 Camden House Daily Monitored CO<sub>2</sub> Levels (Final Report: The Camden Passive House, 2014)

CO<sub>2</sub> concentrations were monitored in the main bedroom and the living space on the first floor. The chart above shows the monthly data desegregated. On average CO<sub>2</sub> levels were good at around 600~700ppm in the living room and 1200~1300ppm in the bedroom at night.

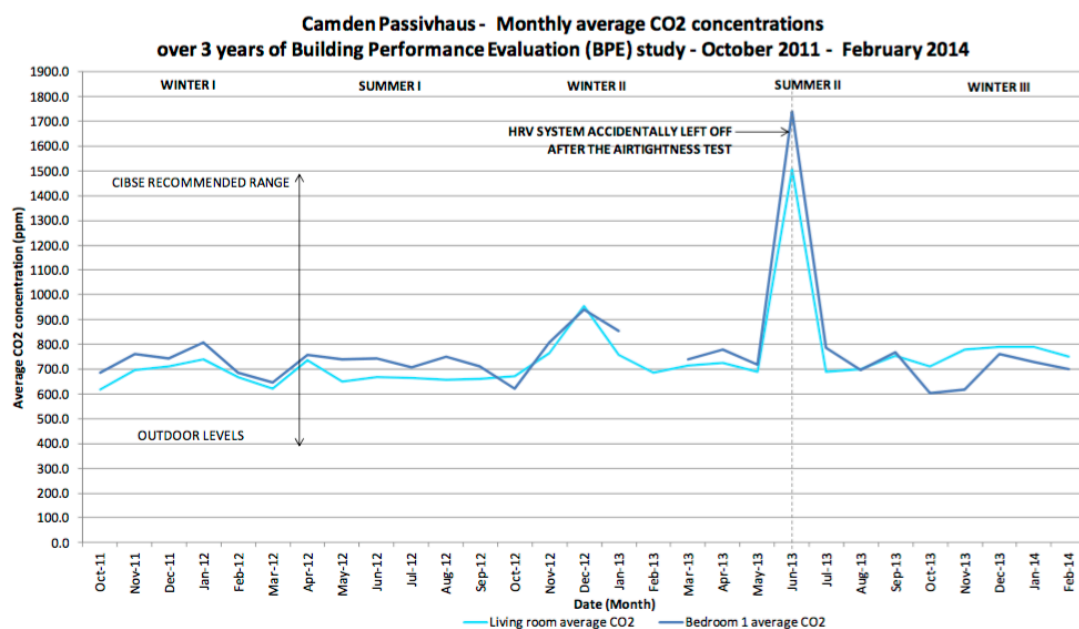


Figure 29 Camden House Annual Monitored CO<sub>2</sub> ppm Concentration Levels (Final Report: The Camden Passive House, 2014)

The above graph highlights the importance of adequate ventilation in airtight homes as the severe spike in CO<sub>2</sub> occurred when the system was mistakenly turned off.

**Build tight – ventilate right!**

The indoor Air Quality study found that the VOC levels were lower in homes using MVHR than both international and UK guidelines and that particulates levels were lower than in traditional homes and lower than outside levels located on the same street.

### Overall the report found that:

*“ Passive House is one of only a few co-heating tested dwellings in the UK that meets its design intent. This is a positive reflection on the design and the built quality of the house and is especially encouraging considering the low heat loss that was targeted here”. (Final report: The Camden Passive House, 2014)*

*“It’s absolutely beautifully warm in here and zero degrees outside. And it’s always got that lovely sort of ambiance in here - it feels really warm and comfortable and fresh” (Final report: The Camden Passive House, 2014)*

## 7.0 Conclusion

Although the report only evaluated on a small quantity of case study, clear evidence backed up the literature review. This confirms that Preston City Council should adopt the Passivhaus Building standard for all new build social housing as a means of providing greater levels of thermal comfort whilst dramatically lowering energy and CO<sub>2</sub> emissions. In general, Passive houses with MVHR systems had lower energy consumption, capable of lifting families out of fuel poverty. The study also found evidence that building to Passivhaus standards will improve tenants general health and is capable of improving local and national financial security.

### 7.1 What are the main barriers for Preston City Council not adopting Passivhaus standards?

- **Minimal demand from the client** – The lack of knowledge from the client in addition to the developer’s primary focus being on profit margins has led to missed opportunities for building more energy efficient housing. Some large contractor/developers, housing associations and local authorities are starting to see the ‘value add benefits’ of providing homes with greater thermal comfort for minimal extra or equivalent cost. This could result in client demand for Passivhaus and low energy buildings to increase.
- **The Governments’ minimum guides** – Building regulations and the side lined ‘Code for Sustainable Homes’ leaves plenty room for improvement, particularly when addressing air tightness.
- **A lack of understanding of the true benefits of Passivhaus design.** Comfort, undoubtedly, but also the environmental, social, and economic benefits.
- **A lack of awareness from the public** – Passivhaus is still in its development stages in the UK so the public, are not yet aware of what they are missing. Once the benefits are understood demand will follow from all market sectors.
- **The technical abilities to achieve this standard** - Implementing the Passivhaus standards requires investment in staff training and appropriate quality control systems in



place to ensure buildings achieve Passivhaus certification.

- **The supply chain is still lacking** – especially when it comes to larger developments, but this is changing as demand begins to grow. This can be seen with the growing number of triple glazed window suppliers available in the UK today.

## 7.2 What further research needs to be undertaken?

One area that could benefit from further research and could potentially increase the popularity of Passivhaus are the advantages of using modular construction to help improve quality control. Off the shelf solution currently offered by the likes of Beattie Passive and Potton could play a significant role in increasing the popularity of Passivhaus by reducing build costs, reducing risks and uncertainty for investors.

Large studies undertaken in Germany have shown a positive correlation between energy performance, property values and desirability within both the private and rental sectors. The government should work more closely with the Royal Institute of Chartered Surveyors (RICS) to value energy performance in UK buildings. If energy efficiency directly increased property values it would stimulate the market to improve energy performance not just in new builds, across the entire sector.

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