
# Passivhaus and Net Zero

Sustainable Construction Topic Support Network, May 2021

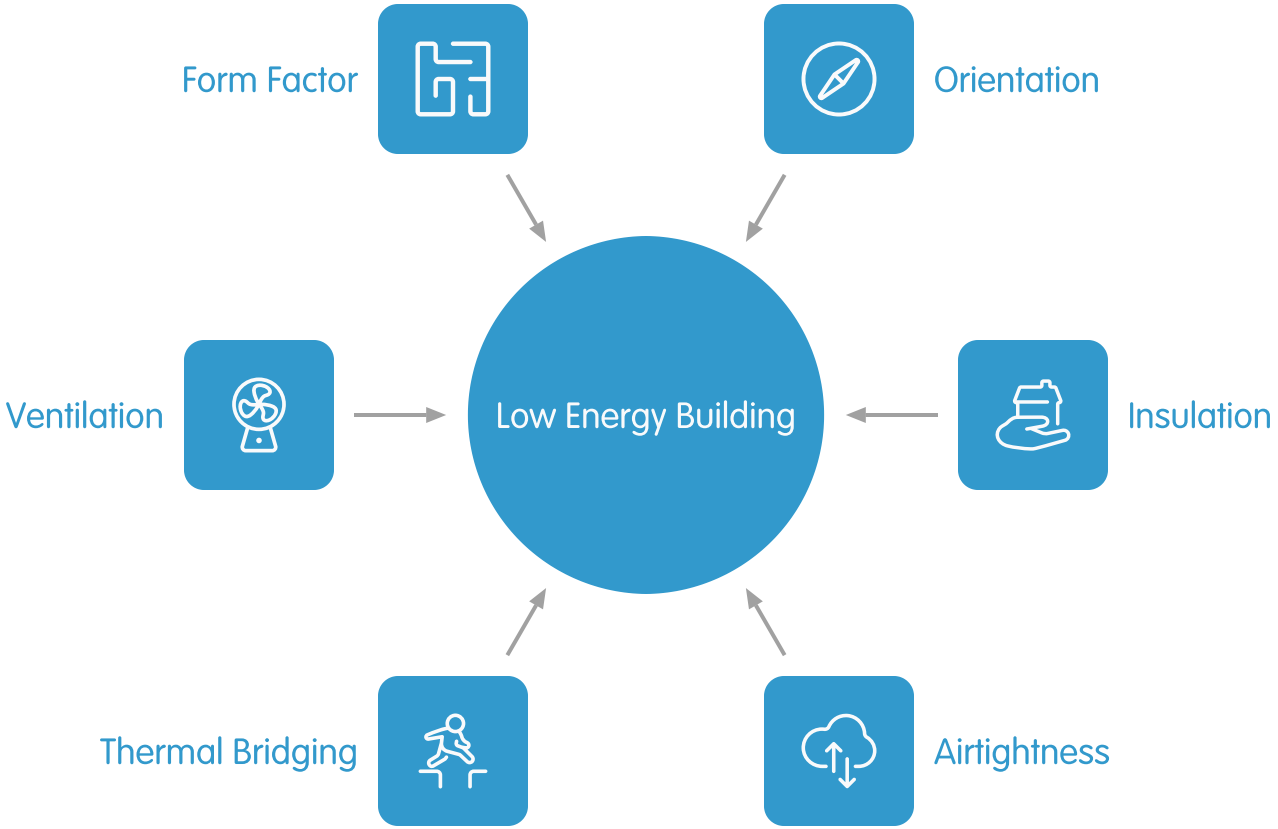
# Agenda

1. Introduction to Passivhaus
2. Getting to Net Zero
3. What else does Passivhaus deliver?
4. Some examples

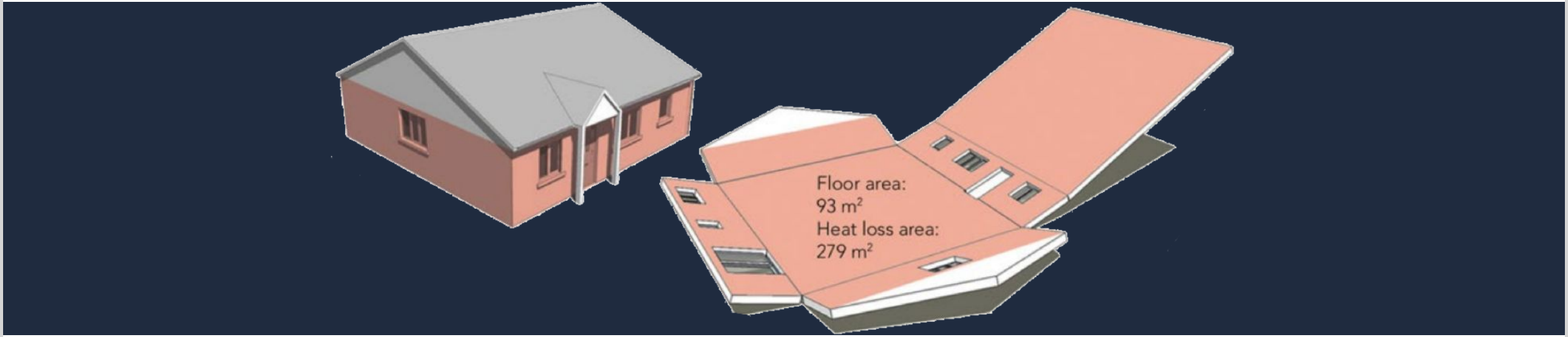
Section 1

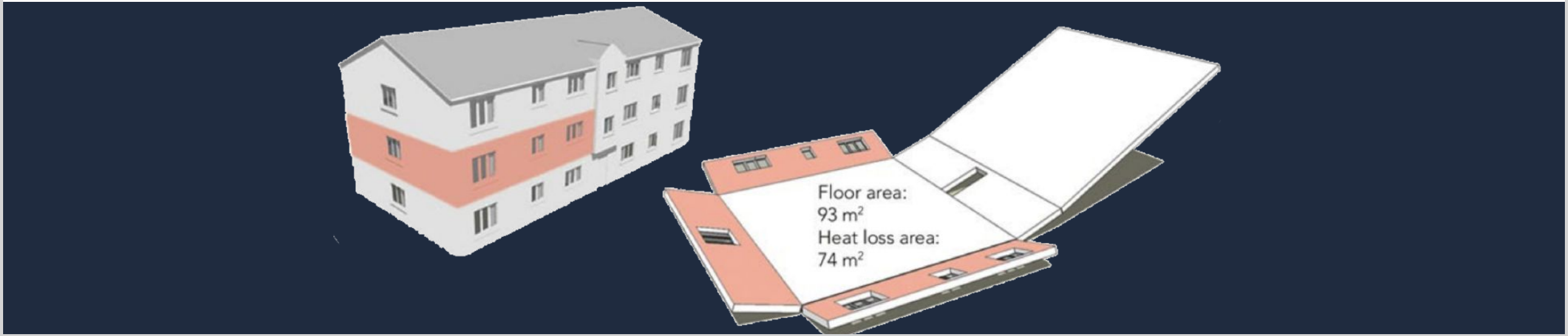
# Introduction to Passivhaus

# Key Principles

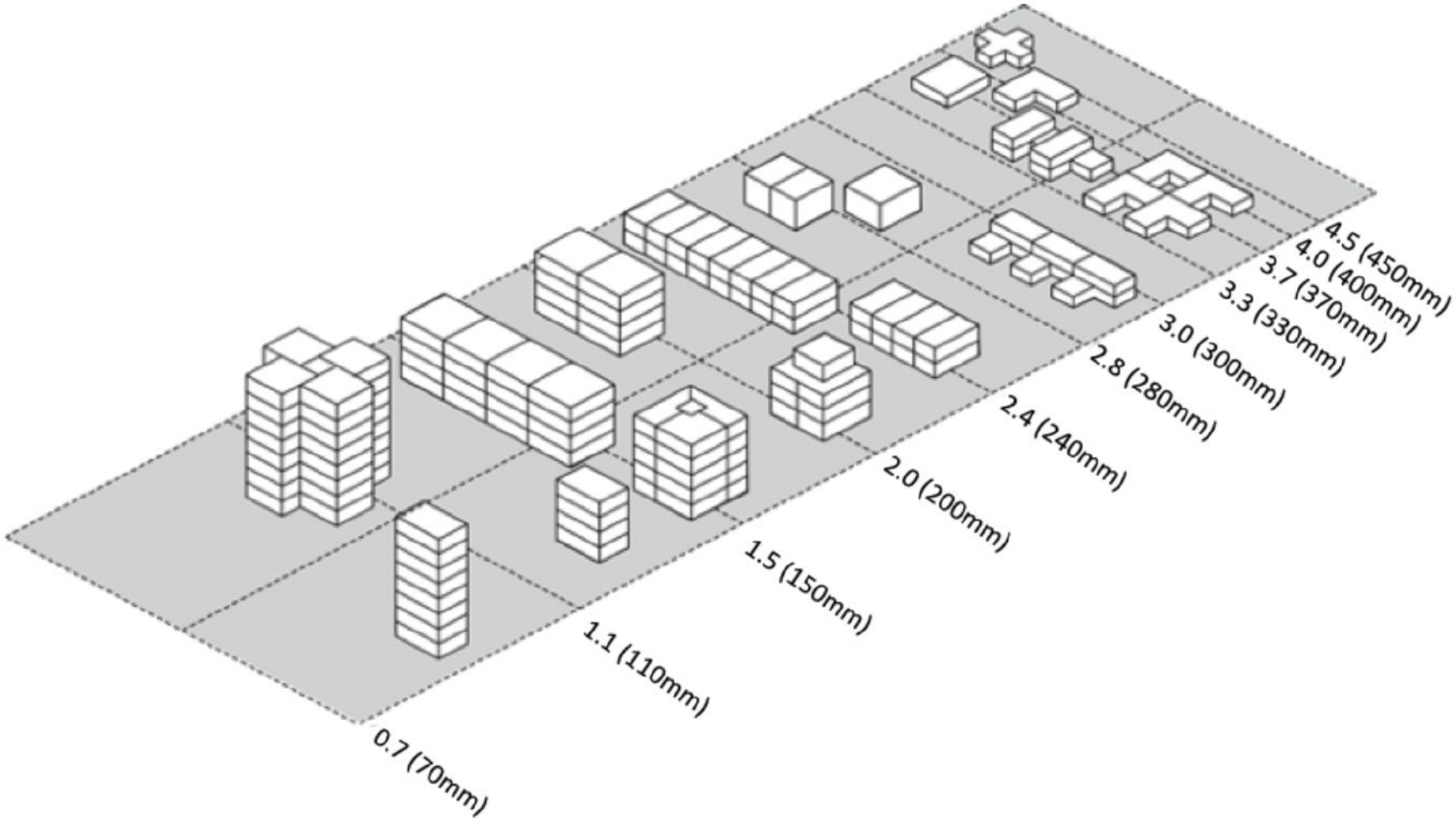


# Form Factor

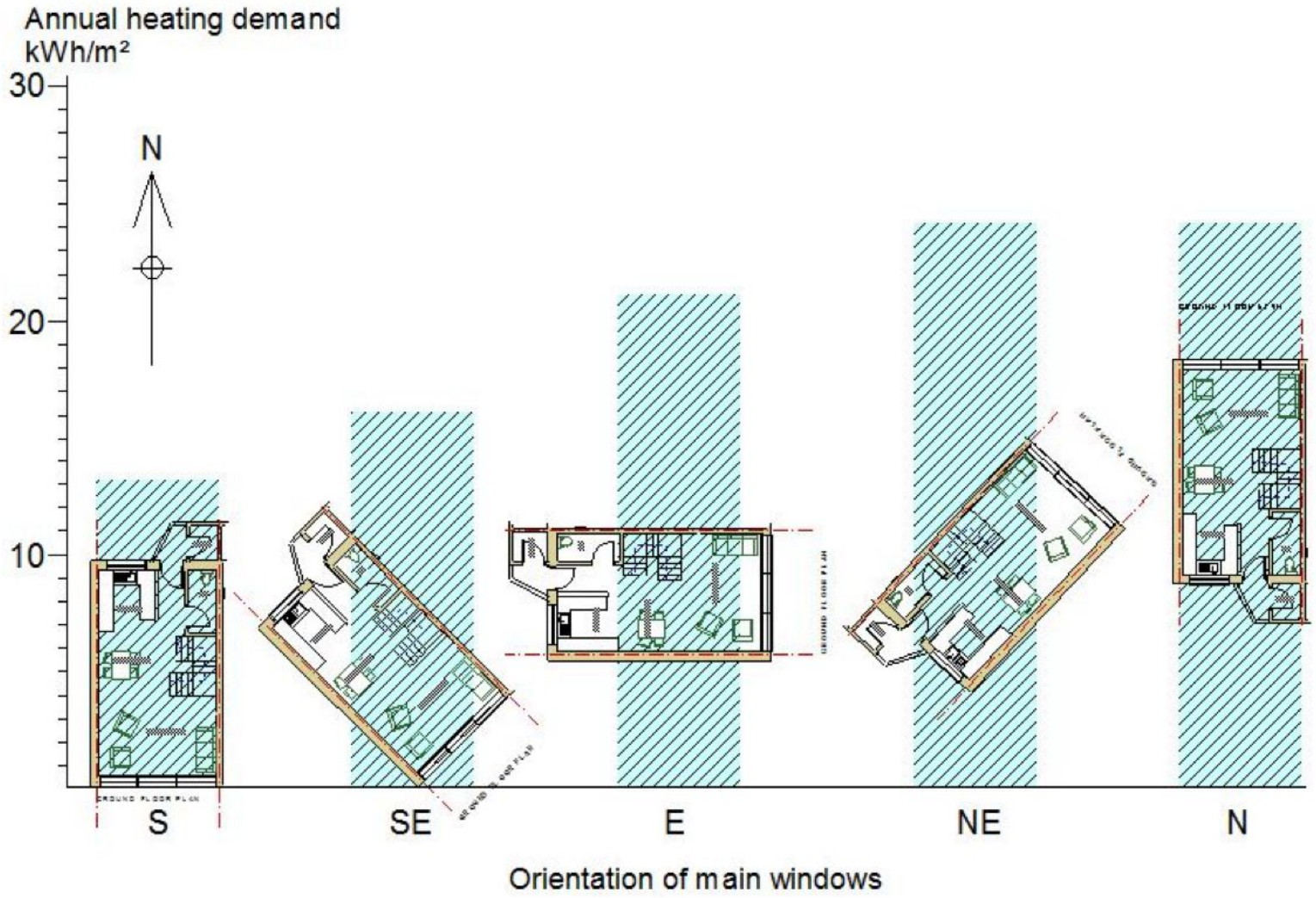

Floor area:
93 m²
Heat loss area:
279 m²


Floor area:
93 m²
Heat loss area:
74 m²

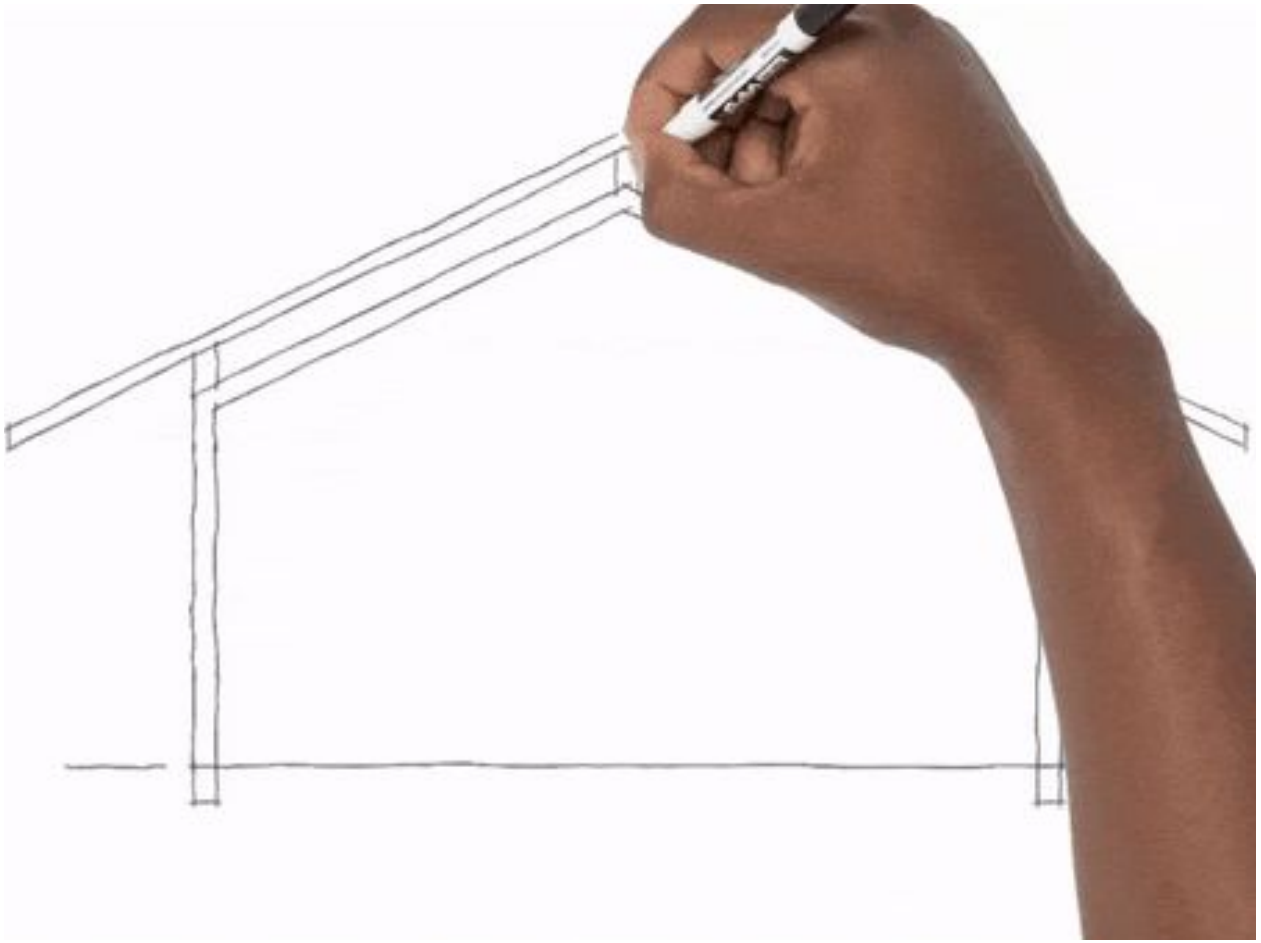
# Form Factor and insulation thicknesses



# Orientation

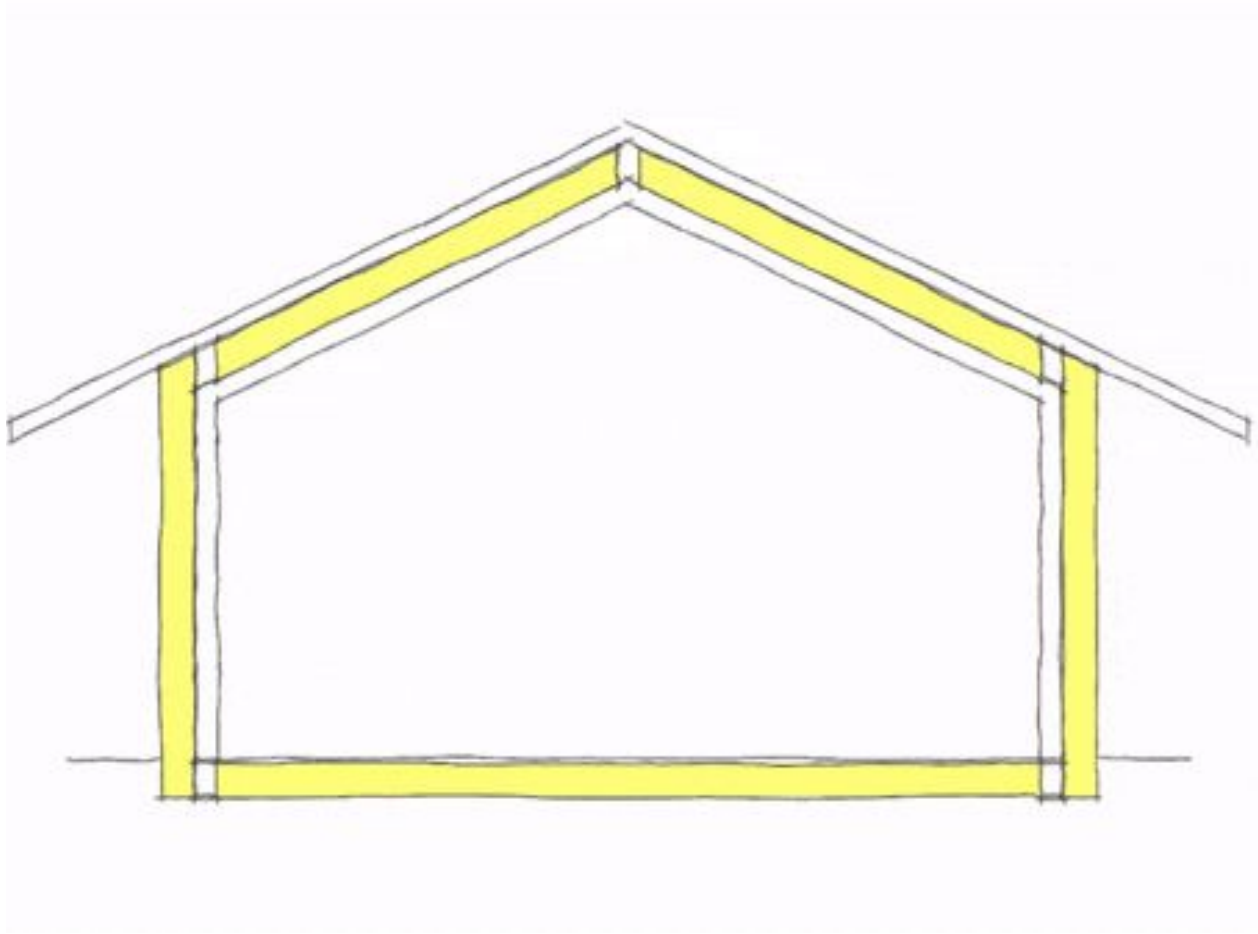


# Continuous Insulation



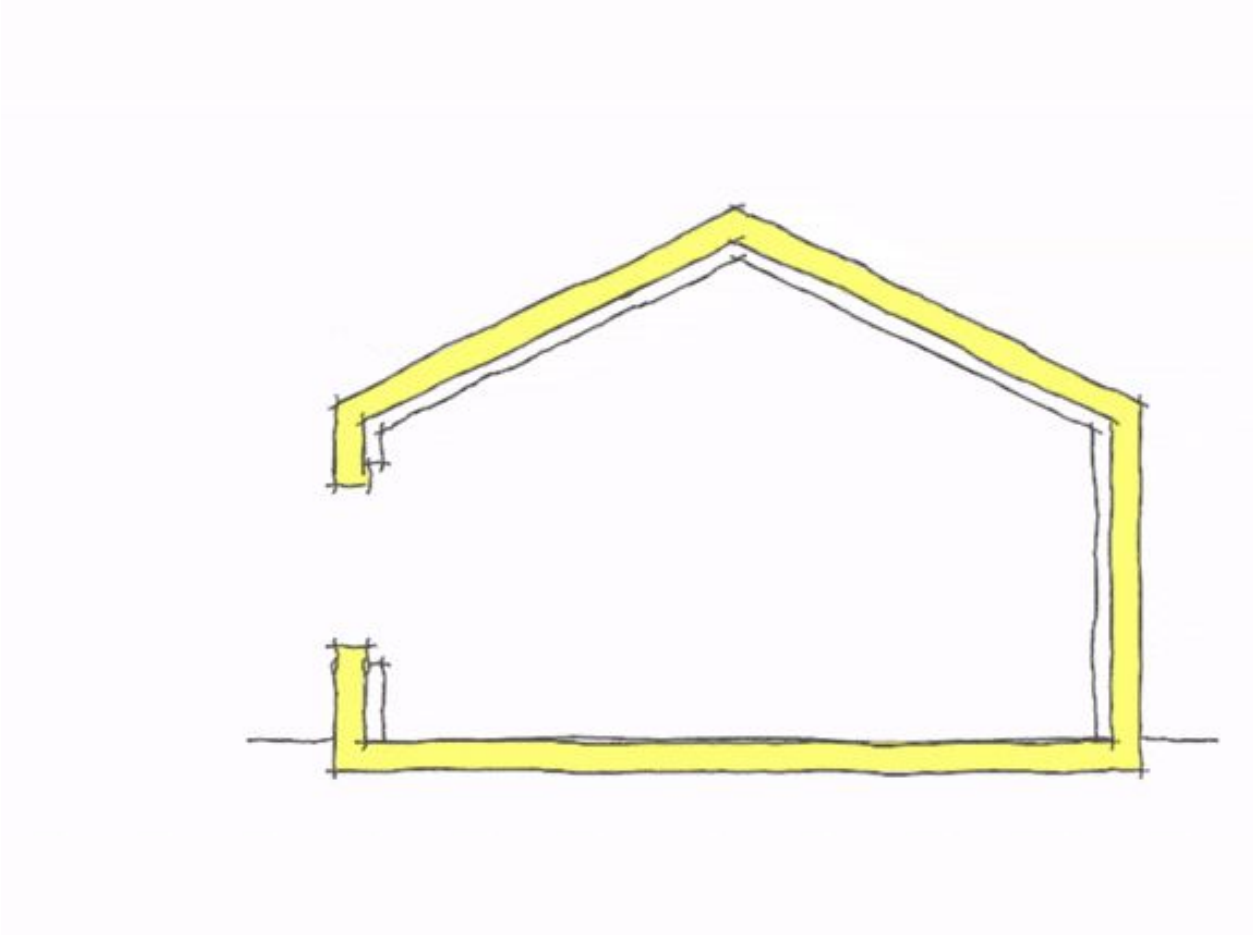
- Continuous insulation in all fabric elements exposed to the outside air
- Thicker than typical - allow up to 500mm for a wall (inc the structure)
- 'Tea-cosy' effect

# No Thermal Bridges



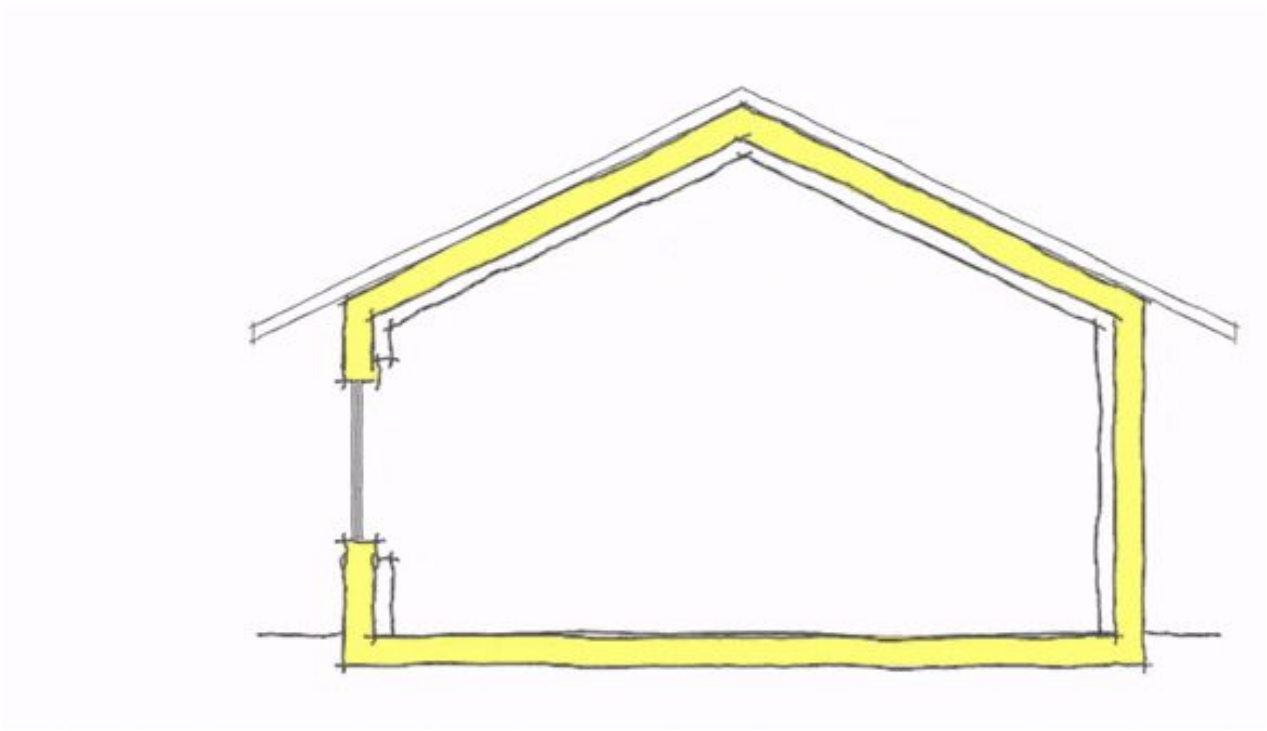
- Discontinuities in the insulation layer - 'Thermal bridges'
- These are in all buildings, but have a significant effect in a Passivhaus
- Really bad thermal bridges can also lead to condensation and mould
- In a Passivhaus we try to design them out

# Glazing



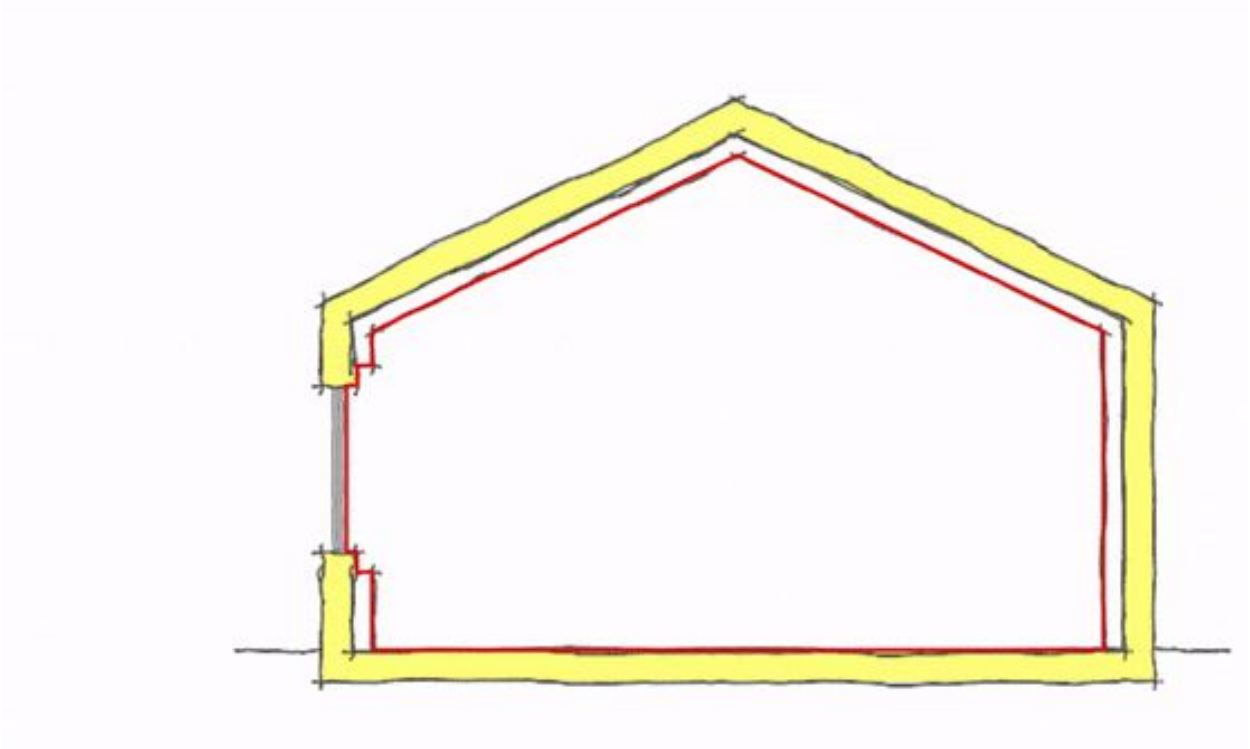
- Triple glazing needed to reduce heat loss and ensure internal comfort levels
- Glazing amount and orientation optimised to achieve solar gains
- Overheating in summer must not exceed 10% (usually much lower)

# Airtight



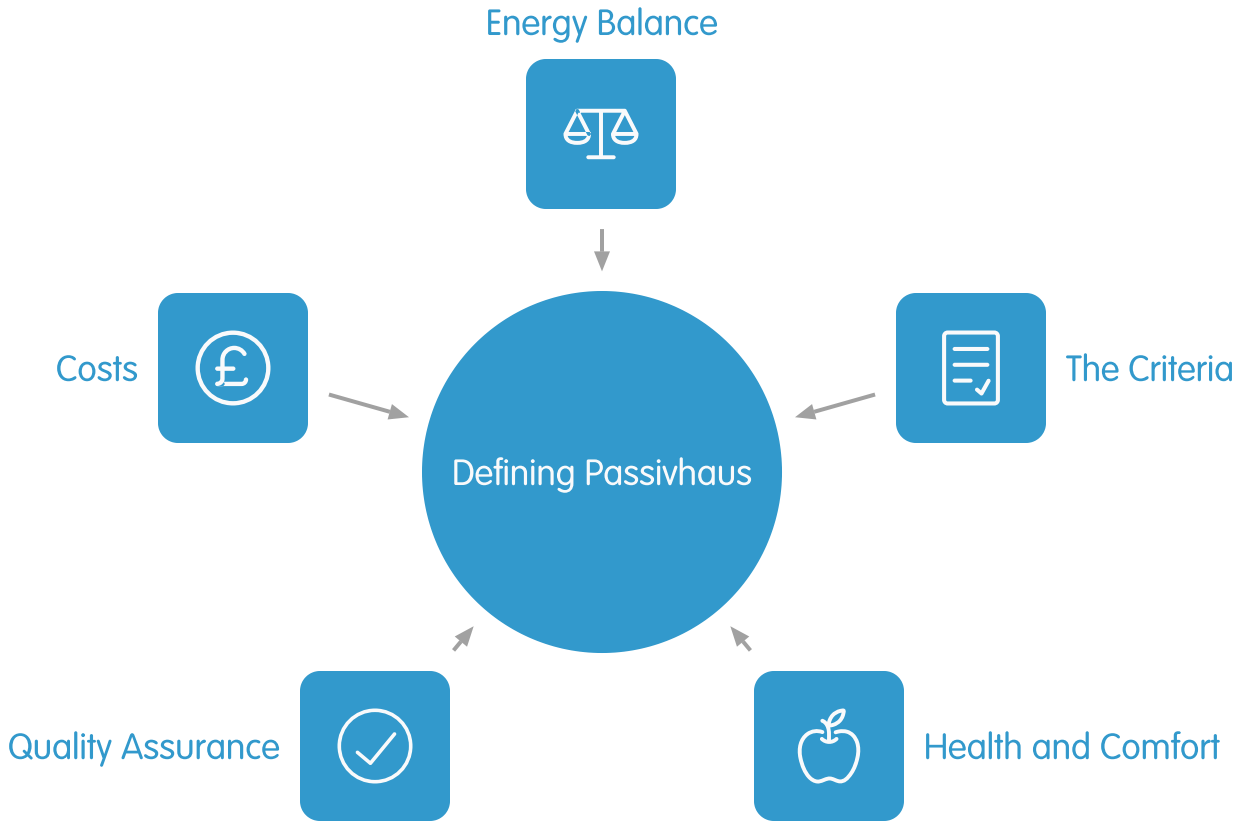
- Highly airtight - 0.6 Air Changes per Hour at 50 Pascals
- Average Building Regs equivalent is 5
- Maximum of 5p piece hole in every 5m2 of external wall/roof/floor
- Follow the red line without pen leaving the paper

# Mechanical Ventilation with Heat Recovery

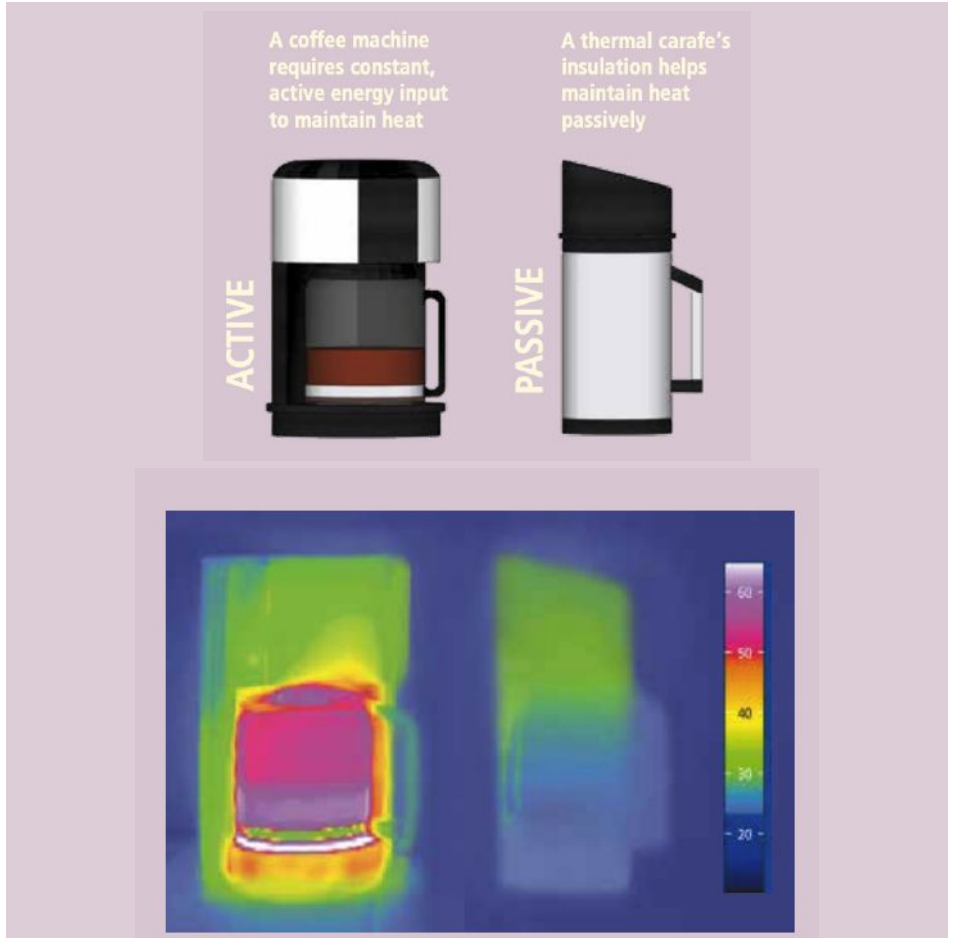


- 'Natural ventilation' generally insufficient
- MVHR constantly extracts and supplies
- Pollutants are removed whilst fresh, filtered air is introduced
- Heat is recovered from the stale air on the way out and used to heat up incoming air
- Typically 30m3 of fresh air per person per hour

# Defining a Passivhaus

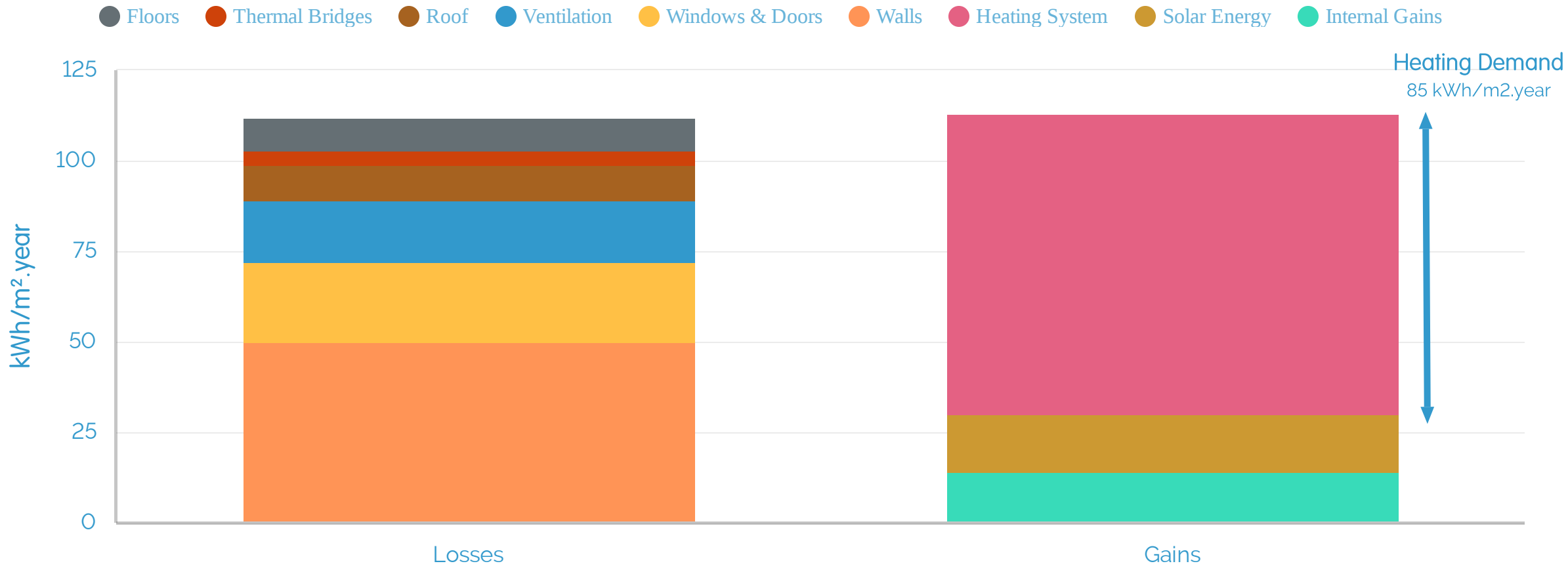


# Energy Balance - Active vs Passive

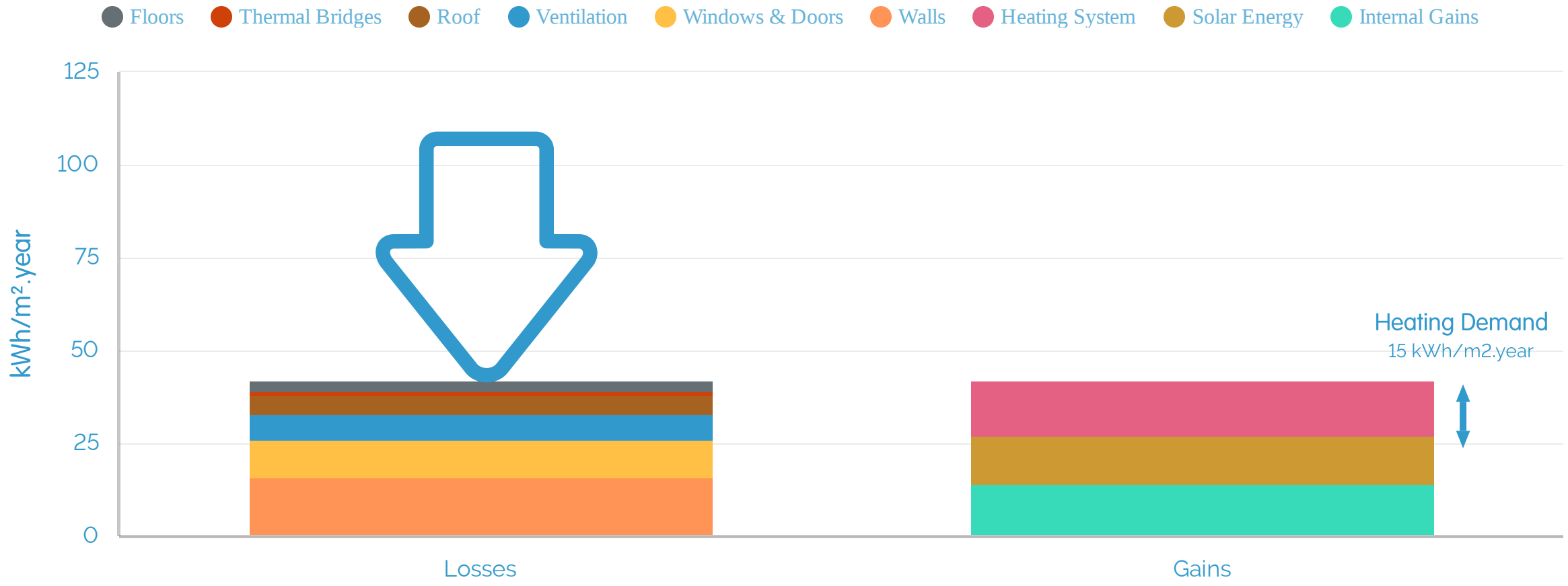



- In a typical building lots of energy is continuously lost through the walls, roof, floor and windows - so lots of active heating is needed to keep the building comfortable
- In a Passive building, heat loss is reduced to a minimum, so very little additional heat is then required to maintain a comfortable temperature

# Energy Balance - Typical UK Home



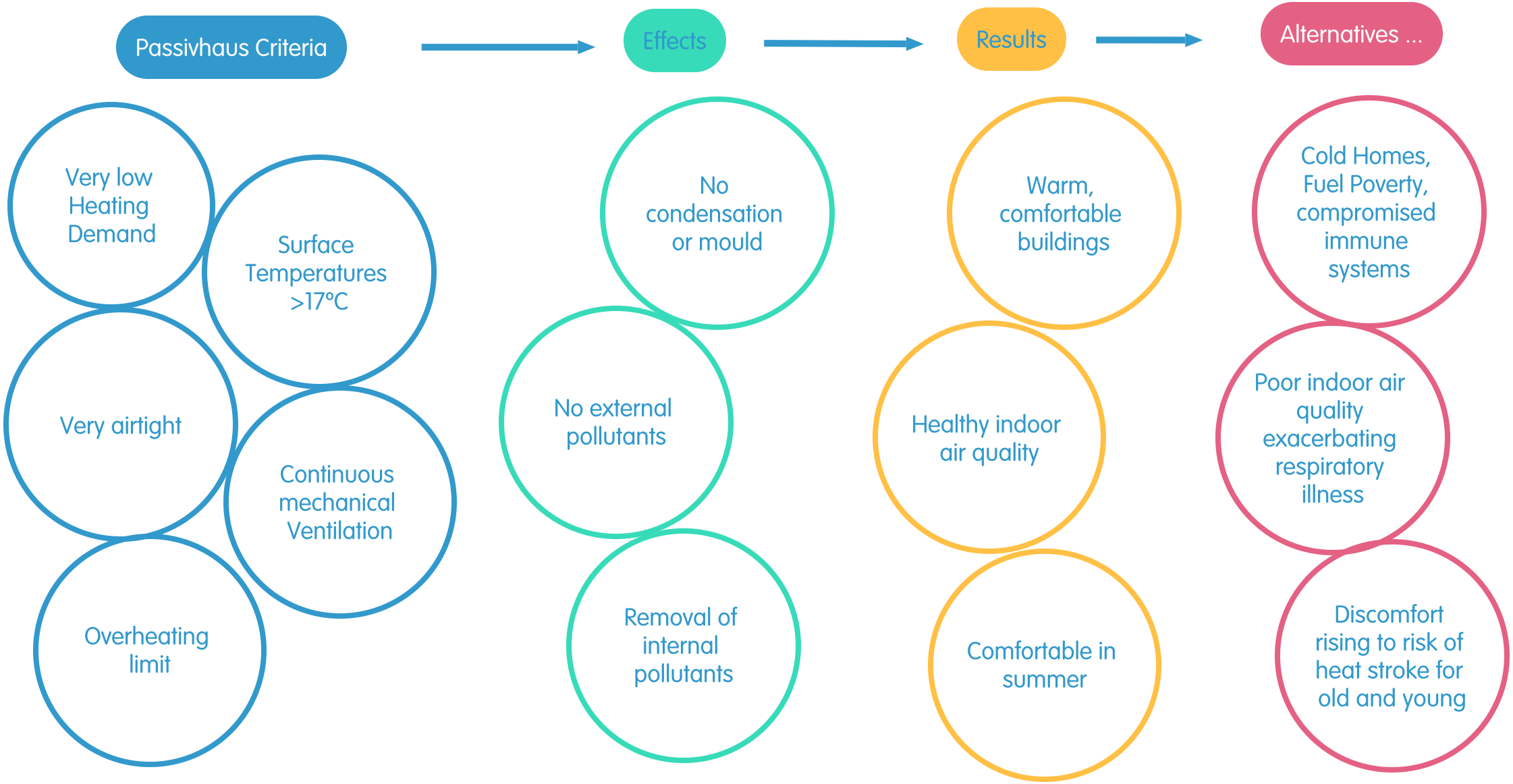
# Energy Balance - Passivhaus



# The Passivhaus Criteria

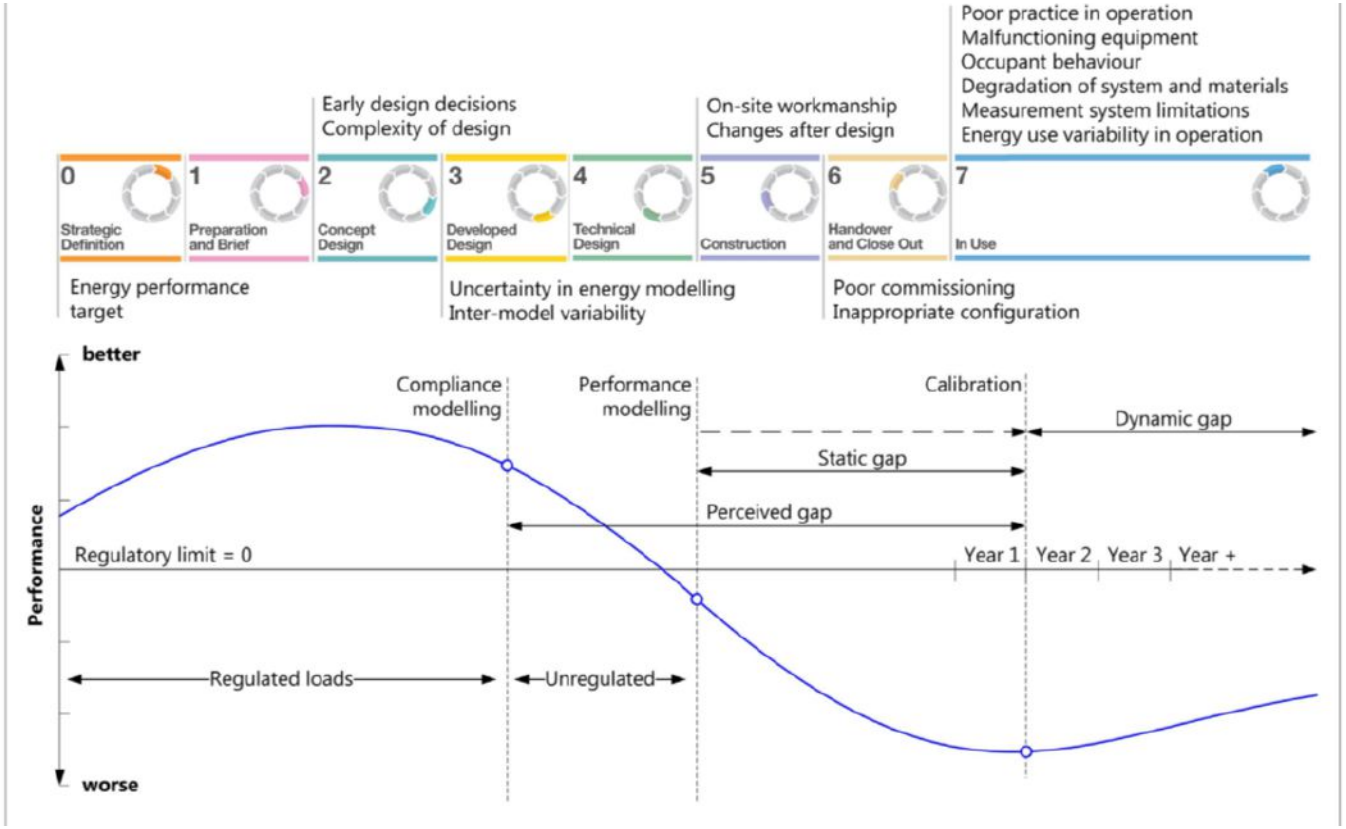
| Criteria | Limiting Value | Comfort & Health Related | Energy Related |
|---|---|---|---|
| Airtightness | 0.6 air changes per hour @50Pa | ✓ | ✓ |
| Internal Surface Temperatures | > 17°C at all times | ✓ | |
| Summer overheating | Less than 10% of the year > 25°C | ✓ | |
| Ventilation | 30$m^3$ of fresh air per person per hour | ✓ | |
| Heating Demand | <15 kWh/$m^2$.year | ✓ | ✓ |
| Primary Energy … | <135 kWh/$m^2$.year | | ✓ |
| Or … Primary Energy Renewable | <60 kWh/$m^2$.year | | ✓ |

# Passivhaus Health and Comfort



# What normally goes wrong - and when ...

Source: A Review of the Energy Performance Gap and Its Underlying Causes in Non-Domestic Buildings. Dronkelaar et al, January 2016



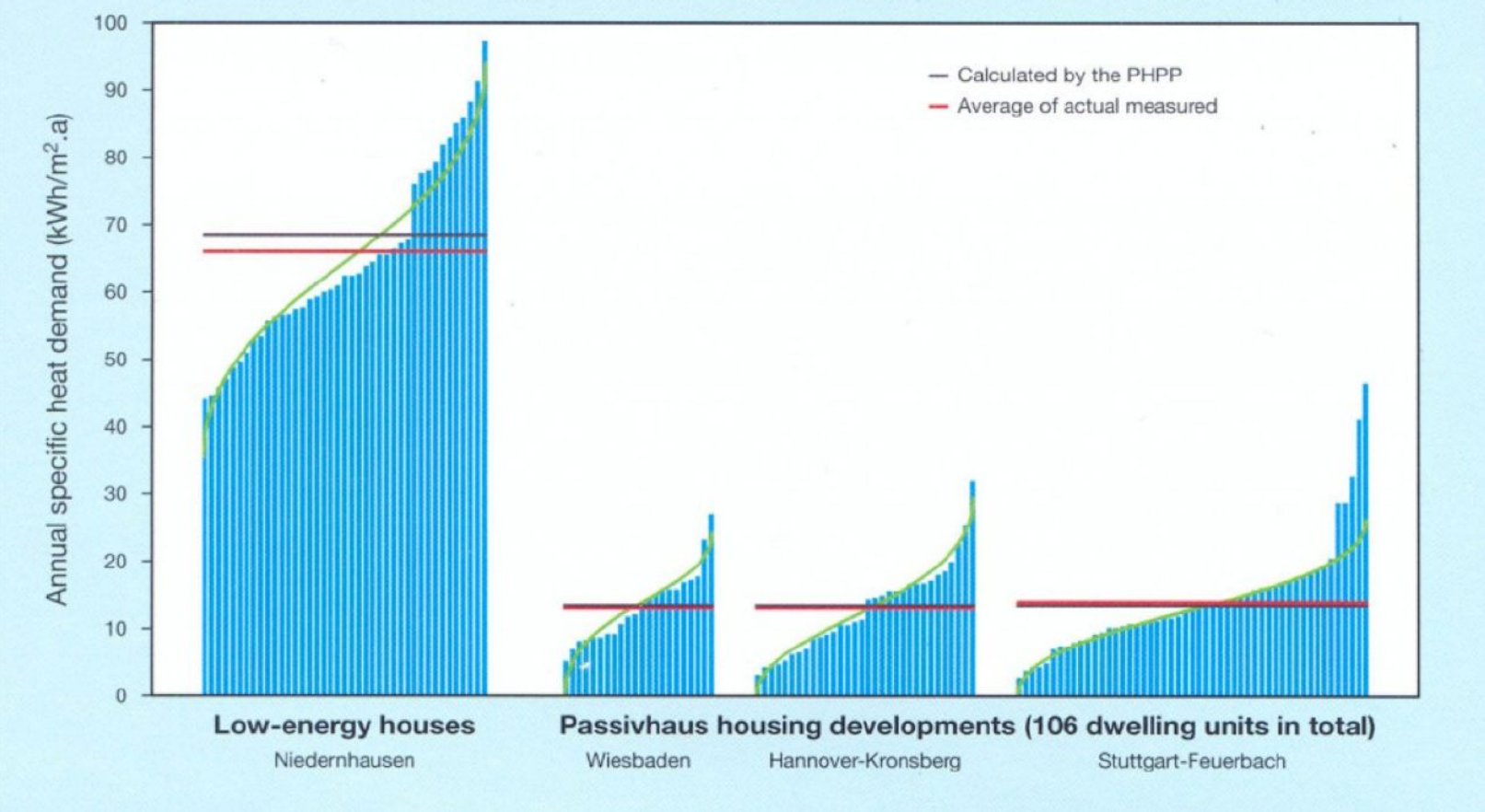

Despite starting off with best intentions, the performance gap develops during the design phase, is further exacerbated on site and by the time the building is occupied, it can't be recovered

# How Passivhaus addresses the Performance Gap ...

| Passivhaus as a strategic objective | Passivhaus as a client requirement | Passivhaus embedded in design principles | Maintaining the aim whilst the goalposts move | Keeping the faith ... | On site compromises ... evidence, site visits | Certification and 'how to use it' | Monitor ... |
|---|---|---|---|---|---|---|---|
| 0 Strategic Definition | 1 Preparation and Brief | 2 Concept Design | 3 Developed Design | 4 Technical Design | 5 Construction | 6 Handover and Close Out | 7 In Use |

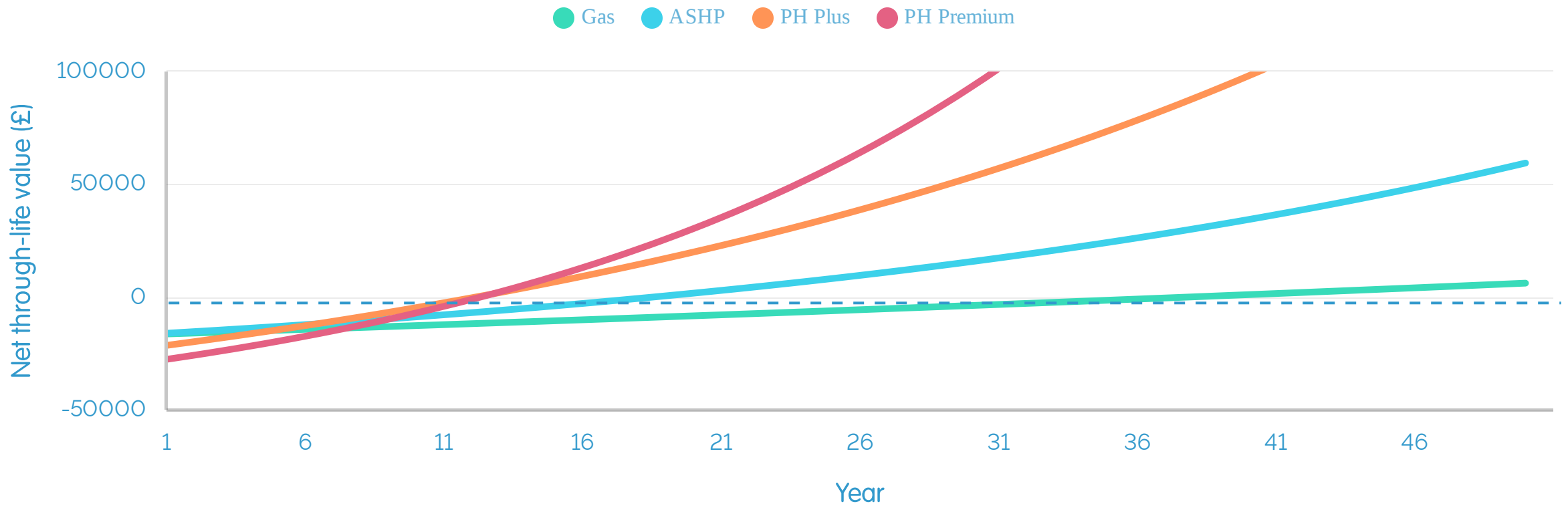

The involvement of a certified Passivhaus Designer, Certifier and Tradespeople at the key stages means that the Performance Gap is not given the opportunity to develop

# And the result is, on average, no performance gap ...




On average, a the space heating demand of a Passivhaus matches what was modelled at design stage

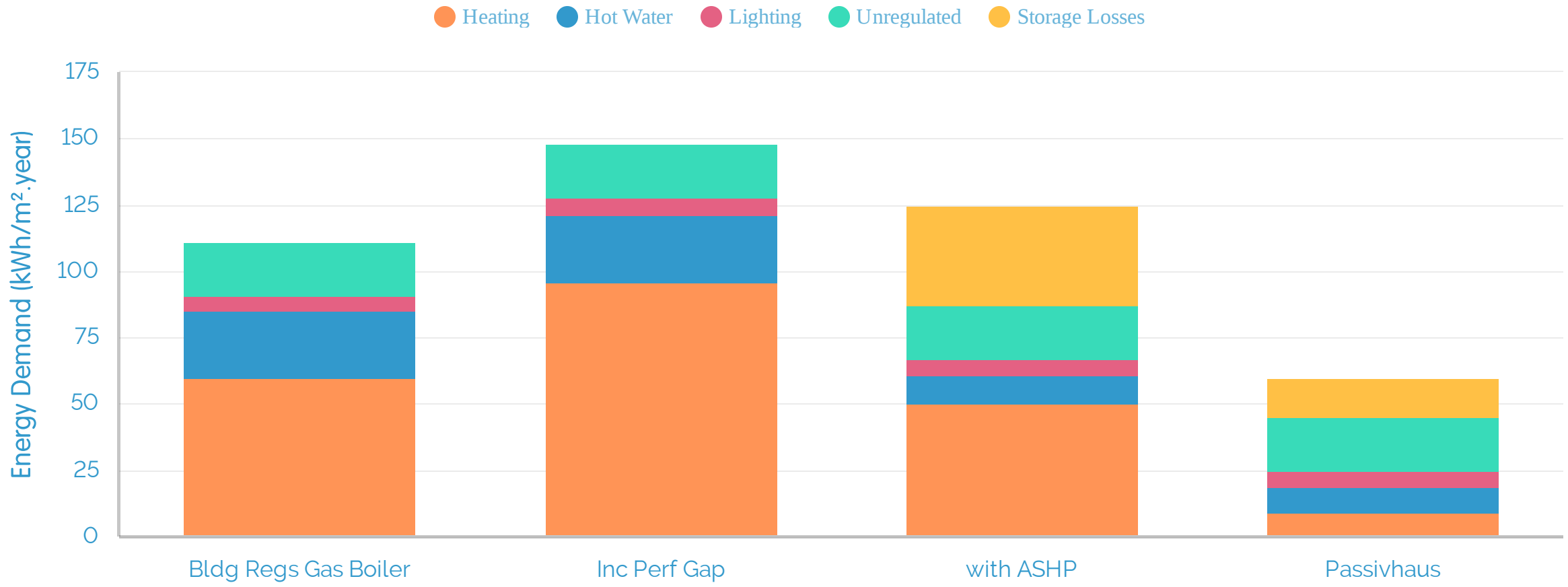
# And through-life costs will be lower ...



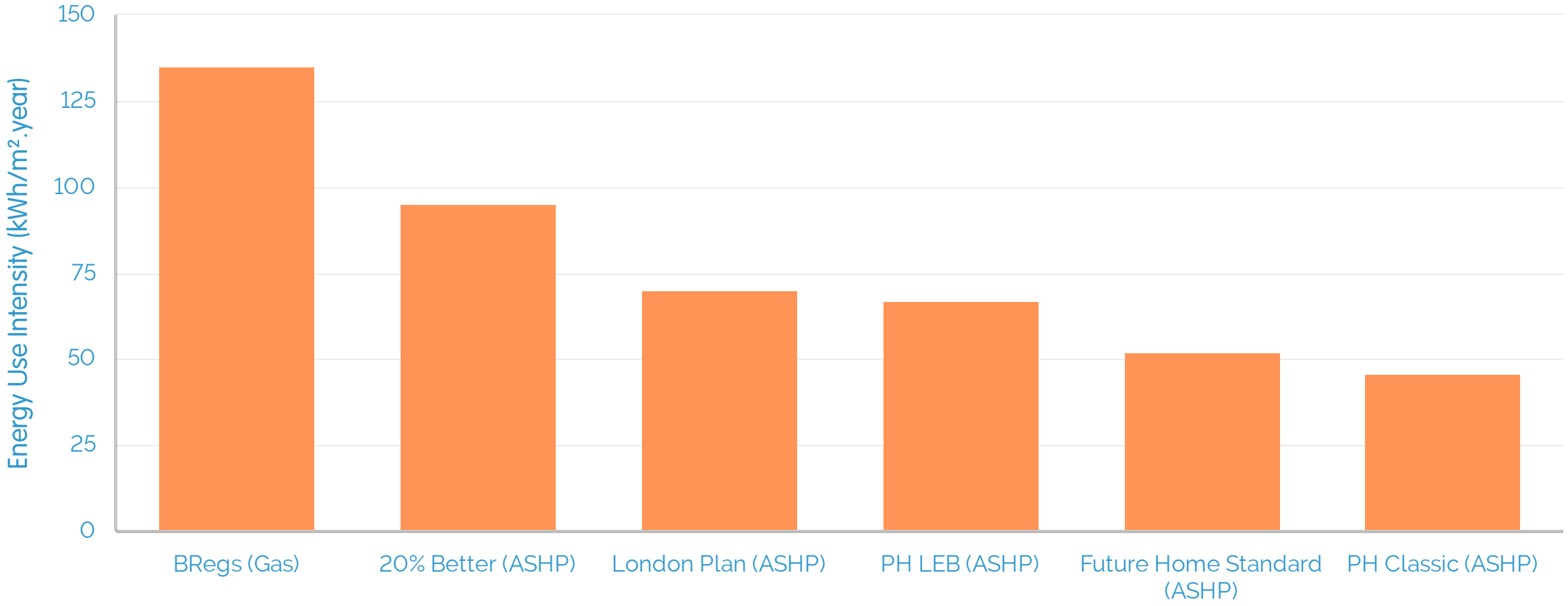

Passivhaus through-life costs vs Building Regulations equivalent

100m² dwelling with an occupancy of 3 people

# How does Passivhaus Compare?

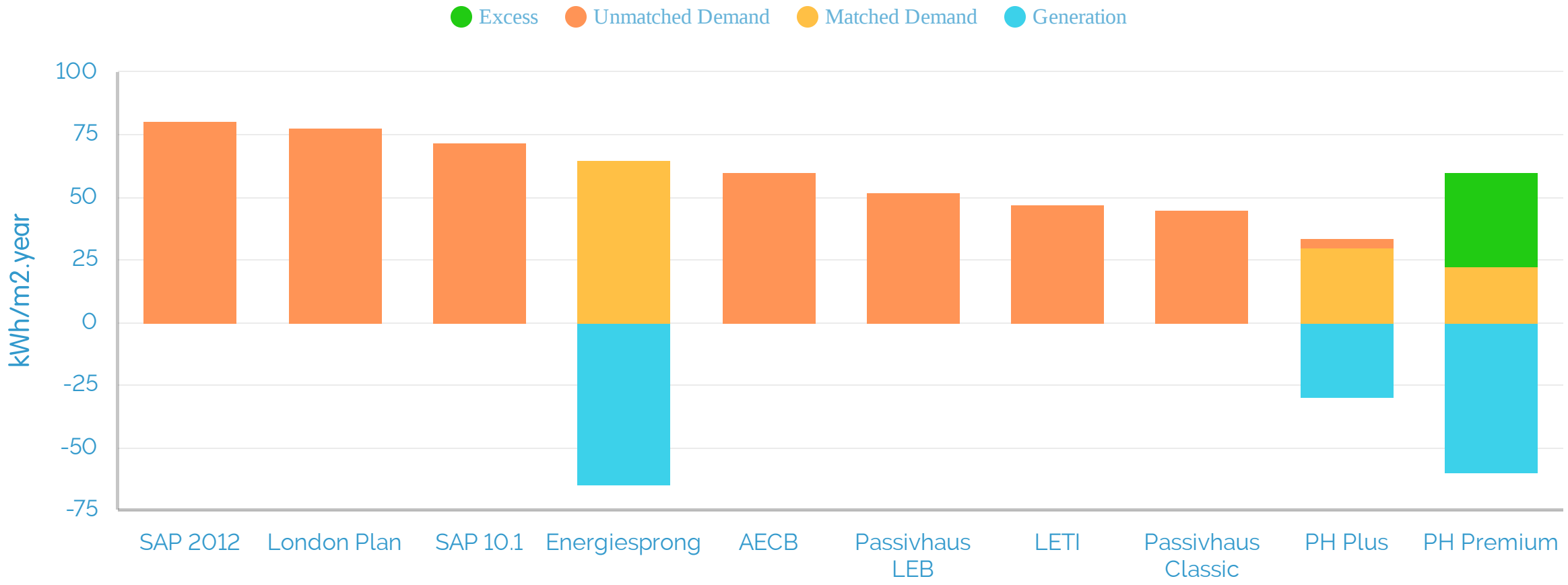


# What about some other standards?




Note: Storage Losses not included

# More standards ... with generation - net zero?




Net Zero balance for 68m2 dwelling. Storage losses not included.

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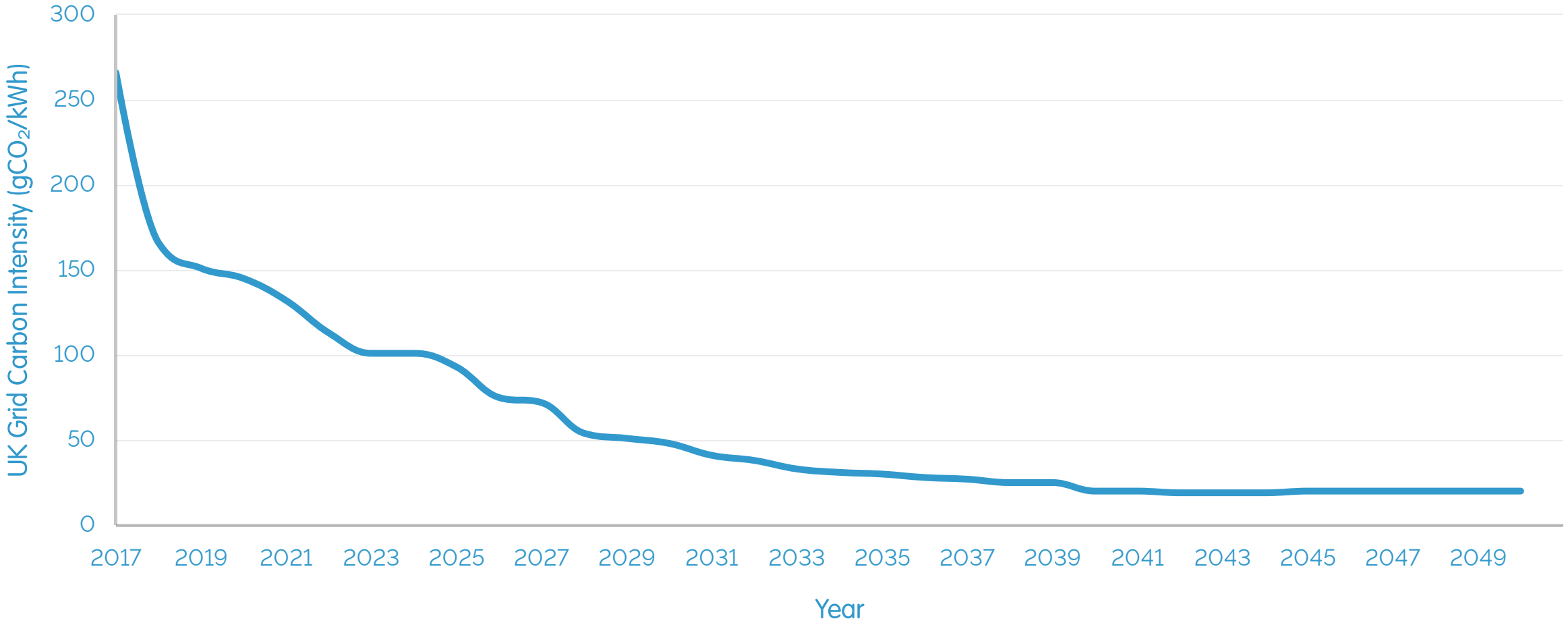
Section 2

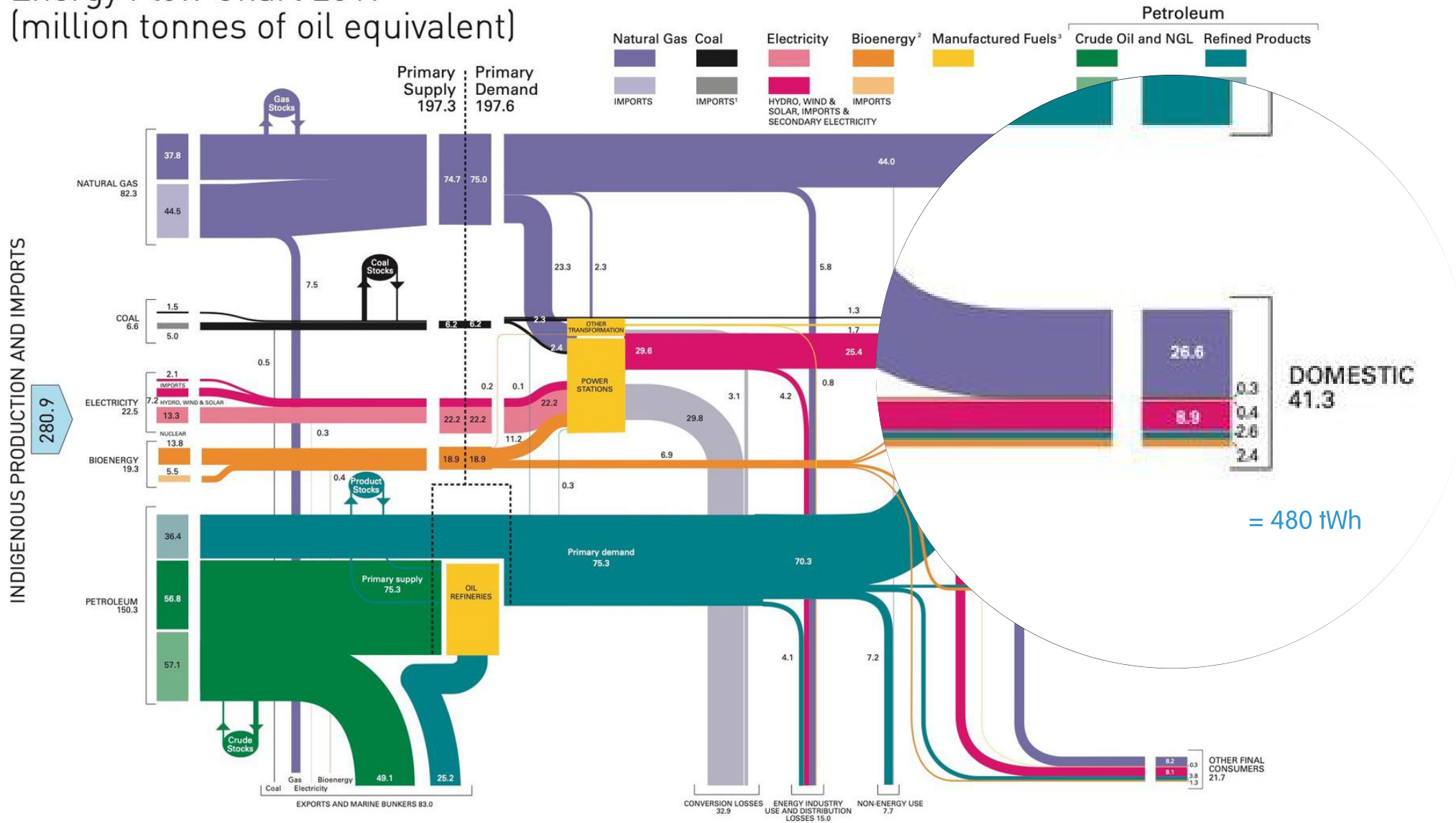
# GETTING TO NET ZERO

# Loads of renewables = less carbon




Source: National Grid Future Energy Scenarios, 2019

# Energy Flow Chart 2019
# (million tonnes of oil equivalent)




FOOTNOTES:
1. Coal imports and exports include manufactured fuels.
2. Bioenergy is renewable energy made from material of recent biological origin derived from plant or animal matter.
3. Includes heat sold.
4. Includes non-energy use.

This flowchart has been produced using the style of balance and figures in the 2020 Digest of UK Energy Statistics, Table 1.1. (gross calorific values basis)

Department for Business, Energy & Industrial Strategy

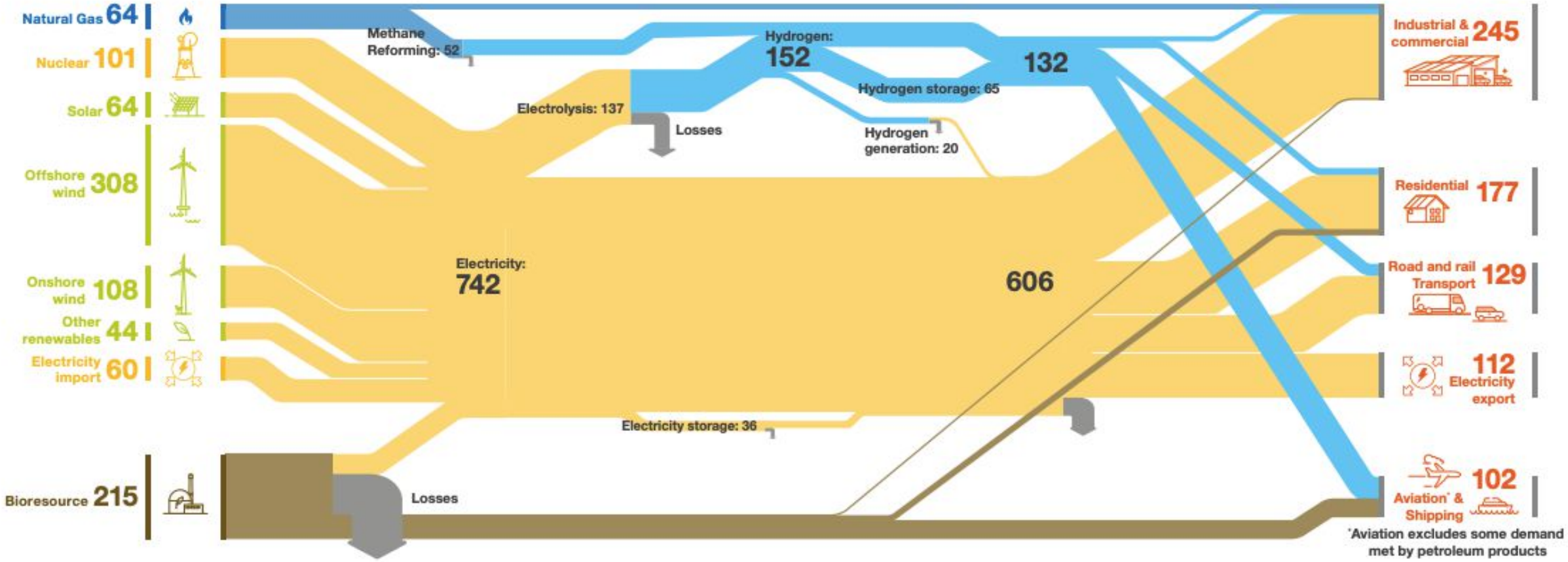
NATIONAL STATISTICS

# Future Energy Scenarios - Consumer Transformation

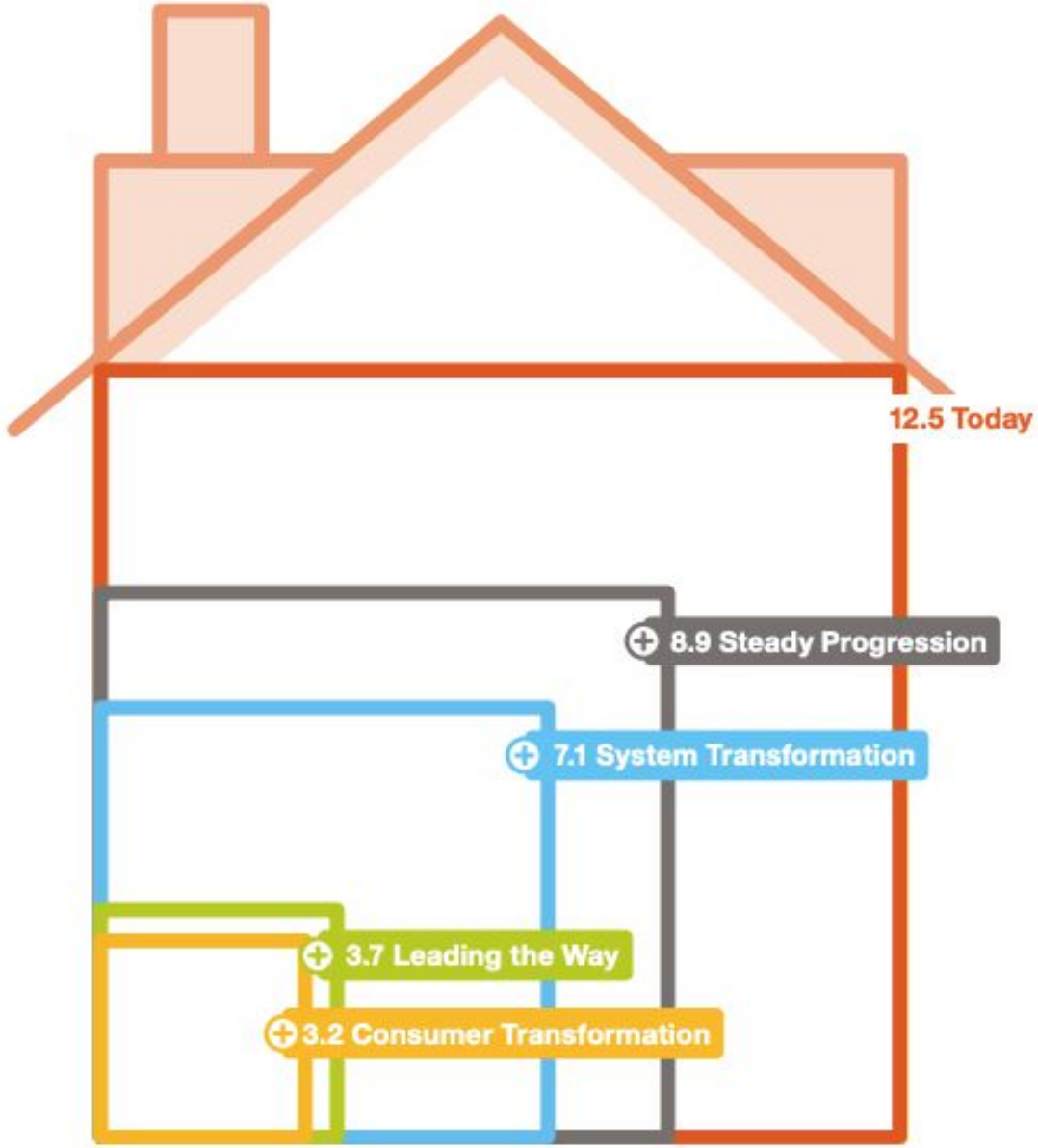
**CONSUMER TRANSFORMATION**

- Electrified heating
- Consumers willing to change behaviour
- High energy efficiency
- Demand side flexibility

Energy flows in 2050 (TWh) - National Grid Future Energy Scenarios 2020

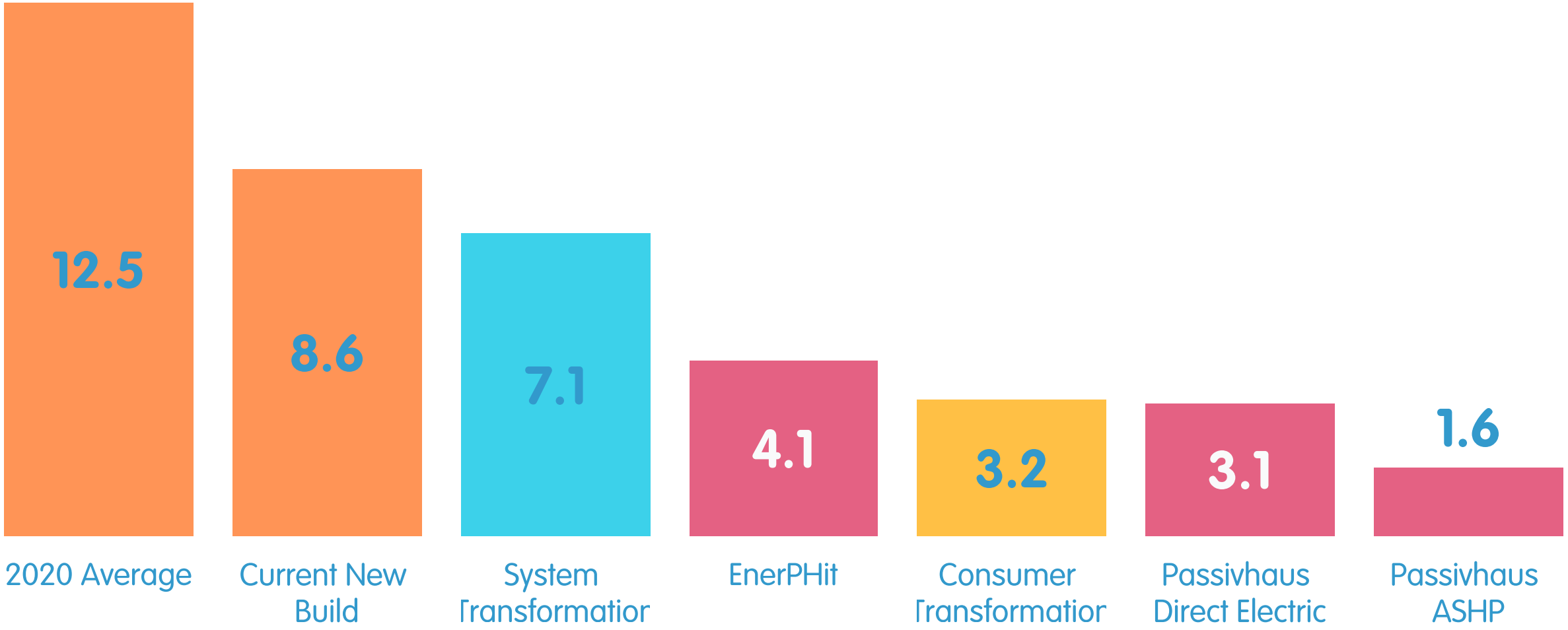


# Average Heating and Hot Water Demand per home (MWh/year)

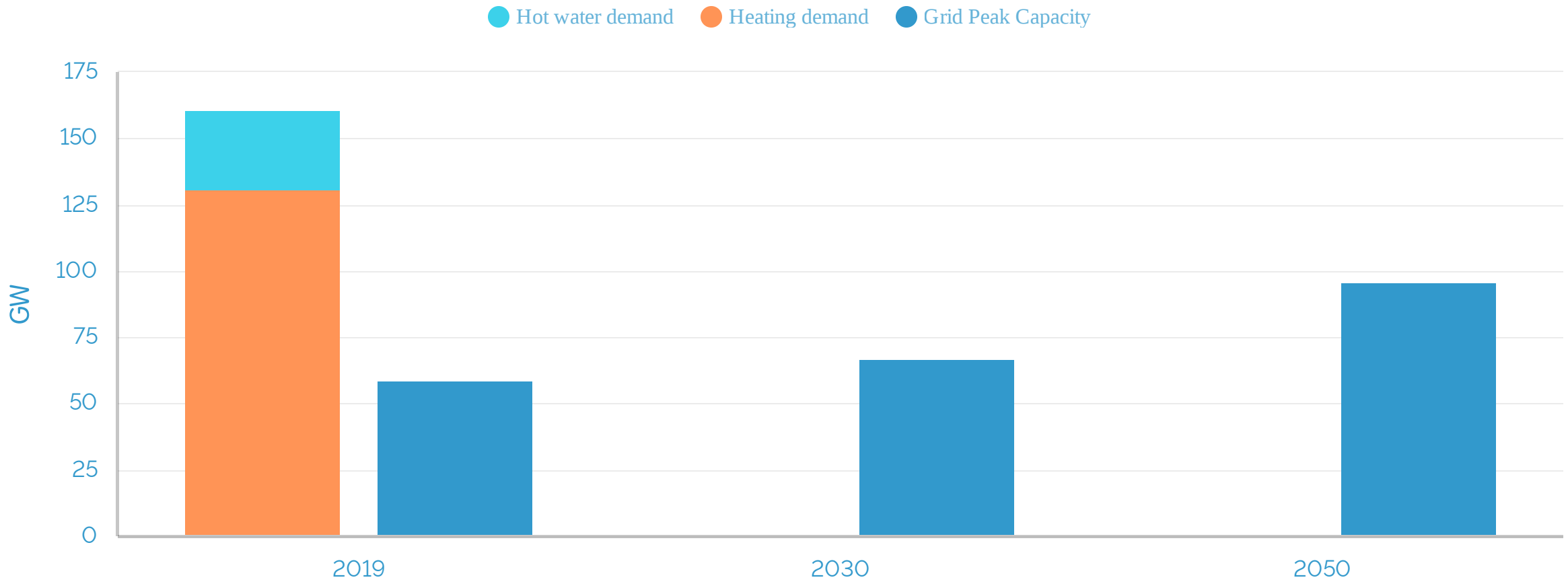



Source: National Grid, Future Energy Scenarios 2020

# Average Domestic Heating and Hot Water Demand (MWh/year)



# But peak load is also an issue …

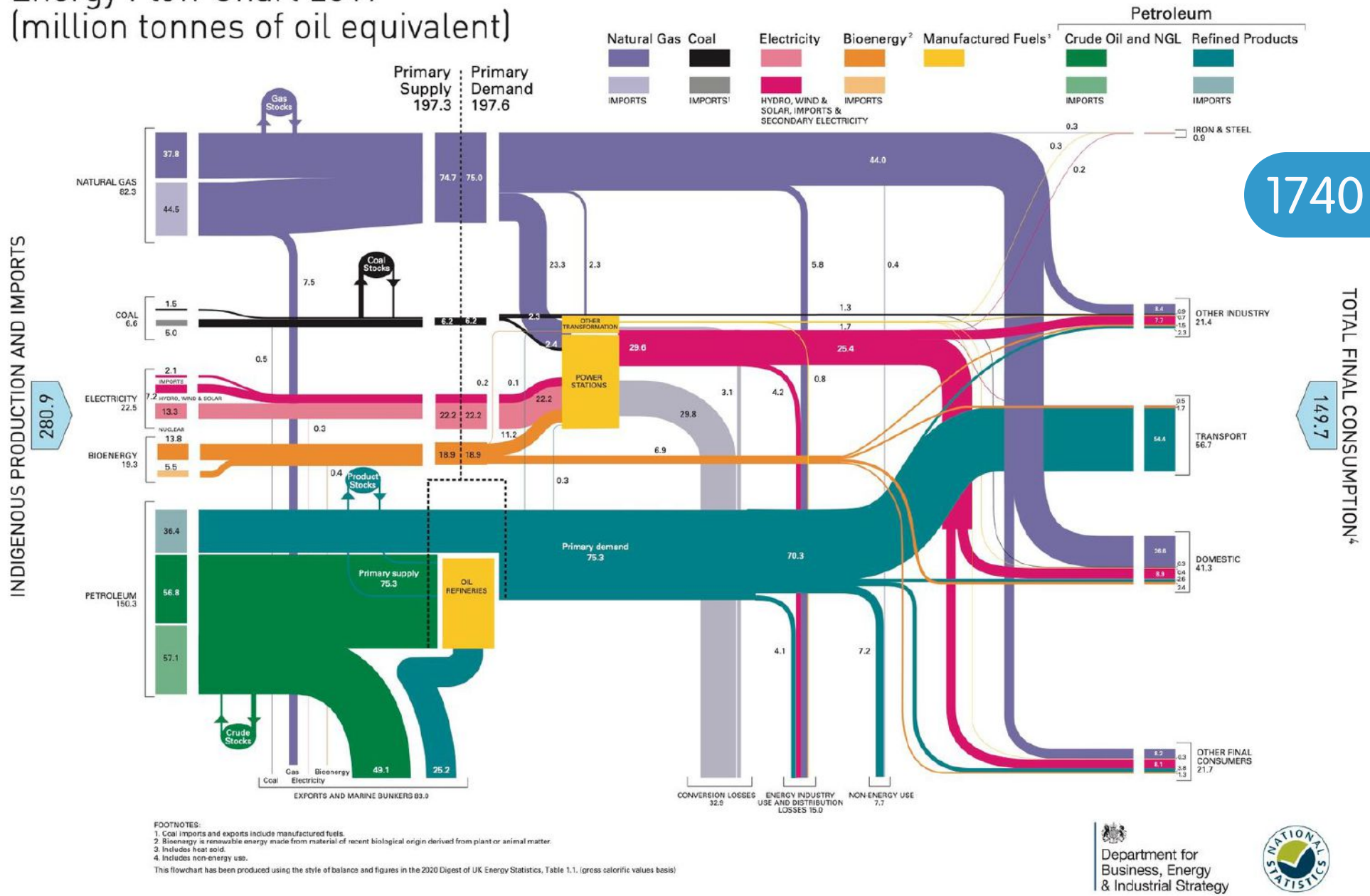


# Residential

"Energy Efficiency is a 'no regrets' measure for all scenarios"

Natiional Grid, Future Energy Scenarios 2020

# Energy Flow Chart 2019
## (million tonnes of oil equivalent)




1740 TWh

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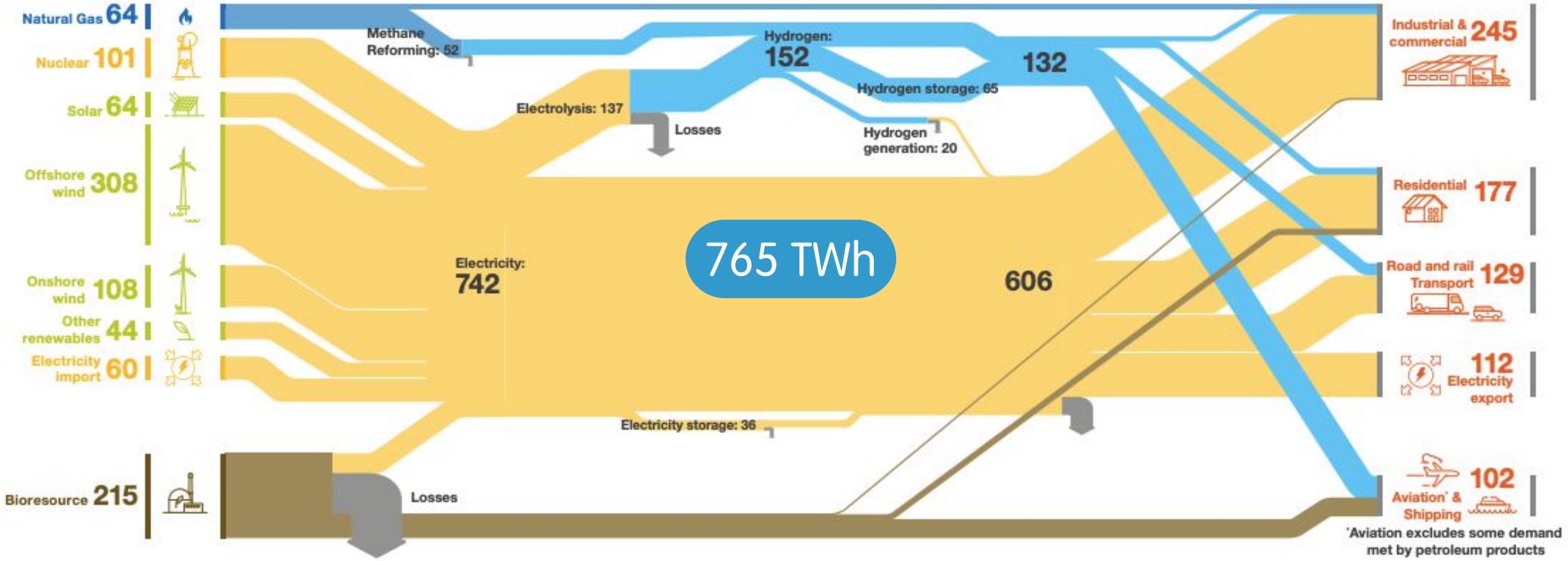
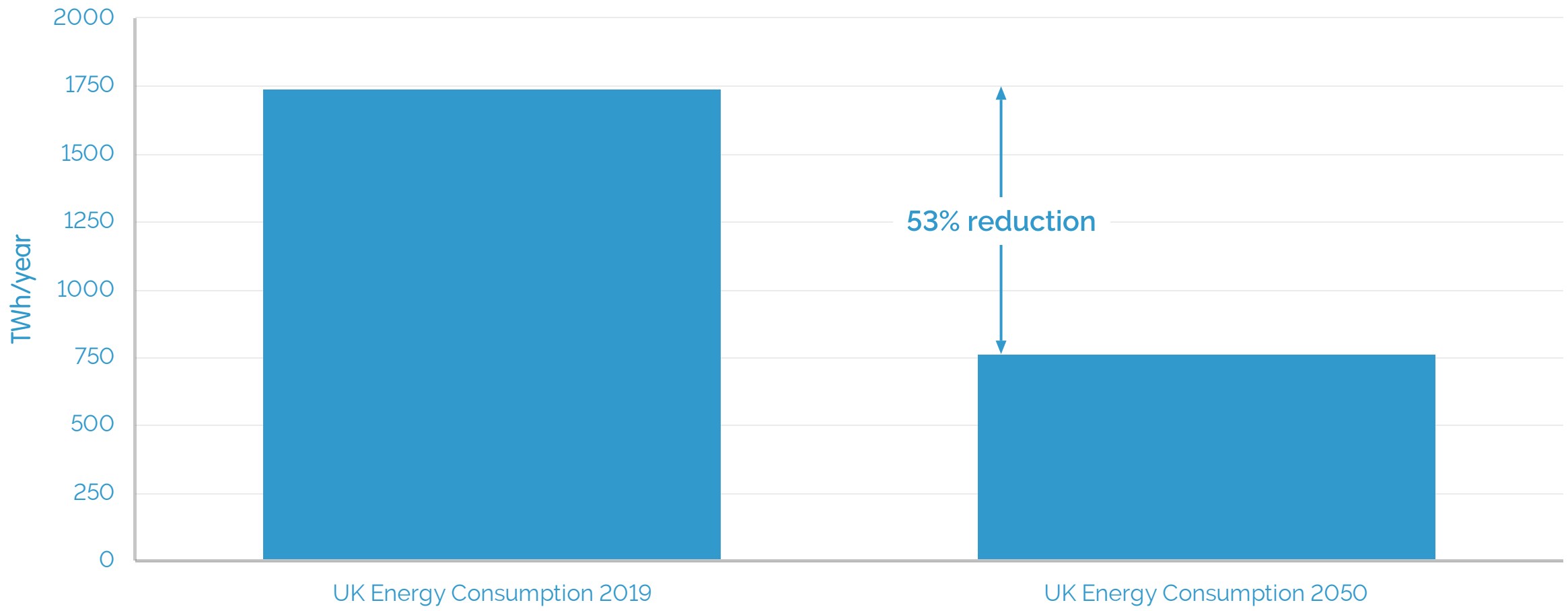
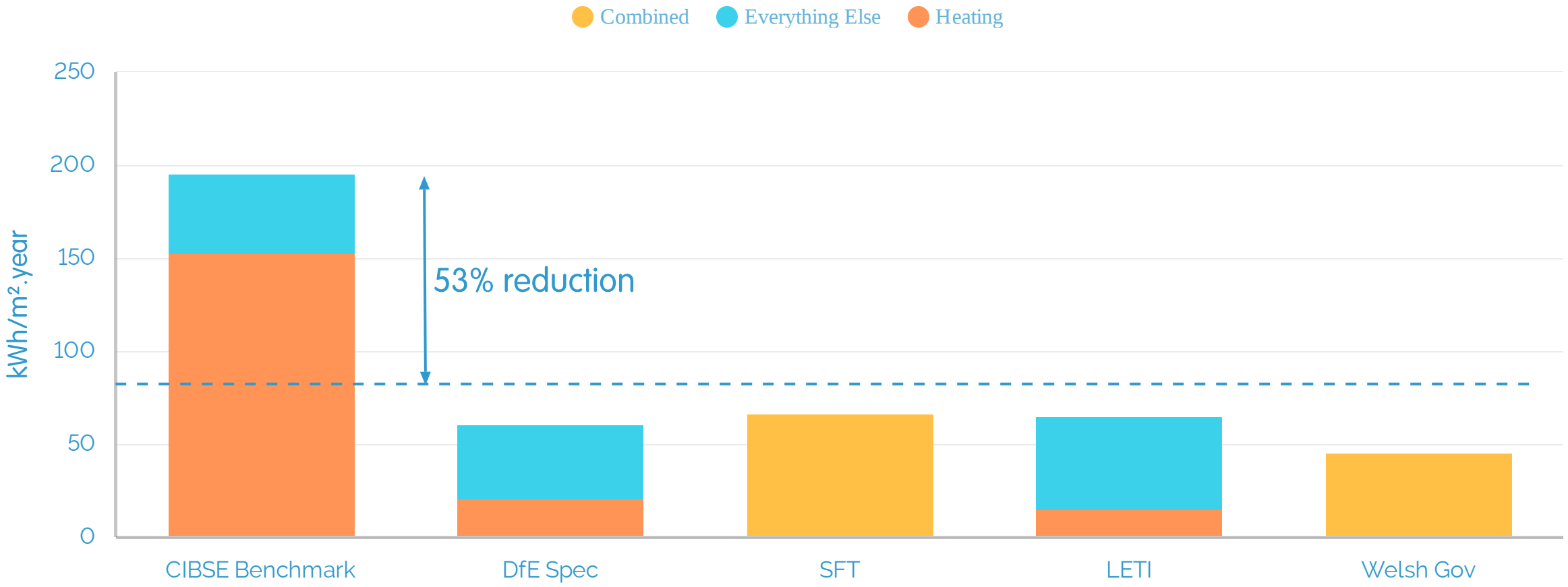


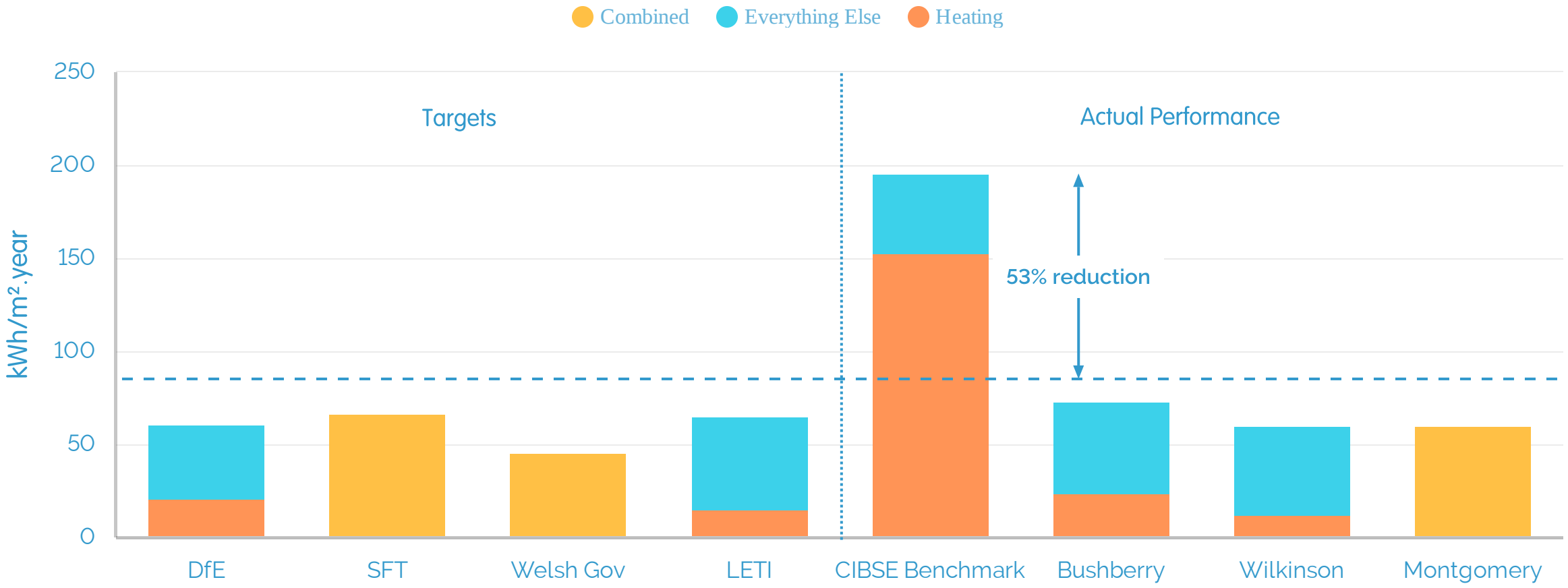
# Reduction in UK energy demand to get to net zero …



# School Energy Standards



# Passivhaus Schools Performance



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Section 3

# What else does Passivhaus deliver?


Climate Emergency
People Performance
Financial
Social
Health & Wellbeing
Building Performance

- Low energy demand
- No performance gap
- High levels of comfort
- Better quality buildings

## Building Performance

- Reduced carbon emissions
- Lowers peak demand
- Lowers the overall requirement for renewable energy
- Cheaper to save energy than to generate it
- Gives us the best chance of achieving net zero in buildings
- Robust in the face of short-term extremes and longer-term climate changes
- Ability to support demand response
- Lower cooling requirement in a future warmer climate

## Climate Emergency

- Rental - fewer void periods
- Higher capital value
- Lower energy bills
- Lower maintenance cost
- Ability to access cheaper time of day tariffs
- Lower whole life costs
- Moves households out of fuel poverty
- Lower borrowing costs / Green mortgages
- Ability to leverage green finance

## Financial

- Reduced absenteeism
- Improved Productivity
- Improved learning outcomes

## People Performance

- Eliminates cold homes
- Reduces risk of buildings becoming too hot in summer
- Guarantees good levels of ventilation
- Eliminates or reduces internal pollutants such as VOCs
- Deals with internal humidity – eliminates condensation and mould
- Protects against external air pollutants
- Reduces the impact of external noise
- Improves quality of life for people with chronic illness or disabilities

## Health & Wellbeing

- Improved community health & wellbeing
- Reduced anti-social behaviour
- Reduced load on health services

## Social

## Building Performance

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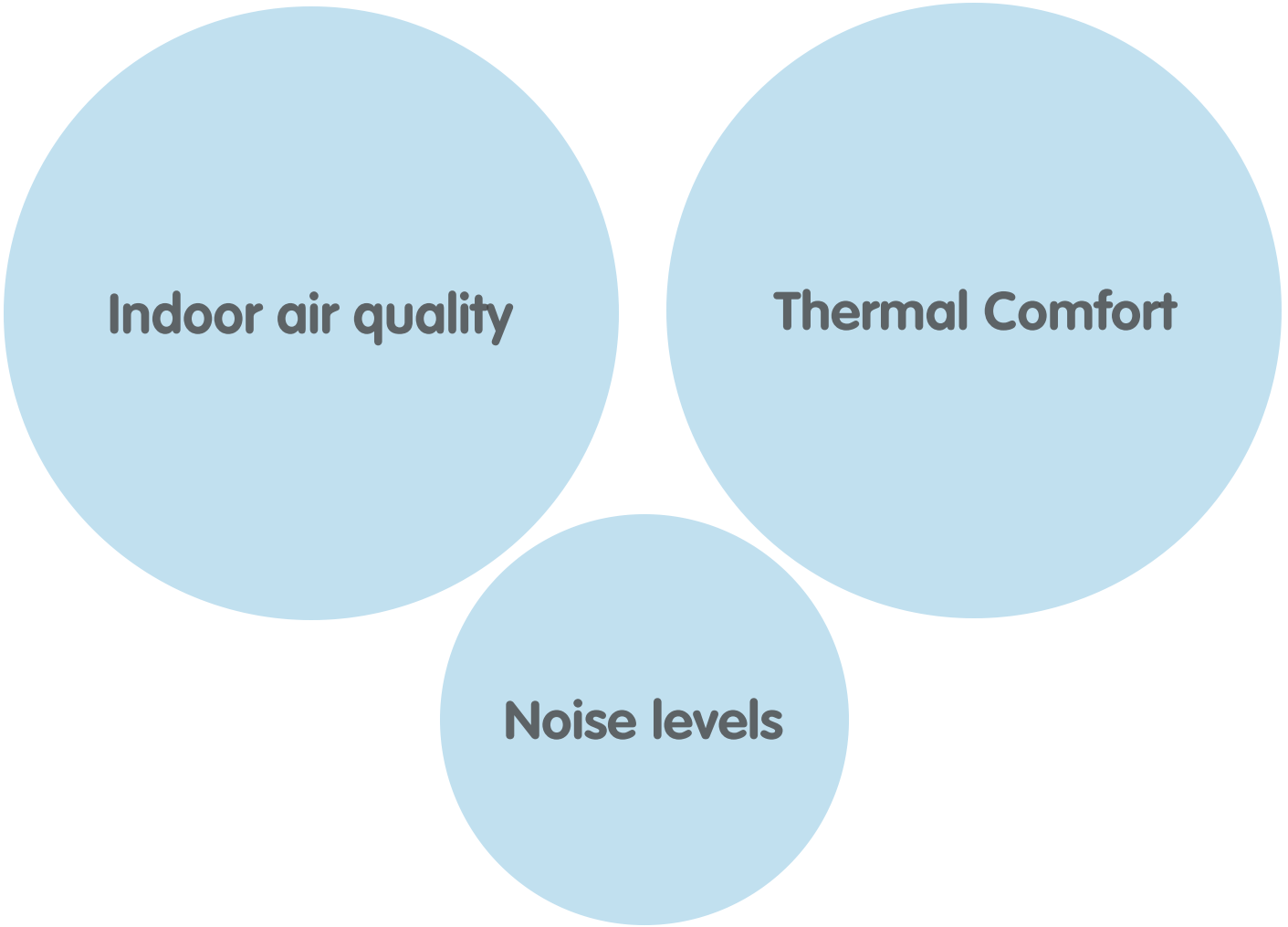
# Three key things that Passivhaus delivers ...



# Comfort - thermal and auditory

"For each degree warmer or cooler than 22 degrees, average speed at performing a test task dropped by around 1 per cent"

Two US studies

"Employees perform 6% worse in tests when the office was overheated, and 4% worse when the office was cold"

Well Standard, wellcertified.com

"The mean reading age of the children in classrooms exposed to high noise levels was found to be 3–4 months behind that of the control children"

CIBSE TM40

# Reduced absenteeism

> “Buildings with higher ventilation rates are associated with 1.6 fewer days sickness per year.”

'Healthy Buildings', Joseph Allen and John Macomber

> “CO2 levels above 900 ppm have been associated with an increase in symptoms such as dry cough, runny nose, asthma ... and more days off school.”

Indoor Air Quality in Passivhaus Dwellings: A Literature Review Alejandro Moreno-Rangel , Tim Sharpe et al 2020

> “The Scottish research team estimated that a 500 ppm difference could very roughly correspond to each student missing on average two-and-a-half extra days of school each year”

RCPCH the Inside Story

# Improved cognition

"In one of the offices, people managed a test in an average of 8 minutes when CO2 was low, compared with 13 minutes when CO2 levels were high"

Oxford Brookes study

"Higher levels of VOCs were associated with lowered cognitive scores"

Associations of cognitive function scores with carbon dioxide ventilation and volatile organic compound exposures Env Health Perp 124 no 6, J Allen et al

"Schools which had higher levels of air pollution had a higher percentage of students who tested below average in maths and English"

Air pollution spikes linked to lower test results, airqualitynews.com, Dec 2020

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Section 4

# SOME EXAMPLES


GALE
SNOWDEN

# Case Study - Agar Grove

- Redevelopment of existing end-of-life social housing to deliver 493 units covering 49,346m2 of floor area
- Concrete frame with block infill, externally insulated
- Communal MVHR to apartments, individual for maisonettes
- Gas boilers and Heat Interface Units

# Case Study - UEA Enterprise Centre

- 3,400 m2 Passivhaus with very low embodied carbon also
- Timber Frame with Lime Render and Thatch Cladding
- Natural and bio-renewable materials sourced through local supply chains

# Passivhaus

## Certificate

Certified Passive House Classic

MEAD Mead: Energy & Architectural Design Ltd.
3 Harvey Road, London, N8 9PD

Authorised by: Passive House Institute
Dr. Wolfgang Feist
64283 Darmstadt
Germany

**The Enterprise Centre**
**University of East Anglia, Norwich Research Park, NR4 7TJ**
**Norwich, United Kingdom/ Britain**

Certified Passive House
Passive House Institute
classic | plus | premium

| | |
|---|---|
| Client | Morgan Sindall<br>69-75 Thorpe Road<br>NR1 1UA Norwich, United Kingdom/ Britain |
| Architect | Architype Ltd<br>1b Leathermarket Street<br>SE1 3JA London, United Kingdom/ Britain |
| Building Services | BDP<br>16 Brewhouse Yard, Clerkenwell<br>EC1V 4LJ London, United Kingdom/ Britain |
| Energy Consultant | Architype Ltd<br>1b Leathermarket Street<br>SE1 3JA London, United Kingdom/ Britain |

Passive House buildings offer excellent thermal comfort and very good air quality all year round. Due to their high energy efficiency, energy costs as well as greenhouse gas emissions are extremely low.

**The design of the above-mentioned building meets the criteria defined by the Passive House Institute for the 'Passive House Classic' standard:**

| Building quality | | This building | | Criteria | Alternative criteria |
|---|---|---|---|---|---|
| **Heating** | | | | | |
| Heating demand | [kWh/(m²a)] | 11 | ≤ | 15 | - |
| Heating load | [W/m²] | 9 | ≤ | - | 10 |
| **Cooling** | | | | | |
| Frequency of overheating (> 25 °C) | [%] | 0 | ≤ | 10 | |
| **Airtightness** | | | | | |
| Pressurization test result ($n_{50}$) | [1/h] | 0.2 | ≤ | 0.6 | |
| **Non-renewable primary energy (PE)** | | | | | |
| PE demand | [kWh/(m²a)] | 111 | ≤ | 120 | |

The associated certification booklet contains more characteristic values for this building.

##
Certifier: Kym Mead, MEAD: Energy & Architectural Design Ltd

www.passivehouse.com 13563_MEAD_PH_20160519_KM

# Outstanding

BREEAM® UK

Code for a Sustainable Built Environment
www.breeam.org

## Interim Certificate – Design Stage

This is to certify that:

**UEA Enterprise Centre**
**University Drive**
**Norwich**
**Norfolk**
**NR4 7TJ**

has been assessed to:

**BREEAM New Construction 2011: Education**
**(Fully Fitted)**

by a licensed assessor for:
**Morgan Sindall**
and has achieved a score of **90.8%**
**Outstanding**

Certificate Number: **BREEAM-0045-6509** Issue: **01**

| | |
|---|---|
| 12 August 2015<br>Date of Issue | BDP<br>Assessor Company |
| Signed on behalf of BRE Global Ltd. | Philip Gray<br>Licensed Assessor |
| Gavin Dunn<br>Director, BREEAM | PG21<br>Assessor Number |
| Morgan Sindall<br>Principal Contractor | Architype<br>Architect |
| rfl 3PM<br>Project Management | BDP<br>Building Services / Structural Engineer |
| Morgan Sindall - Stuart Thompson<br>BREEAM Accredited Professional | Churchman Landscape<br>Landscape Architect |

BREEAM UK

This certificate is issued by BRE Global Ltd to the Licensed Assessor named above based on their assessment of data provided by the Client and verified at the time of Assessment.
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BF1226 Rev 1.2 Page 1 of 2 © BRE Global Ltd, 2014

# DEC A - 20

## 4 years in a row!

## Display Energy Certificate

How efficiently is this building being used?

HM Government

University of East Anglia
**THE ENTERPRISE CENTRE**
**University of East Anglia**
**Earlham Road**
**NORWICH**
**NR4 7TJ**

**Certificate Reference Number:**
0392-2482-4715-7200-2353

This certificate indicates how much energy is being used to operate this building. The operational rating is based on meter readings of all the energy actually used in the building including for lighting, heating, cooling, ventilation and hot water. It is compared to a benchmark that represents performance indicative of all buildings of this type. There is more advice on how to interpret this information in the guidance document *Display Energy Certificates and advisory reports for public buildings* available on the Government's website at: www.gov.uk/government/collections/energy-performance-certificates.

### Energy Performance Operational Rating

**This tells you how efficiently energy has been used in the building. The numbers do not represent actual units of energy consumed; they represent comparative energy efficiency. 100 would be typical for this kind of building.**

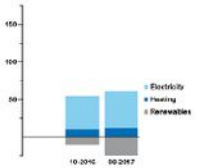
More energy efficient

A 0-25 ◀ 20
B 26-50
C 51-75
D 76-100
100 would be typical
E 101-125
F 126-150
G Over 150

Less energy efficient

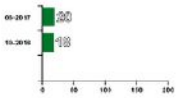
### Total $CO_2$ Emissions

**This tells you how much carbon dioxide the building emits. It shows tonnes per year of $CO_2$.**




### Previous Operational Ratings

**This tells you how efficiently energy has been used in this building over the last three accounting periods.**




### Technical Information

This tells you technical information about how energy is used in this building. Consumption data based on actual meter readings.

**Main heating fuel:** District Heating
**Building environment:** Heating and Natural Ventilation
**Total useful floor area (m²):** 3373
**Asset Rating:** Not available

| | Heating | Electricity |
|---|---|---|
| Annual Energy Use (kWh/m²/year) | 18 | 27 |
| Typical Energy Use (kWh/m²/year) | 240 | 80 |
| Energy from renewables | 0% | 34.2% |

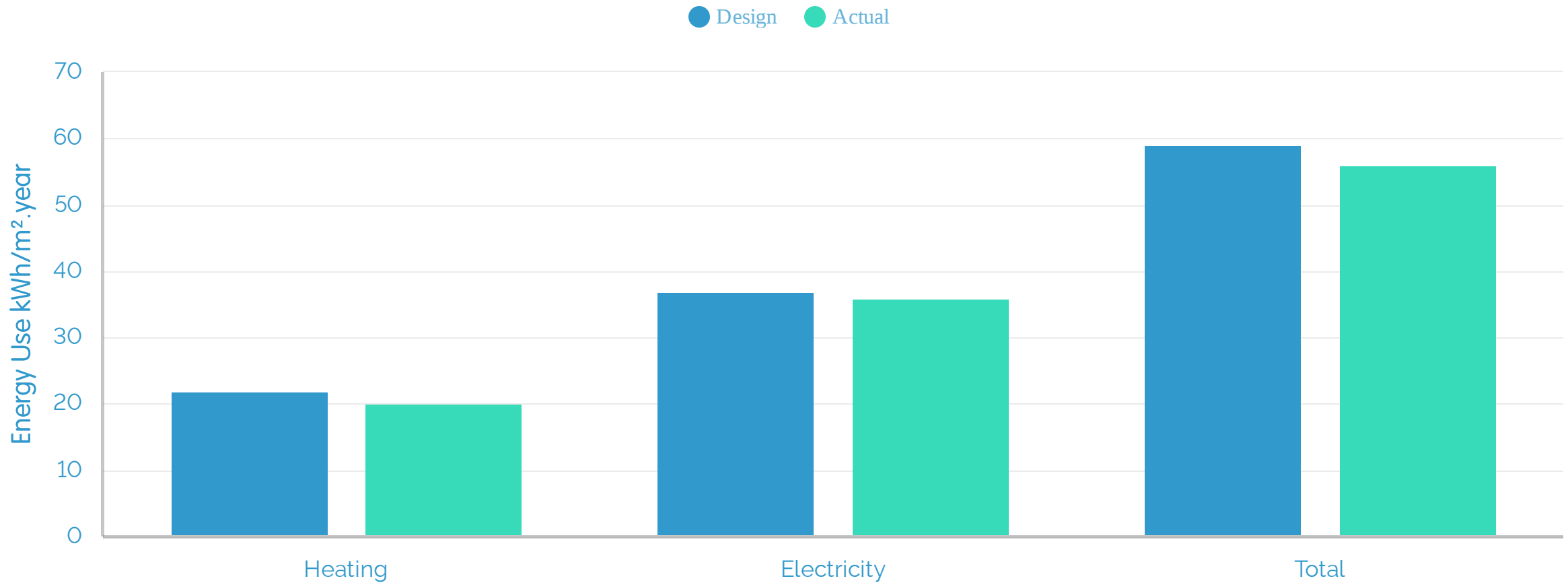
### Administrative Information

This is a Display Energy Certificate as defined in the Energy Performance of Buildings Regulations 2012 as amended.

| | |
|---|---|
| **Assessment Software:** | DCLG, ORCalc, v3.6.3 |
| **Property Reference:** | Z4Z34720055 |
| **Assessor Name:** | Gregory Howard Nash CEng MCIBSE |
| **Assessor Number:** | LCEA053055 |
| **Accreditation Scheme:** | CIBSE Certification Limited |
| **Employer/Trading Name:** | 1st For Energy |
| **Employer/Trading Address:** | Badger Croft, Featherbed Lane, Holmer Green, High Wycombe, HP15 6XQ |
| **Issue Date:** | 04-09-2017 |
| **Nominated Date:** | 31-08-2017 |
| **Valid Until:** | 30-08-2018 |
| **Related Party Disclosure:** | Not related to the occupier. |

Recommendations for improving the energy performance of the building are contained in the associated Recommendation Report - .
You can obtain contact details of CIBSE Certification Limited at cibsecertification.com.

# Case Study - UEA Enterprise Centre



# Passivhaus & Net Zero - takeaways

- Low energy buildings start with good form factor and orientation. They also need good levels of insulation, airtightness, little thermal bridging, high performance glazing and heat recovery
- Passivhaus uses about half the energy of a typical new build - and delivers what the design predicts. There are also significant comfort and health benefits
- As the grid decarbonises, we need to shift to electric heating and hot water
- Buildings will need to be very fabric efficient to reduce the heating demand and peak load to levels commensurate with net zero
- Passivhaus also delivers improved health, comfort and cognitive effects

Passivhaus Trust

The UK Passive House Organisation

# Get in touch!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0207 704 3502

@PassivhausTrust